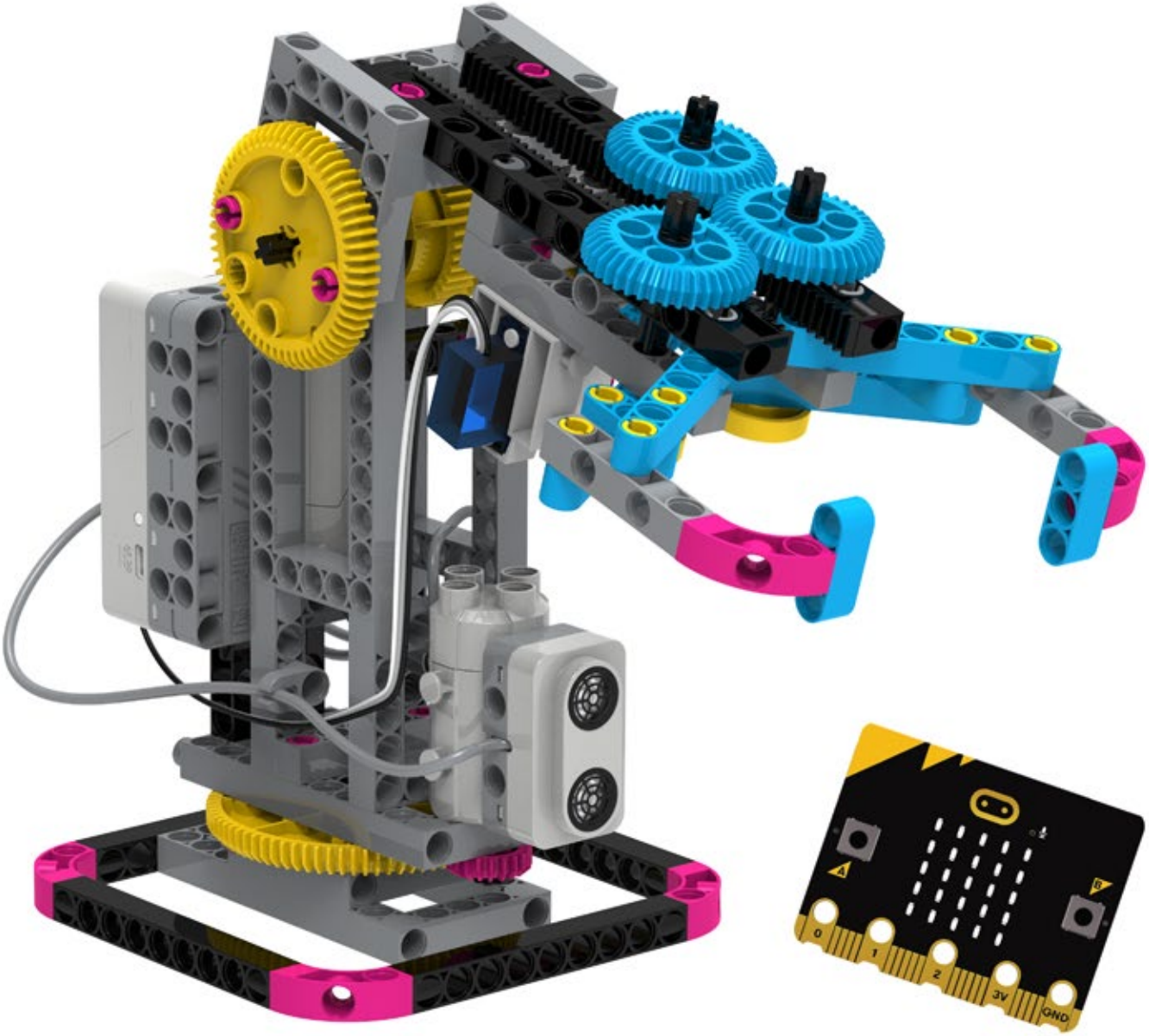
EXPERIMENT MANUAL

ROBOTICS WORKSHOP

WITH micro:bit



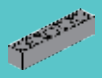
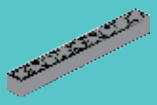
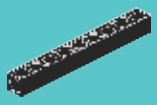
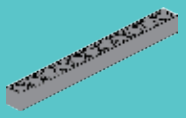
THAMES & KOSMOS

Thames & Kosmos, 89 Ship St., Providence, RI, 02903, USA | 1-800-587-2872 | www.thamesandkosmos.com
Franckh-Kosmos Verlags-GmbH & Co. KG, Pfizerstr. 5-7, 70184 Stuttgart, Germany | +49 (0) 711 2191-0 | www.kosmos.de

What's inside your experiment kit:

Good to know!
If you are missing any parts, please contact Thames & Kosmos technical support.

1	2	3	4	5	6	7	8	9
								
6x	2x	1x	1x	6x	6x	4x	4x	2x

10	11	12	13	14	15	16	17
							
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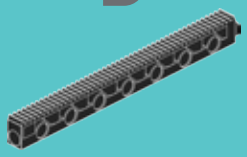
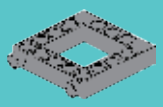
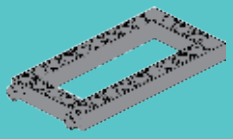
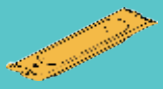
							
2x	6x	4x	20x	4x	30x	10x	4x

26	27	28	29	30	31	32
						
4x	4x	2x	1x	1x	1x	2x

33	34	35	36	37	38	39	40	41	42
									
1x	4x	6x	6x	6x	6x	20x	10x	4x	2x

43	44	45	46	47	48
2x	4x	10x	1x	1x	1x

Wow!
That's a lot of parts!

49	50	T
2x	1x	1x

YOU WILL ALSO NEED:
Personal computer or tablet with Internet access

Device requirements: The micro:bit can be used with any computer running macOS, Windows, Linux (inc. Raspberry Pi) or ChromeOS, and mobile devices running Android or iOS. See microbit.org for current details.
You only need a web browser on your computer. The MakeCode and Python Editor are browser-based, so you do not need to install any additional software to use the micro:bit.

TABLE OF CONTENTS

TIPS

FULL ASSEMBLY AND CODING INSTRUCTIONS ARE INCLUDED IN THIS MANUAL FOR PROJECTS 1, 2, 4, 11, AND 14. (THE ASSEMBLY INSTRUCTIONS FOR THE OTHER PROJECTS ARE ONLINE.)

Checklist:

✓	No.	Description	Quantity	Item No.
○	1	Small gear, magenta	6	7026-W10-D2P
○	2	Medium gear, yellow	2	7026-W10-W5Y
○	3	Large gear, yellow	1	7328-W10-G2Y
○	4	27-mm axle, gray	1	7026-W10-L1S1
○	5	30-mm axle, black	6	7413-W10-N1D
○	6	35-mm axle, black	6	7413-W10-O1D
○	7	60-mm axle, black	4	7413-W10-M1D
○	8	70-axle, black	4	7061-W10-Q2D
○	9	100-mm axle, black	2	7413-W10-L2D
○	10	150-mm axle, black	2	7026-W10-P1D
○	11	3-hole dual rod, black	6	7413-W10-Y1D
○	12	5-hole rod, gray	4	7413-W10-K2S1
○	13	5-hole dual rod, closed, gray	4	7413-W10-W1S1
○	14	5-hole dual rod, gray	4	7413-W10-X1S2
○	15	9-hole rod, gray	4	7407-W10-C1S
○	16	9-hole rod, front closed, black	4	7407-W10-C2D
○	17	11-hole rod, gray	6	7413-W10-P1S2
○	18	150-mm rack	2	7061-W10-T2D
○	19	5x5 square frame	6	7413-W10-Q1S1
○	20	5x10 frame	4	7413-W10-I1S1
○	21	Short anchor pin, black	20	7344-W10-C2D
○	22	Asymmetrical joint pin	4	7413-W10-U1S
○	23	Connector pin, magenta	30	1187-W10-E1K
○	24	Connector tube	10	7066-W10-A1S

✓	No.	Description	Quantity	Item No.
○	25	Washer	4	3620-W10-B1
○	26	Belt	4	7446-W10-C1D
○	27	Dual axis connector	4	7430-W10-B1S1
○	28	3-hole rod with pegs	2	7404-W10-B1S2
○	29	Ball roller	1	1247-W85-C1S
○	30	Anchor pin lever	1	7061-W10-B1Y
○	31	Micro USB cable	1	E30#1247A
○	32	Direct drive motor	2	7412-W85-A-1
○	33	Servo motor	1	1247-W85-D3-1
○	34	Medium gear, blue	4	7408-W10-D2B1
○	35	Curved rod, magenta	6	7061-W10-V1P1
○	36	3-hole wide rounded rod, blue	6	7404-W10-C1B3
○	37	7-hole wide rounded rod, blue	6	7404-W10-C2B3
○	38	7-hole flat rounded rod, blue	6	7404-W10-C3B3
○	39	Joint pin, yellow	20	7413-W10-T1Y
○	40	Button connector	10	7061-W10-W1S1
○	41	Wheel frame	4	7446-W10-B1Y
○	42	Round rod connector, yellow	2	7026-W10-L2Y
○	43	Worm gear, blue	2	7344-W10-A1B
○	44	Cable fixer	4	1409-W10-F1S
○	45	Universal connector	10	1409-W10-G1S
○	46	USB-C cable	1	E30#1409A
○	47	Ultrasonic sensor	1	1409-W85-B
○	48	Smart controller	1	1409-W85-A
○	49	18650 Lithium-ion battery	2	1409-W85-H
○	50	BBC micro:bit (V2)	1	E70#1409-3
○	T	Tool for battery compartment	1	1409-W85-J

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SAFETY INFORMATION

WARNING!

This toy is only intended for use by children over the age of 8 years, due to accessible electronic components. Instructions for parents or caregivers are included and shall be followed. Keep packaging and instructions as they contain important information.

WARNING!

Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled. Strangulation hazard — long cords may become wrapped around the neck.

The battery compartment must be opened with a special tool. See page 6.

Store the experiment material and completed models out of the reach of small children.

Safety for Experiments with Batteries

››› Never perform experiments using household current! The high voltage can be extremely dangerous or fatal!
››› To operate the models, you will need two 18650 rechargeable lithium-ion batteries (3.7-volt) which are included in the kit.
››› Avoid short circuiting the batteries. A short circuit can cause the wires to overheat and the battery to explode.
››› The supply terminals are not to be short-circuited. A short circuit can cause the wires to overheat and the batteries to explode.
››› Different types of batteries or new and used batteries are not to be mixed.
››› Do not mix old and new batteries.
››› Do not mix alkaline, standard (carbon-zinc), or rechargeable (nickel cadmium) batteries.
››› The batteries are to be inserted with the correct polarity (+ and -). Press them gently into the battery compartment (see page 6). The battery must be inserted by an adult.
››› Non-rechargeable batteries are not to be recharged. They could explode!
››› Rechargeable batteries are only to be charged under adult supervision.
››› Rechargeable batteries are to be removed from the toy before being charged (or they must be charged as described in the instructions).
››› Exhausted batteries are to be removed from the toy (e.g., if no experiments are to be carried out with them for a prolonged period of time).
››› The supply terminals are not to be short-circuited.
››› Dispose of used batteries in accordance with environmental provisions, not in the household trash.
››› Be sure not to bring batteries into contact with coins, keys, or other metal objects.
››› Avoid deforming the batteries.
››› Do not expose the toy to extreme heat or long periods of direct sunlight; protect it from heavy, persistent rain and frost.
››› As all of the experiments use batteries, have an adult check the models before use to make sure they are assembled properly. Always operate the motorized models under adult supervision.

Notes on Disposal of Electrical and Electronic Components

The electronic components of this product are recyclable. For the sake of the environment, do not throw them into the household trash at the end of their lifespan. They must be delivered to a collection location for electronic waste, as indicated by the following symbol:

Please contact your local authorities for the appropriate disposal location.

Safety Instructions for the BBC micro:bit

See the safety information in the safety guide packed with the micro:bit.
Do not place any metal objects across the BBC micro: bit battery socket.
Do not place any metal objects across the printed circuit board and the board components as this can cause the board to fail.
Do not use your BBC micro: bit in water or with wet hands.
Do not leave your BBC micro: bit plugged into a USB device unsupervised.
Please handle your BBC micro: bit by its edges, taking special care when it is plugged into a power supply.
All leads and accessories used with your BBC micro: bit should meet the relevant local standards.
Please use third-party products and accessories with caution, ensuring to review before purchase to ensure compatibility and read all associated safety information.
Please do not leave your BBC micro:bit within reach of children under 8 years.
Only connect your BBC micro:bit to a power supply rated at 3 Volts DC. The maximum current safely supplied to an external circuit using the 3V pin on edge connector is 200mA.
Please do not store or use your BBC micro:bit in extremely hot or cold environments.

DC Power Supply

A USB-type C power adapter is required to charge the lithium-ion batteries.
››› The transformer or a power supply used with the toy shall be regularly examined for damage to the supply cord, plug, enclosure or other parts, and in the event of damage, it shall not be used until the damage has been repaired.
››› The toy shall only be used with a transformer for toys or a power supply for toys.
››› The transformer is not a toy.

USB Statement

This toy is only to be connected to equipment bearing either of the following symbols:

or

FCC Compliance Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions or satisfying RF exposure compliance. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

ISED Compliance Statement

This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science, and Economic Development Canada's license-exempt RSS(s). Operation is subject to the following two conditions: (1) This device may not cause interference. (2) This device must accept any interference, including interference that may cause undesired operation of the device.

ISED Radiation Exposure Statement

This equipment complies with IC RSS-102 radiation exposure limits set forth for an uncontrolled environment.

Simplified EU Declaration of Conformity

The Micro:bit Educational Foundation declares that this device is in compliance with the essential requirements and other relevant provisions of the Radio Equipment Directive 2014/53/EU. A full copy of the Declaration of Conformity can be found at http://microbit.org/hardware.

IMPORTANT INFORMATION

Dear Parents, Teachers, and Supervising Adults

Children want to explore, understand, and create new things.

They want to try things and do it by themselves. They want to gain knowledge!

They can do all of this with Thames & Kosmos experiment kits.

With every single experiment, they grow smarter and more knowledgeable.

Before building and experimenting, read the instructions together with your child or students and discuss the safety instructions.

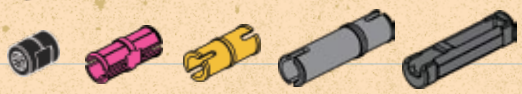
Support children with advice and a helping hand, especially during tricky assembly or coding steps or experiments. Some assembly steps require more strength, which you may need to provide.

To prevent damage to the work surface on which your child is building and experimenting, provide them with a mat or other surface protection.

Children must be supervised when playing with the experiment kit.

We hope you have a lot of fun building and coding with Robotics Workshop with micro:bit!

BUILDING TIPS



ANCHOR PINS AND CONNECTORS

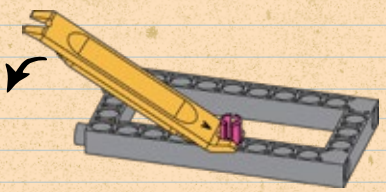
TAKE A CAREFUL LOOK AT THE DIFFERENT ASSEMBLY COMPONENTS: BLACK ANCHOR PINS, PINK CONNECTOR PINS, YELLOW JOINT PINS, LIGHT GRAY ASYMMETRICAL JOINT PINS, DARK GRAY CONNECTOR TUBES. THESE PARTS LOOK PRETTY SIMILAR AT FIRST GLANCE. WHEN YOU ASSEMBLE THE MODELS, IT'S IMPORTANT TO USE THE RIGHT ONES.

UNIVERSAL CONNECTOR

THIS PART CAN BE USED TO CONNECT THE PARTS IN THIS KIT TO OTHER BUILDING SYSTEMS, LIKE LEGO.

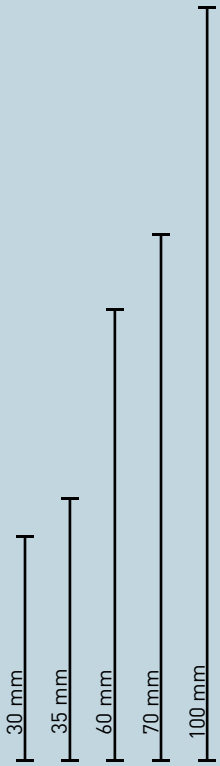
ANCHOR PIN LEVER

USE THIS TOOL TO DISASSEMBLE MODELS. END "A" OF THE TOOL MAKES IT EASY TO REMOVE ANCHOR PINS FROM THE FRAMES. END "B" CAN BE USED TO PRY PIECES APART.



AXLES

THE BUILDING SYSTEM CONTAINS AXLES (ALSO CALLED SHAFTS) OF VARIOUS LENGTHS. WHEN ASSEMBLING THE MODEL, ALWAYS BE SURE THAT YOU'RE USING THE RIGHT ONE. MEASURE YOUR AXLE AGAINST THE SCALE ON THE RIGHT IF YOU'RE NOT SURE.



ROBOTIC COMPONENTS

This system has five primary functional components that enable the robots to work:

A. The micro:bit smart controller holds the micro:bit and batteries. It has ports for connecting the other components (sensors and motors) to the micro:bit.

B. The ultrasonic sensor uses sound to detect objects in front of it. A sound wave is sent out and received again after bouncing off obstacles.

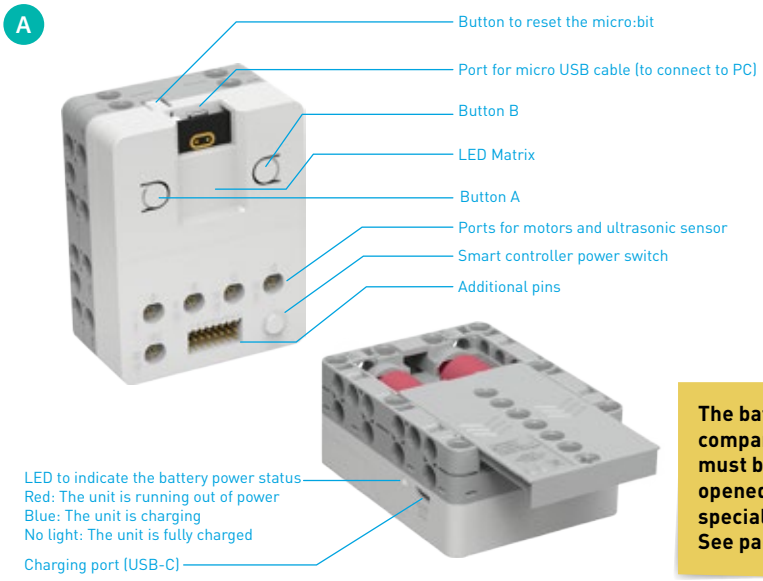
C. The direct drive motors (x2) are high torque motors that turn gears and wheels to activate your models. You can control both the speed and direction of rotation.

D. The servo motor can be programmed to rotate to an angle between 0 – 180°. Due to its sensitivity, **do not rotate the servo motor by hand;** rotate it only via the code.

E. The micro:bit contains many inputs (touch sensor, light sensor, temperature sensor, accelerometer, magnetometer) and outputs (LED matrix, speaker). It is also the "brain" of your robot, using feedback from the sensors along with programmed instructions to control the models. You will write code for your micro:bit using a web application called **MakeCode** and then download your programs to the micro:bit to bring your robotic creations to life.

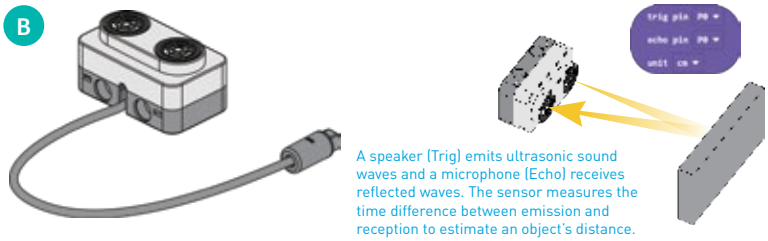
These elements, in combination with all the mechanical parts — rods, gears, axles, frames, and so on — allow you to build and program mechanical robots that can sense and respond to their environment.

A



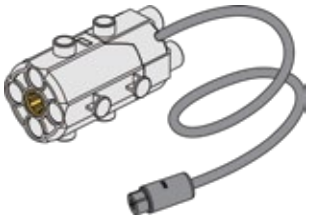
The battery compartment must be opened with a special tool. See page 6.

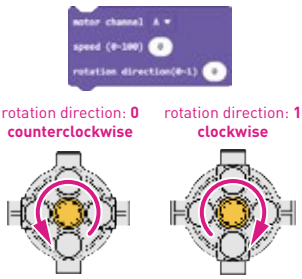
B



A speaker (Trig) emits ultrasonic sound waves and a microphone (Echo) receives reflected waves. The sensor measures the time difference between emission and reception to estimate an object's distance.

C





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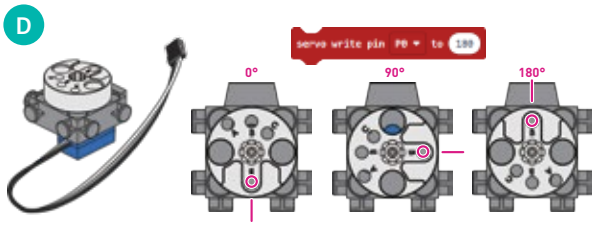
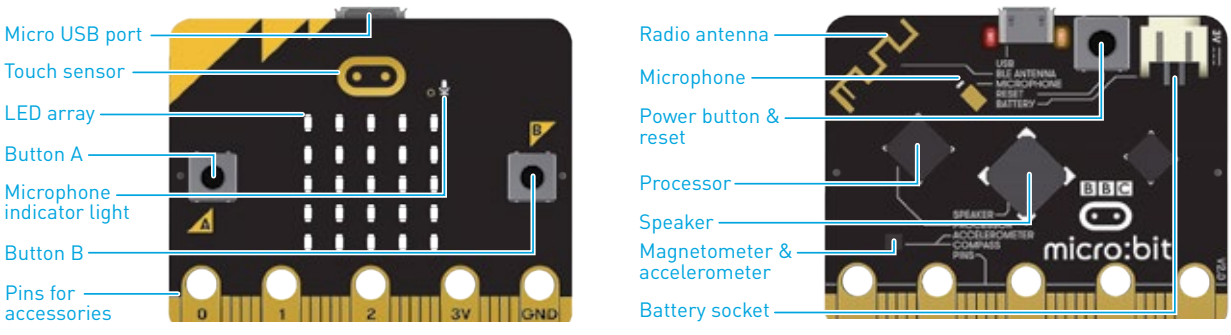


Do not rotate the servo motor by hand. Scan this QR code to access a program that will help you adjust the angle if needed.

E



OVERVIEW OF THE PROJECTS

This manual is just the beginning! Lots of additional content for Robotics Workshop with micro:bit can be found online.
For each project, you will find ...

- Detailed assembly steps
- Detailed coding instructions
- Downloadable code files

Scan this QR code or visit https://roboticsworkshop.thamesandkosmos.com

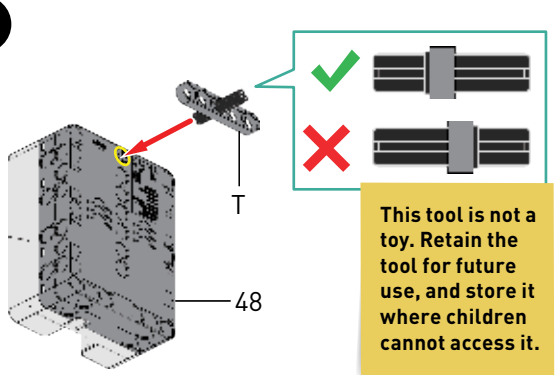
TIP

EACH PROJECT HAS A LEARNING TARGET DESIGNED TO INTRODUCE THE ROBOTIC COMPONENTS AND CODING CONCEPTS. EACH PROJECT ALSO INCLUDES PROMPTS TO "GO FURTHER"!

			Inputs							Outputs				
			Ultrasonic sensor	Buttons A + B	Accelerometer	Touch sensor	Temperature sensor	Light sensor	Magnetometer	Microphone	Servo motor	Direct drive motor(s)	LED matrix	Speaker
1	Name Tag	I can create and download code to my micro:bit.		✓									✓	
2	Counting Game	I can define and change variables.		✓	✓								✓	✓
3	Sundial	I can detect Earth's magnetic field.							✓				✓	
4	Countdown Timer	I can program a servo motor.		✓							✓		✓	✓
5	Mixer	I can program a direct drive motor.		✓								✓		
6	Smart Fan	I can program the temperature sensor.	✓	✓			✓					✓	✓	
7	Drummer Bot	I can program the light sensor.						✓				✓	✓	
8	Digital Safe	I can create a digital password.		✓							✓		✓	
9	Delivery Truck	I can program a car to follow a route.	✓	✓							✓	✓		
10	Auto Gate	I can program the ultrasonic sensor.	✓									✓		
11	Obstacle-Avoiding Robot	I can program a robot using functions.	✓	✓							✓	✓	✓	
12	Four-Legged Bionic Bot	I can command a robot with sounds.								✓		✓		
13	Conveyor Belt	I can program a factory operation.	✓	✓								✓	✓	
14	Robotic Arm	I can build an arm with three degrees of freedom.	✓	✓		✓					✓	✓	✓	

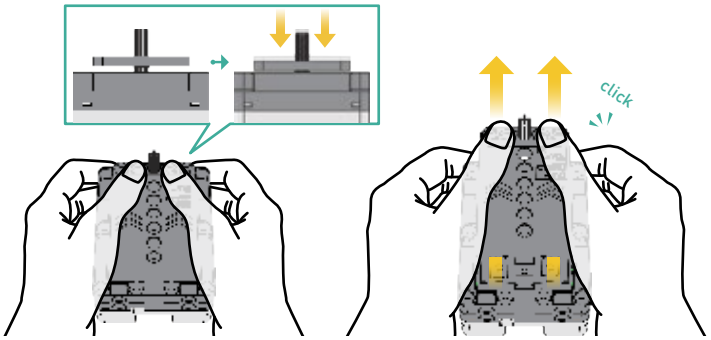
INSTALLING THE BATTERIES

1

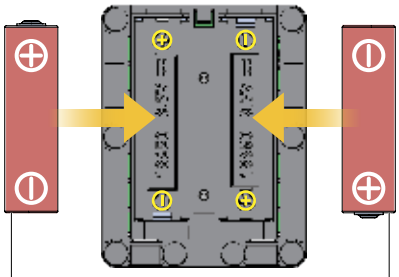


This tool is not a toy. Retain the tool for future use, and store it where children cannot access it.

2 Press down and slide out simultaneously.



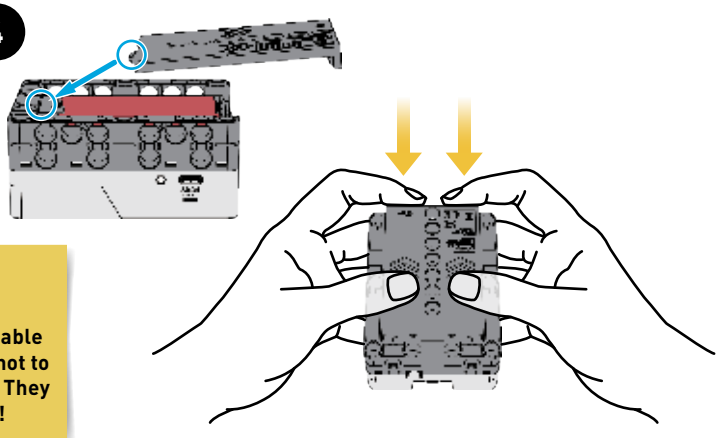
3 Carefully insert two 18650 Lithium-ion batteries (included in the kit), paying attention to the correct polarity (+ and -).



3.7-volt rechargeable lithium-ion battery, type 18650

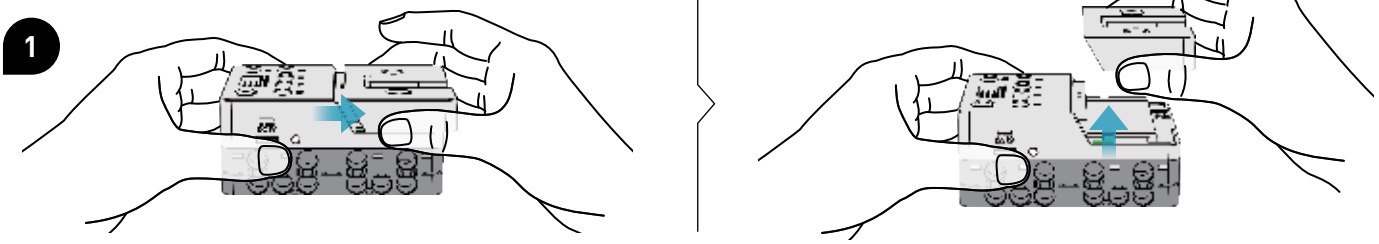
Non-rechargeable batteries are not to be recharged. They could explode!

4



INSTALLING THE MICRO:BIT

1



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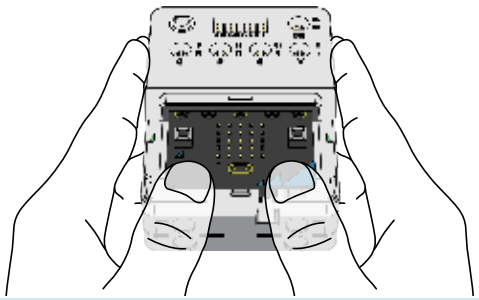
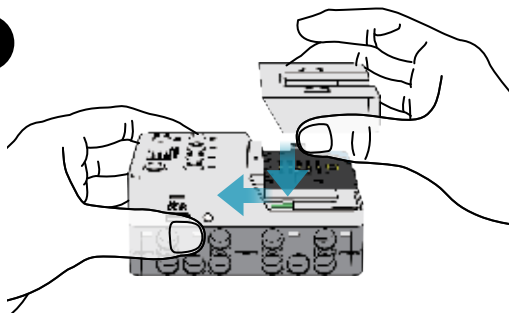
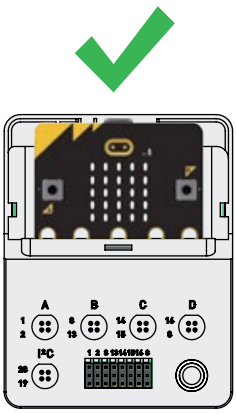
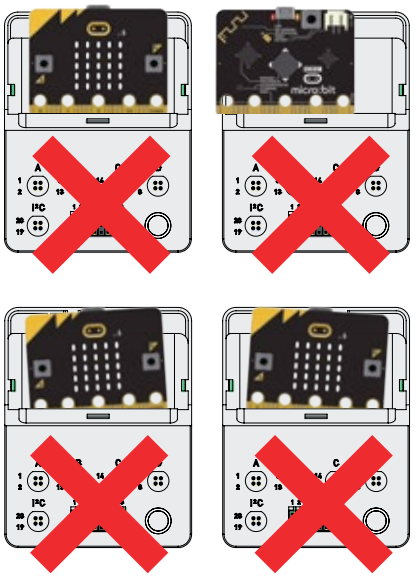


3





Make sure the micro:bit is installed properly. The base of the pins should not be visible, and the micro:bit should not be skewed to either side.

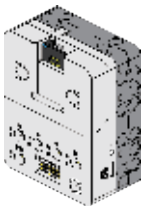


PROJECT 1: NAME TAG

Learning Target:
I can create and download code to my micro:bit.

PROJECT 1 ONLINE CONTENT

1 Make sure the batteries and micro:bit are inserted properly (see page 6).
Make sure the batteries are charged (see page 2).



2 Open a web browser on your computer and type in **"makecode.microbit.org".**

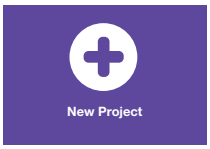
>> Alternatively, download the **micro:bit** app from the Google Play Store or the Apple App Store (see app stores for details).

For more detailed information on how to get started with your micro:bit, visit our website by scanning the QR code at the top of this page.

3 If you're using a web browser, click on "New Project".

>> From the mobile app, click on "Create Code", then click on "New Project".

Then give your project a name.



SAMPLE PROGRAM FOR PROJECT 1

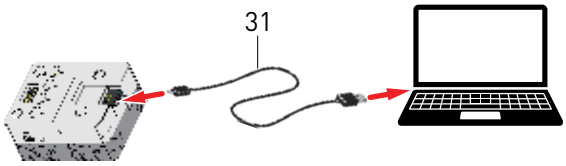
4 Drag and drop the coding blocks to create your code. If you're not sure how, visit our website for a how-to video (see link above).

Buttons are very common input devices. The micro:bit has two buttons: A and B.

In programming, **strings** are sequences of characters that can contain letters, numbers, symbols, and spaces. Strings must be inside of quotation marks to be recognized.

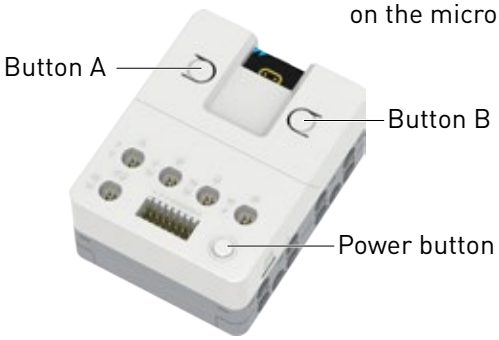
5 Connect the micro:bit to your computer using the micro USB cable.

>> If you're using the mobile app, click on "Manage Connections" to connect your micro:bit via bluetooth.



6 Click on "Download" in the bottom left corner of the screen.
You can either pair your micro:bit, or download the .hex file to your computer, then upload it to your micro:bit from your computer.

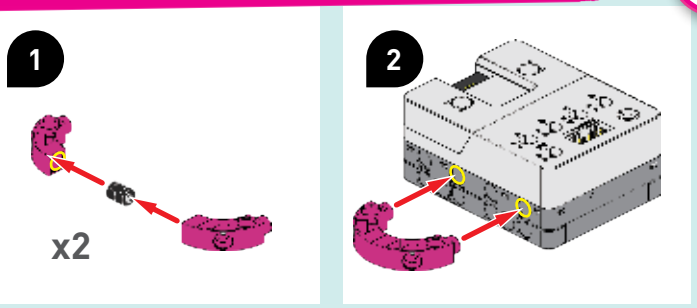
7 Eject the micro:bit from your computer. Make sure your smart controller is powered on. Then test your code by pressing the buttons on the micro:bit.



GO FURTHER!

1. The micro:bit's other built-in output is its speaker. Program your micro:bit to play music at the push of a button.
2. Turn your smart controller into digital dice that can generate random numbers.
3. Create simple animations using your micro:bit's LED display.

PROJECT 2: COUNTING GAME



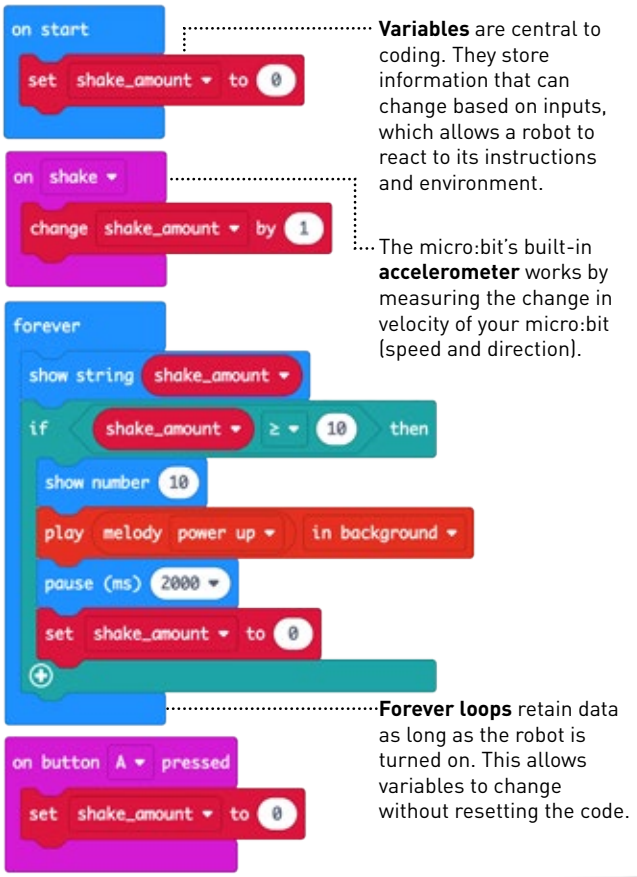
Learning Target:

I can define and change variables.

PROJECT 2 ONLINE CONTENT

SAMPLE PROGRAM FOR PROJECT 2

Shake the smart controller ten times to win the game, then press button A to reset.



Variables are central to coding. They store information that can change based on inputs, which allows a robot to react to its instructions and environment.

The micro:bit's built-in **accelerometer** works by measuring the change in velocity of your micro:bit (speed and direction).

Forever loops retain data as long as the robot is turned on. This allows variables to change without resetting the code.

GO FURTHER!

1. Can you make a pedometer (step counter)?
2. What else can the accelerometer detect besides shaking?

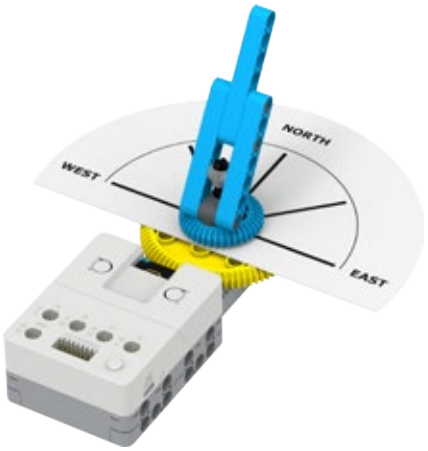
PROJECT 3: SUNDIAL

Learning Target:

I can use the magnetometer to detect Earth's magnetic field.

PROJECT 3 ONLINE CONTENT

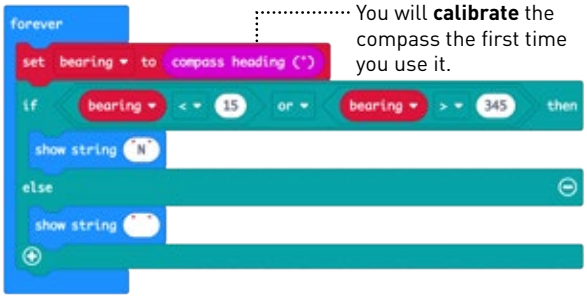
Full assembly and coding steps can be found online. You will also find a link to download a printable dial plate for your approximate latitude.



Full assembly and coding steps can be found online.

SAMPLE PROGRAM FOR PROJECT 2

Orient the sundial so it is pointing north, then use it to tell the time on a sunny day.



You will **calibrate** the compass the first time you use it.

GO FURTHER!

1. Change the code to make the compass more accurate.
2. Add other points to your compass (E, W, and S).

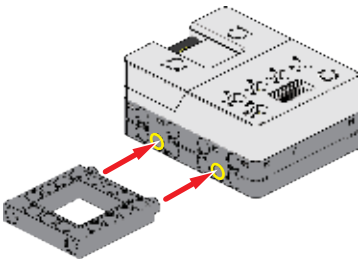
PROJECT 4: COUNTDOWN TIMER

Learning Target:

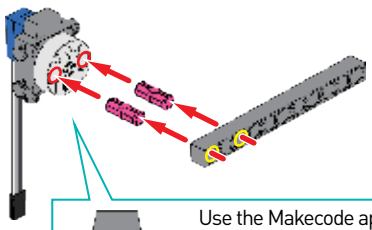
I can program a servo motor.

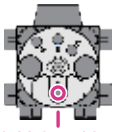
PROJECT 4 ONLINE CONTENT

1



2

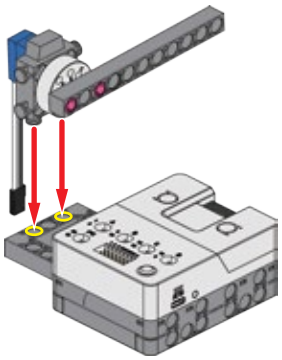




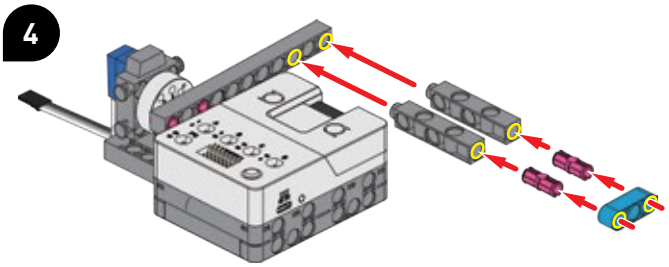
Initial position

Use the Makecode app to gently adjust the servo motor to this initial position (angle 0). Do not rotate it with your hands, or you might damage it.

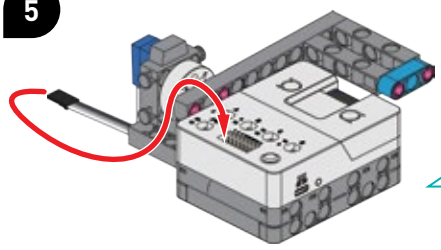
3

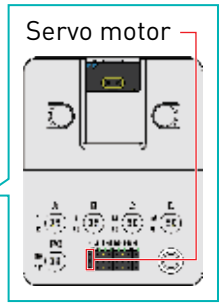


4



5





Done!

SAMPLE PROGRAM FOR PROJECT 4

When button A is pressed, the countdown begins. After 5 seconds, the timer raises a flag.

```
on start
    servo write pin P1 to 0
on button A pressed
    for index from 0 to 4
    do
        if index < 4 then
            play tone Middle C for 1 beat until done
            show number 5 - index
        else if index = 4 then
            servo write pin P1 to 95
            play melody entertainer in background
            repeat 4 times
            do
                show icon
                show icon
on button B pressed
    reset
```

For loops repeat sequences of code a certain number of times. In Blocks and Python, the variable is automatically incremented by 1 at the end of each sequence.

Servo motors rotate to a specific angle between 0 and 180°. They are used for exact, repeated movements.

GO FURTHER!

1. Make the timer count down from 10. Can you make it count up from 10?

2. Change the final position of the flag.

PROJECT 5: MIXER

Learning Target:

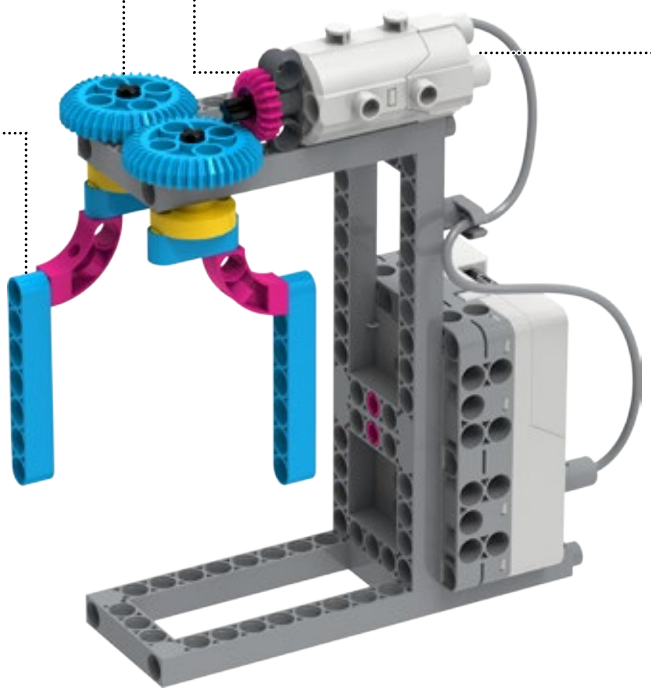
I can program a direct drive motor.

PROJECT 5 ONLINE CONTENT

This pink gear acts like a **bevel gear,** changing the axis of rotation.

Two meshed gears, called a **gear train,** always turn in opposite directions. When one gear turns clockwise, the gear next to it will turn counterclockwise.

While the blades of the mixer pass through the same area, they never touch. This type of **counter-rotation** can also be seen in tandem rotor helicopters.



Unlike a servo motor, which rotates to a specific angle, a **direct drive motor** rotates its axle in a particular direction (clockwise or counterclockwise) at a given speed, for a given duration.

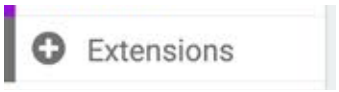
Full assembly and coding steps can be found online.

GO FURTHER!

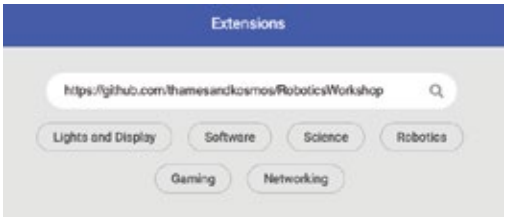
1. Change the speed and direction of motion.
2. Add some code to make the motor run for a certain amount of time.
3. What other motorized machines can you model?

Follow these steps to access the coding blocks you will need to program the direct drive motors and ultrasonic sensor.

1 With a new project open in MakeCode, click on "Extensions".



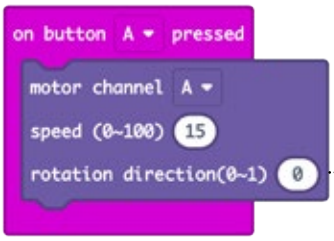
2 Type in: "https://github.com/thamesandkosmos/RoboticsWorkshop"



3 Click on the box below, then you will have RoboticsWorkshop in your panel of coding blocks.

SAMPLE PROGRAM FOR PROJECT 5

Press button A to turn the mixer on low speed. Press button B to turn the mixer on medium speed. Press A and B together to stop the motor.



This piece of the code controls direction of rotation.
"0" is counterclockwise;
"1" is clockwise.

This piece of the code controls the speed of rotation.

PROJECT 6: SMART FAN

SAMPLE PROGRAMS FOR PROJECT 6

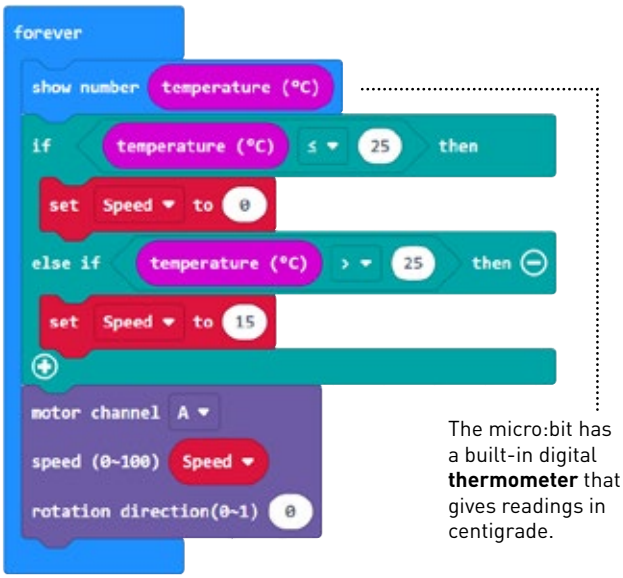
Learning Target:

I can program the temperature sensor and the ultrasonic sensor.

PROJECT 6 ONLINE CONTENT

Mode 1: Automatic Fan

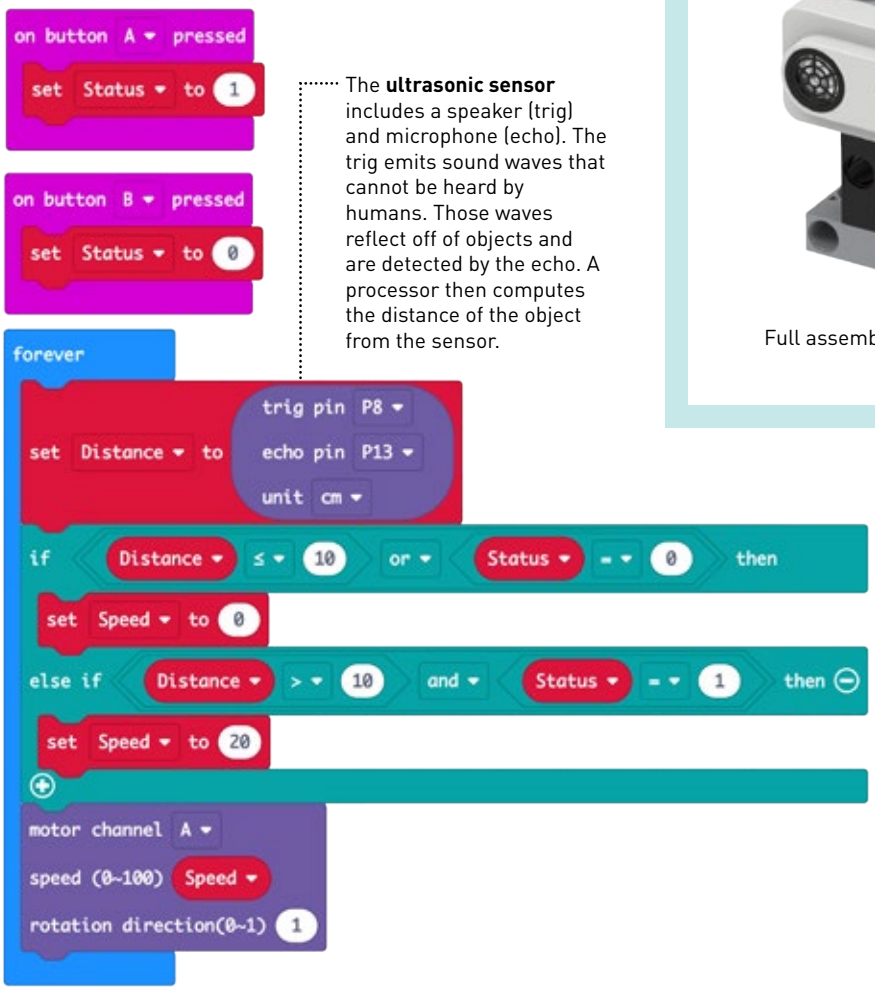
Turns on automatically when the temperature rises above a certain threshold.



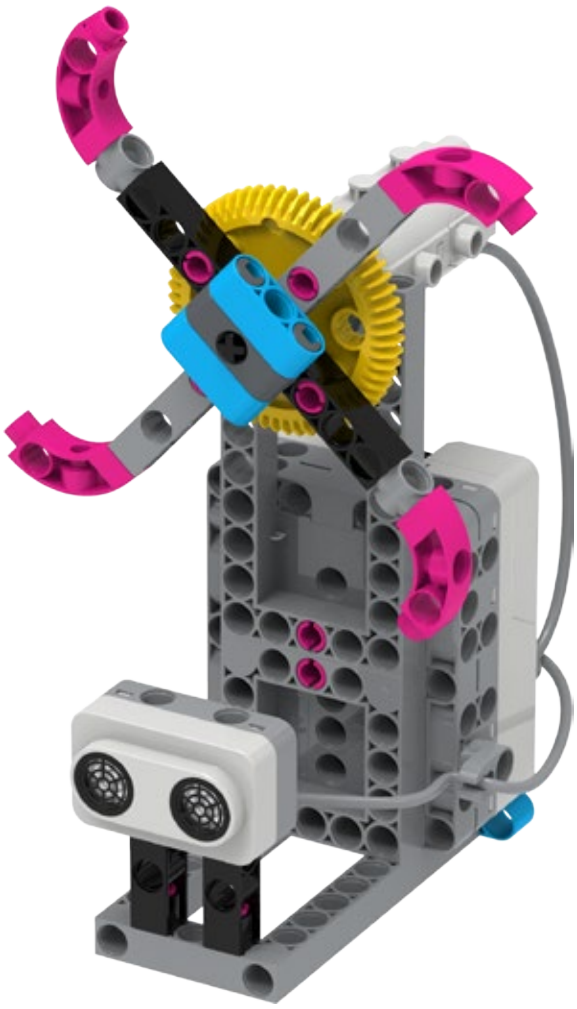
The micro:bit has a built-in digital **thermometer** that gives readings in centigrade.

Mode 2: Safety Fan

When an object approaches the fan, the blades automatically stop.



The **ultrasonic sensor** includes a speaker (trig) and microphone (echo). The trig emits sound waves that cannot be heard by humans. Those waves reflect off of objects and are detected by the echo. A processor then computes the distance of the object from the sensor.



Full assembly and coding steps can be found online.

GO FURTHER!

1. Make an energy-saving fan that only turns on when an object is within a certain distance.
2. Make an adjustable-speed fan that uses the micro:bit's touch sensor to increase the speed little by little. (Make sure to set a maximum speed.)
3. Add a function to your code to convert the temperature to Fahrenheit.

PROJECT 7: DRUMMER BOT

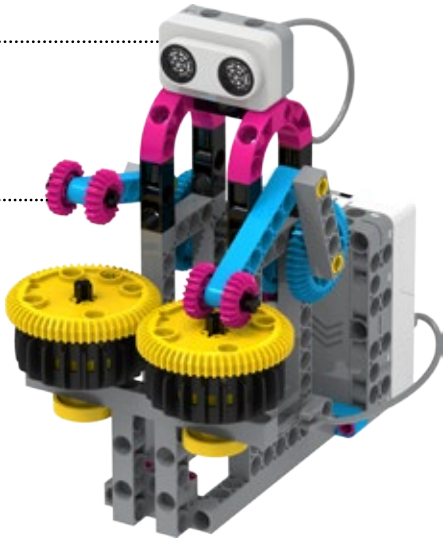
Learning Target:

I can program a light sensor.

MODEL 7 ONLINE CONTENT

GO FURTHER!

1. Incorporate the ultrasonic sensor into the robot's functionality.
2. Adjust the arms to change the "beat" of the drum.



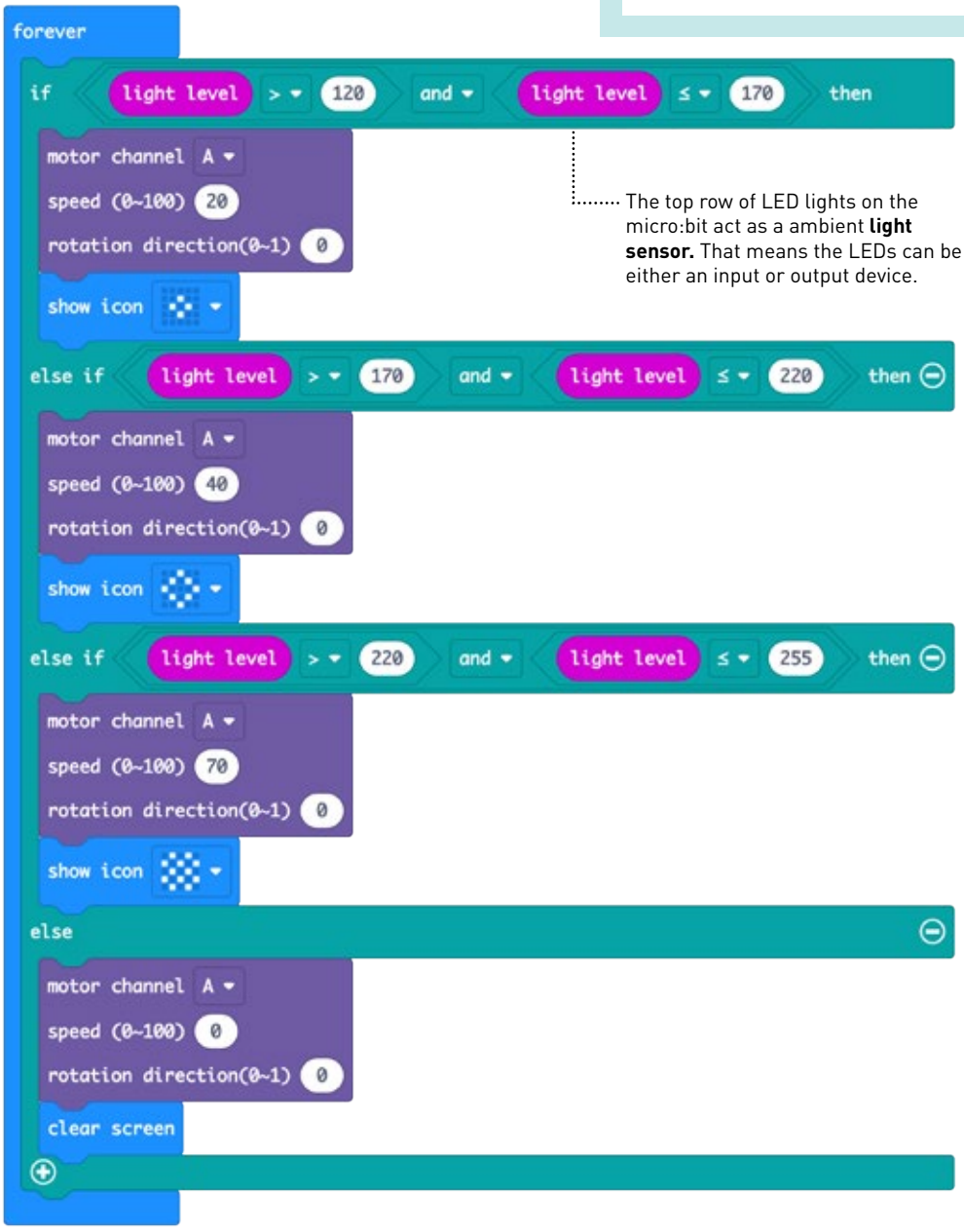
The ultrasonic sensor is only used for decoration in this model.

The drummer's arms are **cranks,** which are a type of **linkage.** The gray bars are driven by the rotary motion of the blue gears on the axle, which gives the arms a reciprocating up and down motion.

Full assembly and coding steps can be found online.

SAMPLE PROGRAM FOR PROJECT 7

Use a flashlight to control the intensity of the drumming. The closer you bring the flashlight to the LED array, the faster the drummer will go.



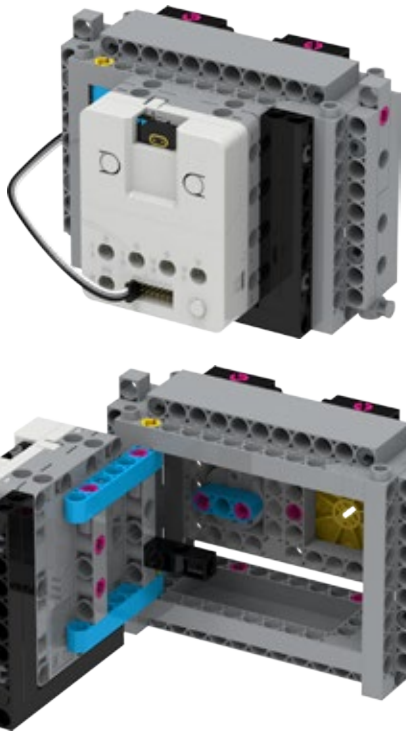
The top row of LED lights on the micro:bit act as a ambient **light sensor.** That means the LEDs can be either an input or output device.

PROJECT 8: DIGITAL SAFE

Learning Target:

I can create a digital password.

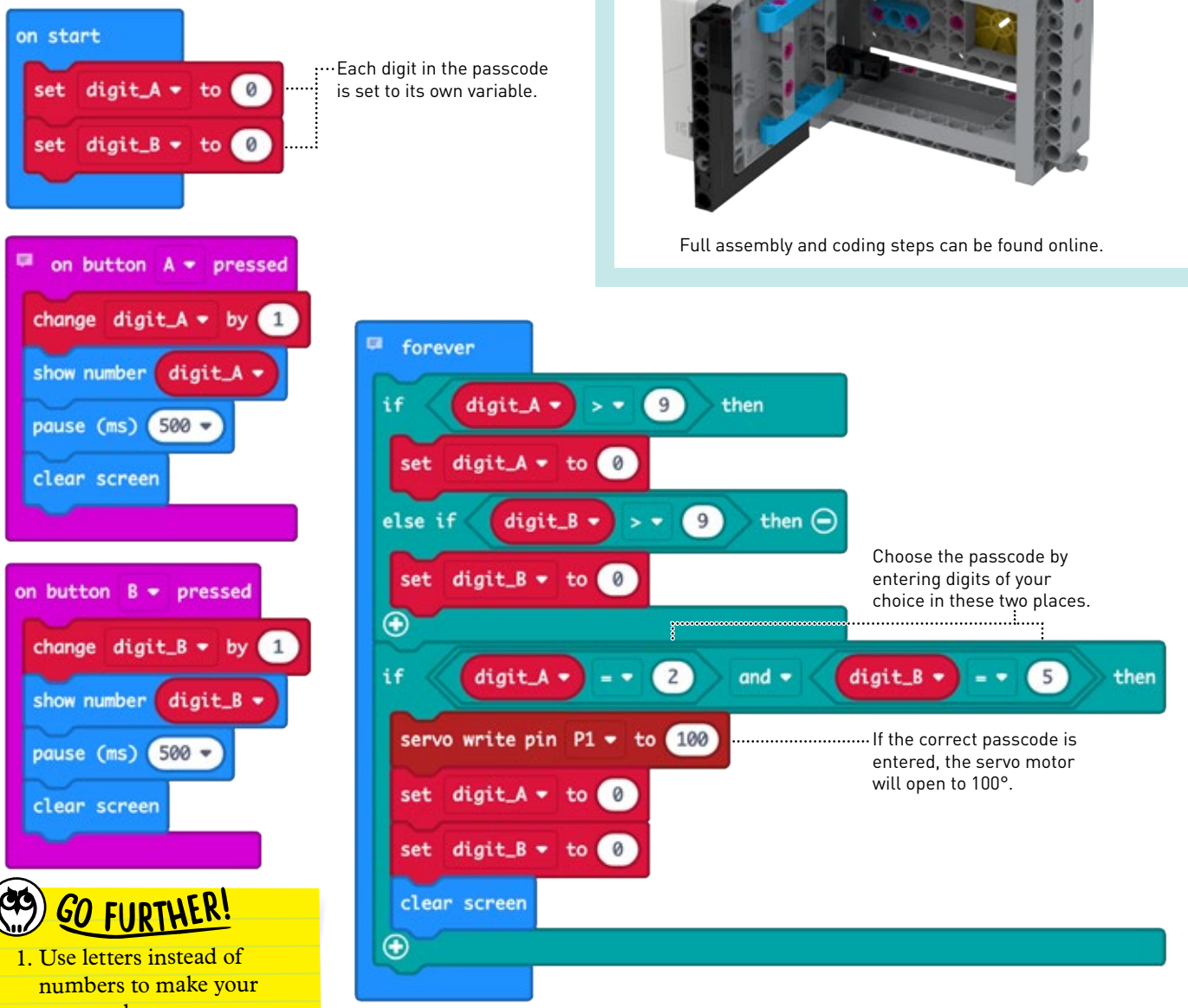
MODEL 8
ONLINE CONTENT



Full assembly and coding steps can be found online.

SAMPLE PROGRAM FOR PROJECT 8

Set your preferred two-digit passcode as you're writing the code. (The passcode in this example is 2 5).
Press button A until you reach 2, then press button B until you reach 5. The lock opens automatically. Press buttons A and B together to relock the safe.



GO FURTHER!

1. Use letters instead of numbers to make your password more secure, because instead of 100 2-number combinations, there are 676 2-letter combinations. If you use both letters and numbers, this jumps up to 1,296 possible passwords!

PROJECT 9: DELIVERY TRUCK

Learning Target:

I can program a car to follow a route.

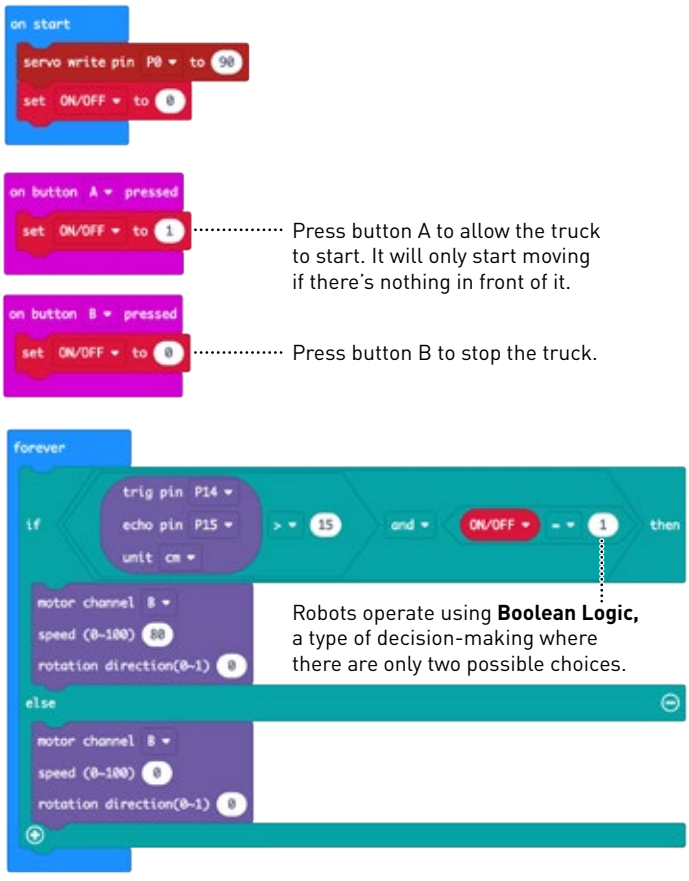
PROJECT 9 ONLINE CONTENT

Full assembly and coding steps can be found online.

SAMPLE PROGRAM FOR PROJECT 9

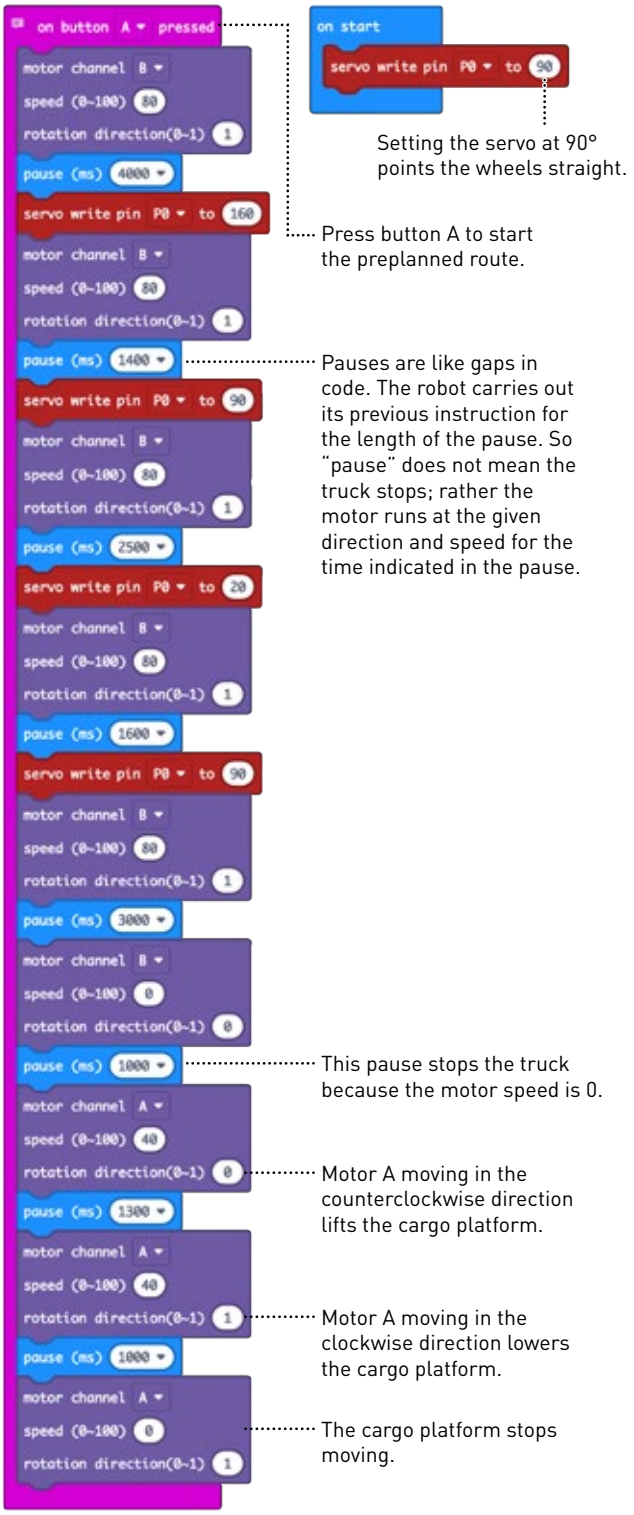
Mode 1: Obstacle-Sensing Truck

The motor connected to port B moves the truck forward. An ultrasonic sensor, connected to port C, detects objects on a straight route and stops the truck.



Mode 2: Route-Following Delivery Truck

The motor connected to port A drops the cargo. The motor connected to port B moves the truck forward. A servo motor connected to pin 0 steers the front wheels.



GO FURTHER!

1. With a second micro:bit, program a remote control for your truck.
2. Create a city complete with bridges, streets, garages, etc. for your truck to traverse.

PROJECT 10: AUTOMATIC GATE

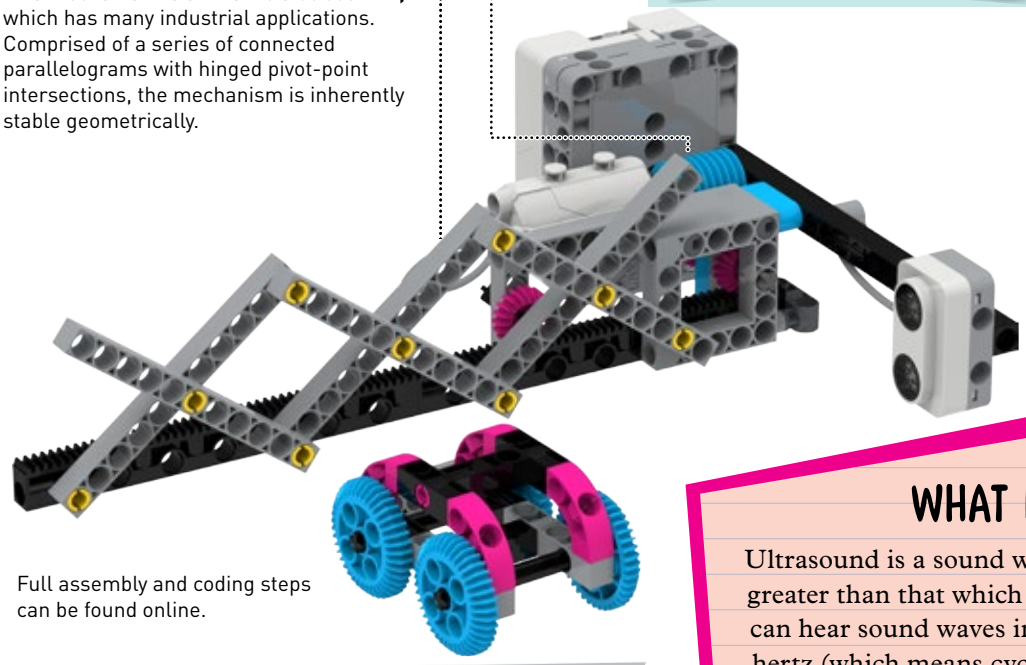
Learning Target:

I can program the ultrasonic sensor to detect an approaching object.

PROJECT 10 ONLINE CONTENT

Worm drives transfer rotational motion to linear motion. The worm is a gear shaped like a screw that rotates and drives the movement of the gear meshing with it. This makes it ideal for machines with high torque.

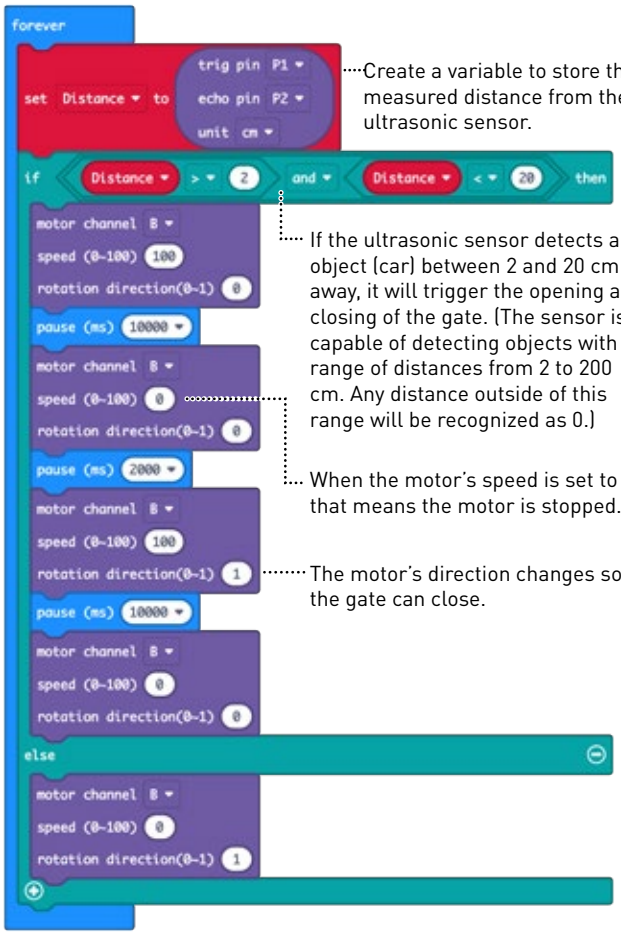
This mechanism is similar to a **scissor lift,** which has many industrial applications. Comprised of a series of connected parallelograms with hinged pivot-point intersections, the mechanism is inherently stable geometrically.



Full assembly and coding steps can be found online.

SAMPLE PROGRAM FOR PROJECT 10

Approach the gate with a car. The gate will automatically open then close.



Create a variable to store the measured distance from the ultrasonic sensor.

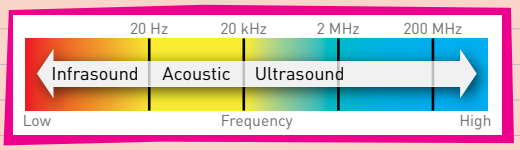
If the ultrasonic sensor detects an object (car) between 2 and 20 cm away, it will trigger the opening and closing of the gate. (The sensor is capable of detecting objects with a range of distances from 2 to 200 cm. Any distance outside of this range will be recognized as 0.)

When the motor's speed is set to 0, that means the motor is stopped.

The motor's direction changes so the gate can close.

WHAT IS ULTRASOUND?

Ultrasound is a sound wave that has a frequency greater than that which humans can hear. Humans can hear sound waves in the frequency range of 20 hertz (which means cycles per second) to 20,000 hertz (20 kilohertz).



ANIMAL SONAR

In the natural world, bats, whales, and some birds use sound waves to detect objects around them. This is especially useful for hunting in the darkness of night or underwater. This type of sensing is called **echolocation,** or **biosonar.** The animal emits sound waves that move outward in all directions. When the sound waves hit an object, they bounce off of it and travel back to the animal's ears. The sound waves reach the two ears at slightly different times, allowing the animal to perceive the size, direction of movement, and speed of objects.

GO FURTHER!

1. Change the build and code to use a servo instead of a direct drive motor. Which works better for this situation, and why?

2. Create a robot that navigates like a bat.

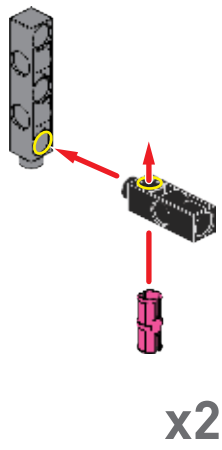
PROJECT 11: OBSTACLE-AVOIDING ROBOT

Learning Target:

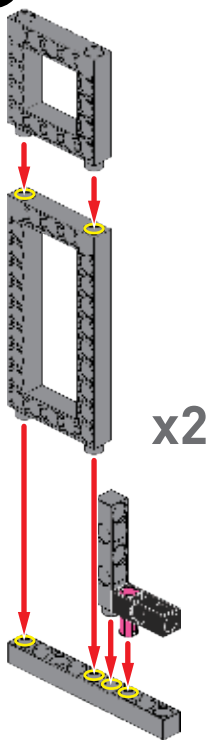
I can program a robot using functions.

PROJECT 11 ONLINE CONTENT

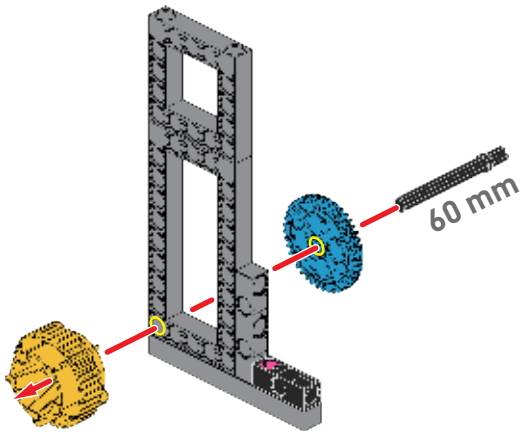
1



2



3



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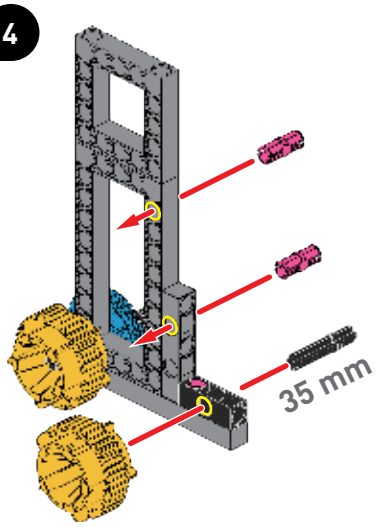

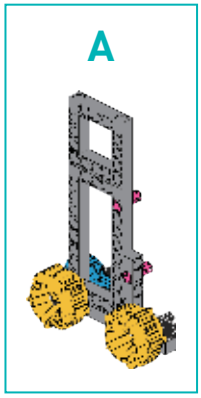

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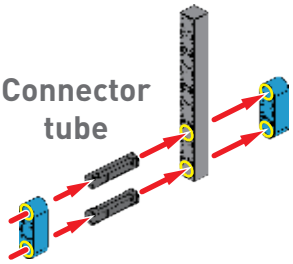

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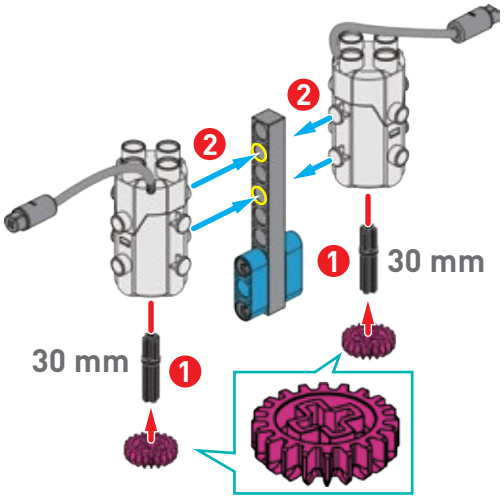

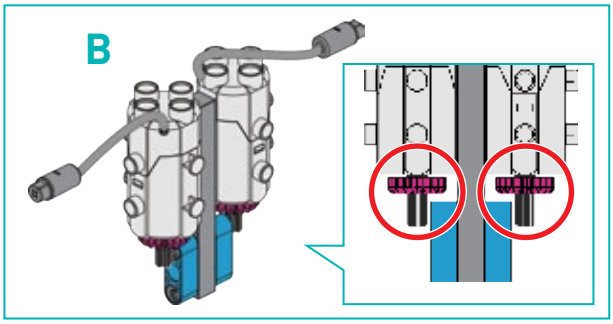

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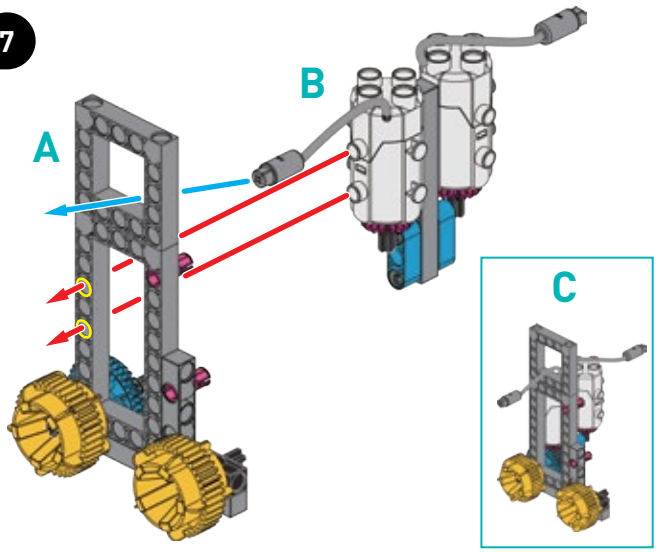

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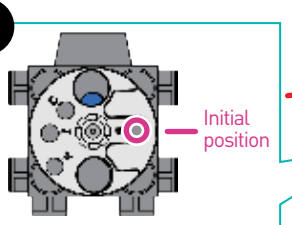
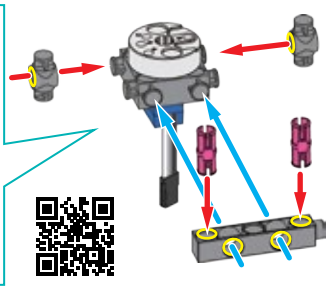


Use the Makecode app to gently adjust the servo motor to this initial position if necessary.



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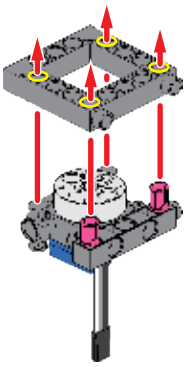

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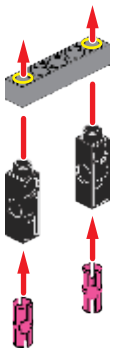

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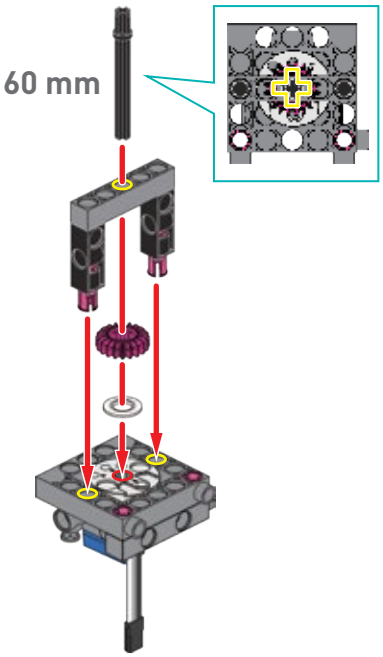

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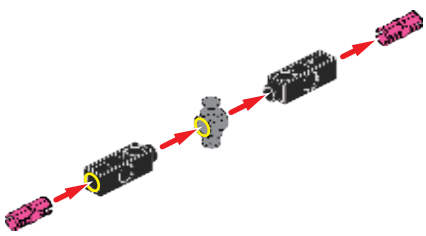

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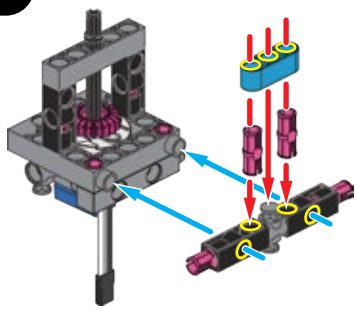

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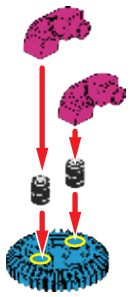

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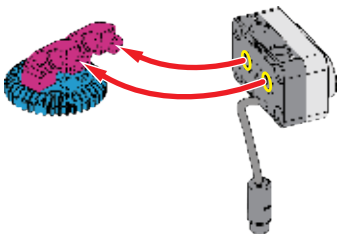

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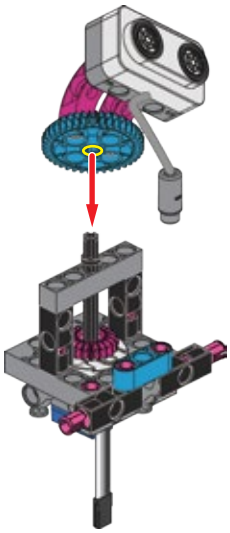

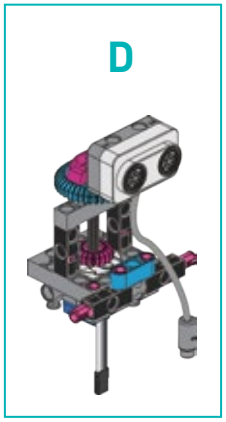

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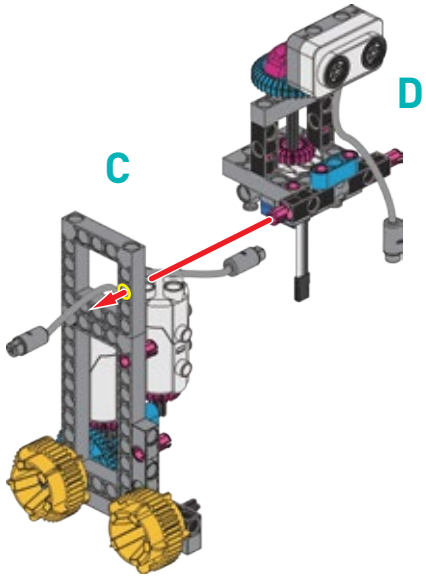

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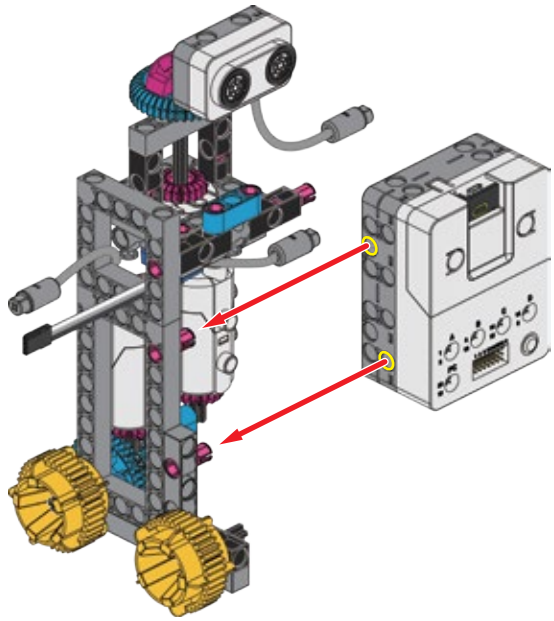

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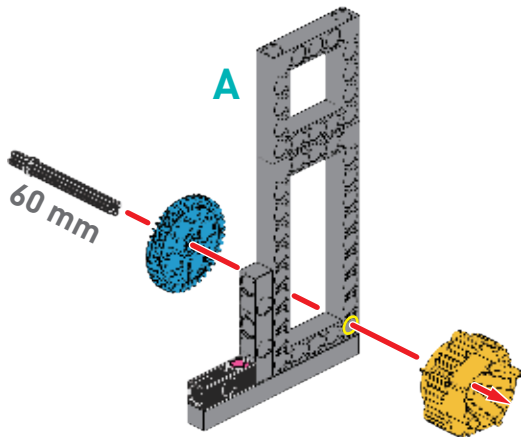

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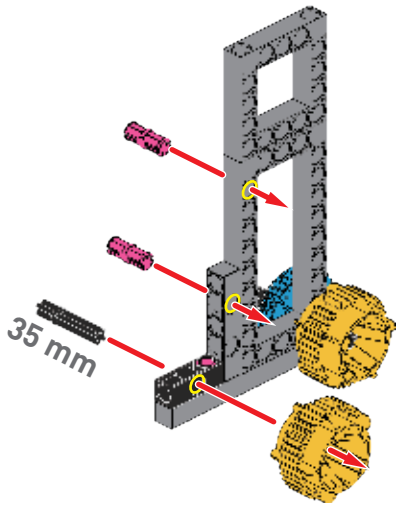

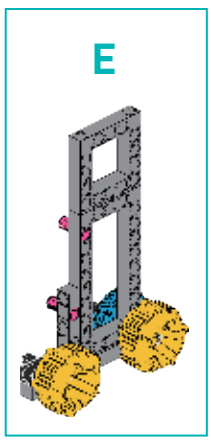

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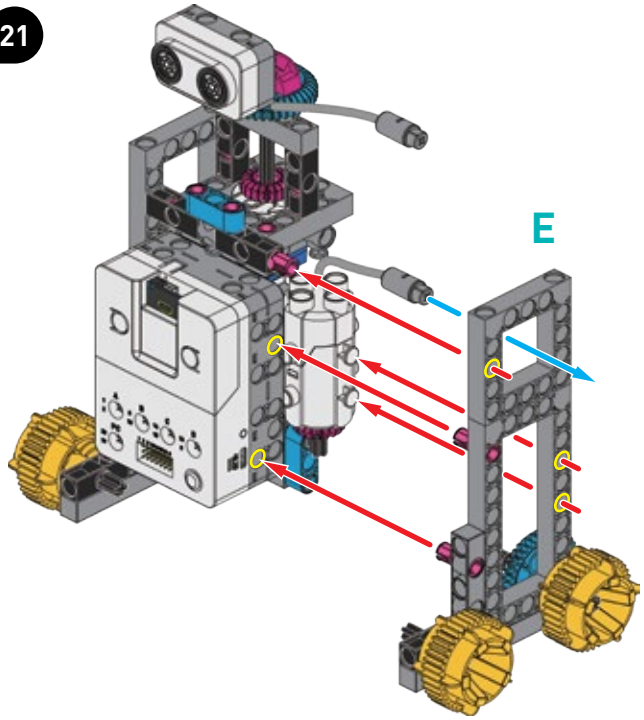

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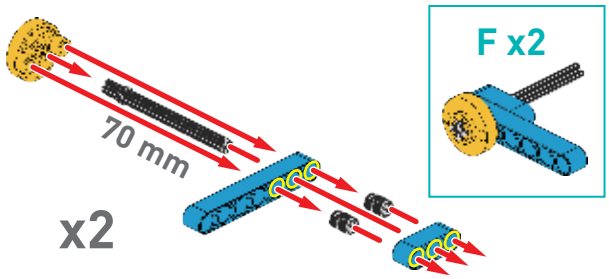

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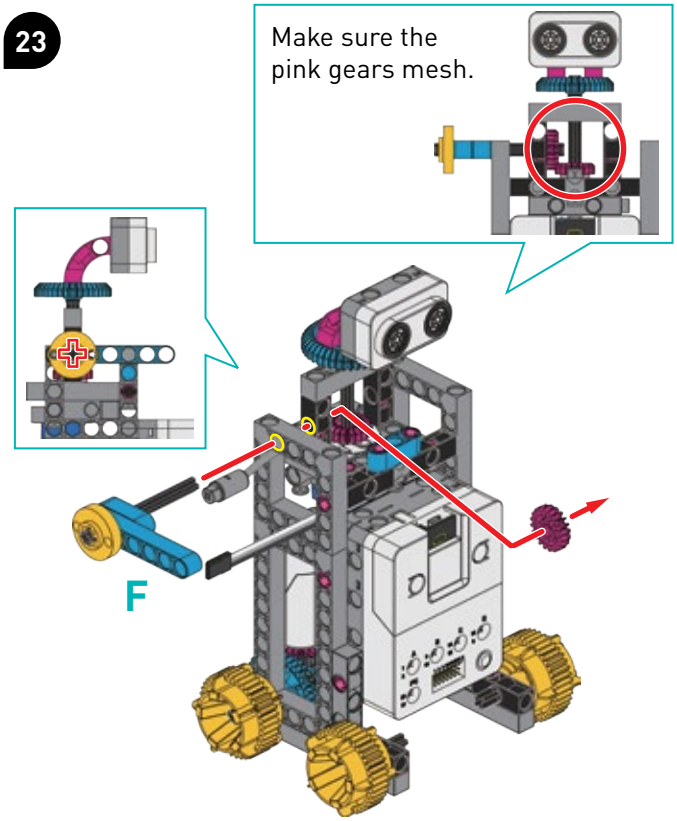

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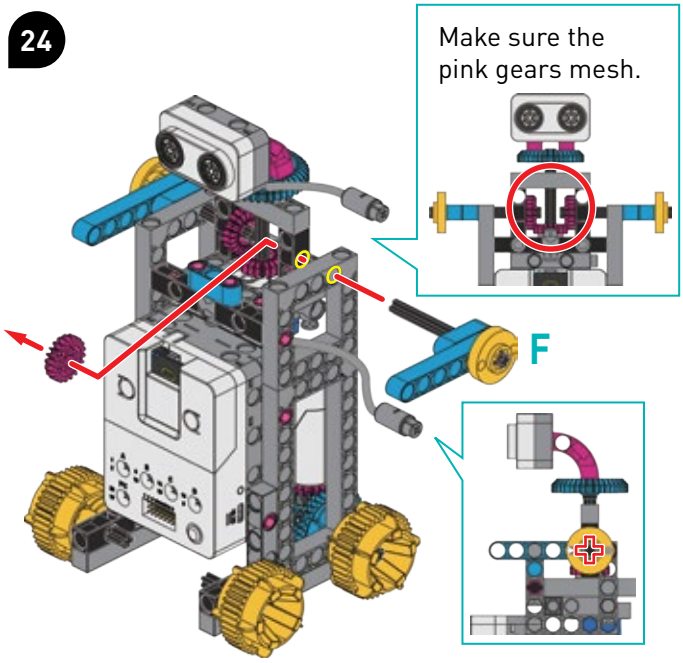

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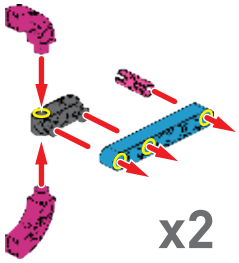

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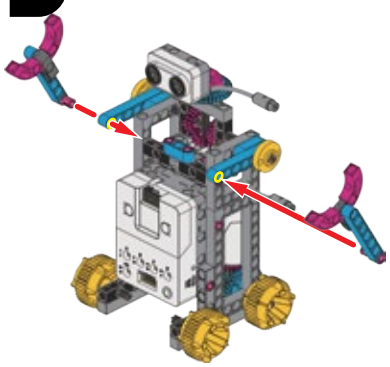

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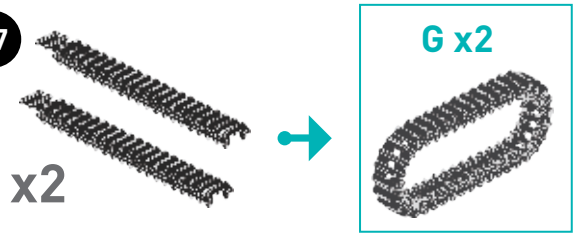

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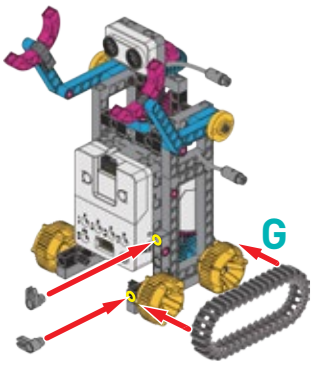

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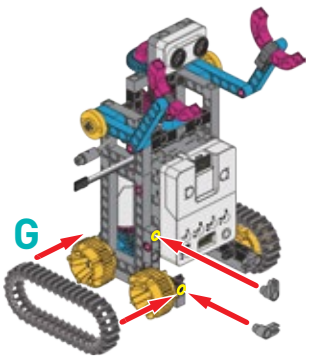

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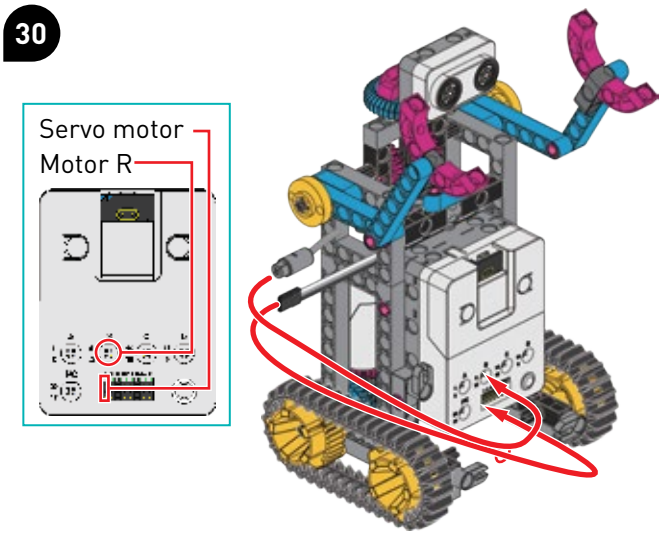

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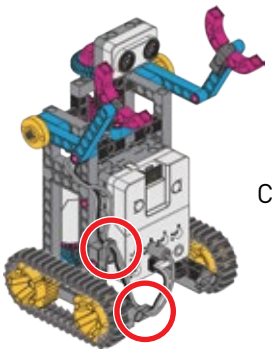
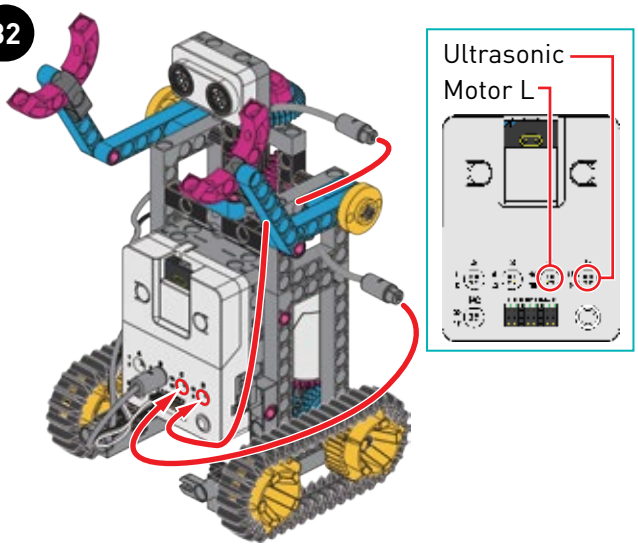


Clean up the wires.

32



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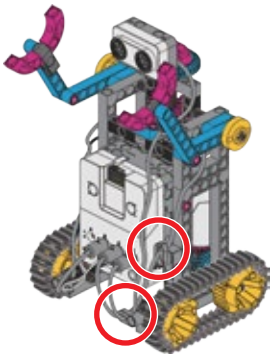
Clean up the wires.



SAMPLE PROGRAMS FOR PROJECT 11

The obstacle-avoiding robot is able to move around and sense objects using its ultrasonic sensor. When it detects an object, it moves its head left and right, and determines the best way to go next.

```
function go
    motor channel B
    speed (0-100) 60
    rotation direction(0-1) 1
    motor channel C
    speed (0-100) 60
    rotation direction(0-1) 0
```

Begin by writing four functions for the robot. **Functions** are self-contained modules of code that accomplish a certain task.

The function "go" makes the robot move forward by spinning the right motor clockwise and the left motor counterclockwise. The robot will move forward until it receives another command.

```
function stop
    motor channel B
    speed (0-100) 0
    rotation direction(0-1) 0
    motor channel C
    speed (0-100) 0
    rotation direction(0-1) 0
    pause (ms) 500
```

The function "stop" tells both motors to stop spinning for a half of one second (500 ms).

```
function right
    show string "R"
    motor channel B
    speed (0-100) 60
    rotation direction(0-1) 0
    motor channel C
    speed (0-100) 60
    rotation direction(0-1) 0
    pause (ms) 500
    call go
```

The function "right" tells both motors to spin counterclockwise for a half of one second, so the robot will turn to the right. The LED screen will also show the string "R".

After turning to the right, the robot will move forward.

```
function left
    show string "L"
    motor channel B
    speed (0-100) 60
    rotation direction(0-1) 1
    motor channel C
    speed (0-100) 60
    rotation direction(0-1) 1
    pause (ms) 500
    call go
```

The function "left" tells both motors to spin clockwise for a half of one second, so the robot will turn to the left. The LED screen will also show the string "L".

After turning to the left, the robot will move forward.

Done!

```
on start
    servo write pin P1 to 90
    set Check to 0
    set ON/OFF to 0
```

When the program is run, the servo motor is set to 90° so the ultrasonic sensor faces forward.

Create the variable "Check" to switch between different checkpoints.

Create the variable "ON/OFF" to show if the robot is on (1) or off (0).

```
on button A pressed
    set ON/OFF to 1
```

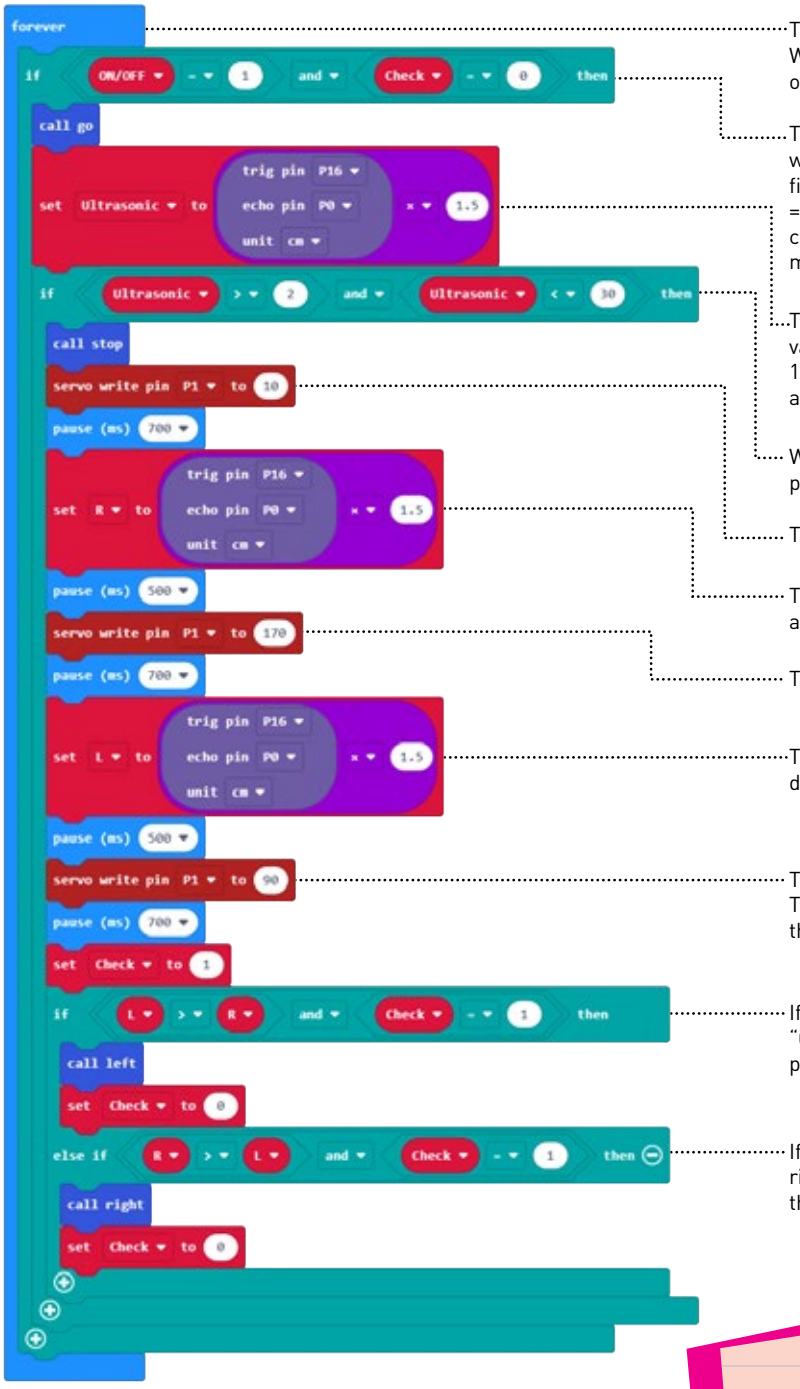
When button A is pressed, ON/OFF is changed to 1 and the robot starts moving forward.

```
on button B pressed
    set ON/OFF to 0
    call stop
    set Check to 0
```

When button B is pressed, ON/OFF is changed to 0, and the "call stop" function makes the robot stop moving.

TIP

EACH MOTOR MAY HAVE A DIFFERENT STRENGTH, AND THE RESISTANCE BETWEEN THE GEARS CAN AFFECT THEIR SPEED. YOU MIGHT ENCOUNTER A SITUATION WHERE YOUR ROBOT DOESN'T DRIVE STRAIGHT WHEN YOU PROGRAM BOTH MOTORS AT THE SAME SPEED. TO OVERCOME THIS, YOU MAY NEED TO ADJUST THE SPEED SETTINGS TO ENSURE THAT BOTH MOTORS DRIVE AT THE SAME SPEED.



This forever loop contains the logic for the robot. When the program is running, the robot checks for obstacles and chooses the best path.

The code contains three nested **if-else statements,** which are read by the robot from top to bottom. The first if-else statement says, if the robot is on ("ON/OFF" = 1) and "Check" = 0, then the function "go" will be called. The robot's ultrasonic sensor also begins measuring distances to send data back to the robot.

The reading from the ultrasonic sensor is stored as a variable called "Ultrasonic". The data is multiplied by 1.5 so that the robot can detect objects with a higher accuracy.

When the sensor senses something in front of it, the program calls the function "stop" and the robot stops.

The servo motor turns the robot's head to the right.

The ultrasonic sensor is now pointed to the right side, and data from the sensor is now stored as a variable "R".

The servo motor turns the robot's head to the left.

The ultrasonic sensor is now pointed to the left side, and data from the sensor is now stored as a variable "L".

The servo motor turns the robot's head back to center. The variable "Check" is set to 1, so that the robot can run the next part of the code sequence.

If there is more space to the left, the robot will turn left. "Check" is set back to 0 so that the robot will run the first part of the if-else statement again.

If there is more space to the right, the robot will turn right. "Check" is set back to 0 so that the robot will run the first part of the if-else statement again.

GO FURTHER!

1. Add sounds to your robot as it navigates the world.
2. Program your robot to move backwards under a certain circumstance.
3. Teach your robot a dance.
4. Make yourself a butler bot. Rebuild your robot so that it can carry objects for you.
5. Add capabilities to your robot using the micro:bit's built-in sensors, like the microphone.

WAS THAT A CAT?

Robotic vacuums are increasingly using obstacle-avoidance technology to improve performance. Mostly these vacuums use laser beams to detect and even identify objects in their path. These robots are able to create real-time maps of their environment. Also because they use lasers, they are able to work in the dark.

PROJECT 12: FOUR-LEGGED BIONIC BOT

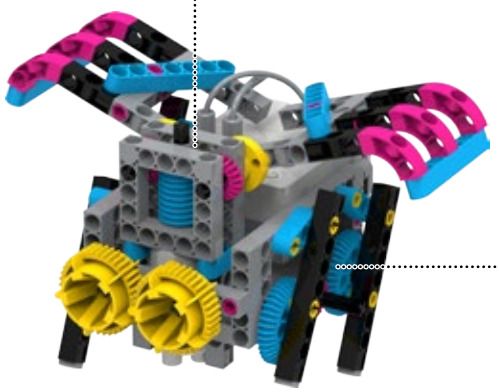
Learning Target:

I can command a robot with sounds.

PROJECT 12 ONLINE CONTENT

Motor A powers the axle underneath the bionic robot. This single axle moves all four legs, thanks to the pink and blue gears.

The worm gear activates the opening and closing of the wings. These are controlled by motor B in the code.



Full assembly and coding steps can be found online.

GO FURTHER!

1. Vary the initial position of each leg on your robot. What are the advantages to each type of gait? What if each foot contacts the ground at the same time?

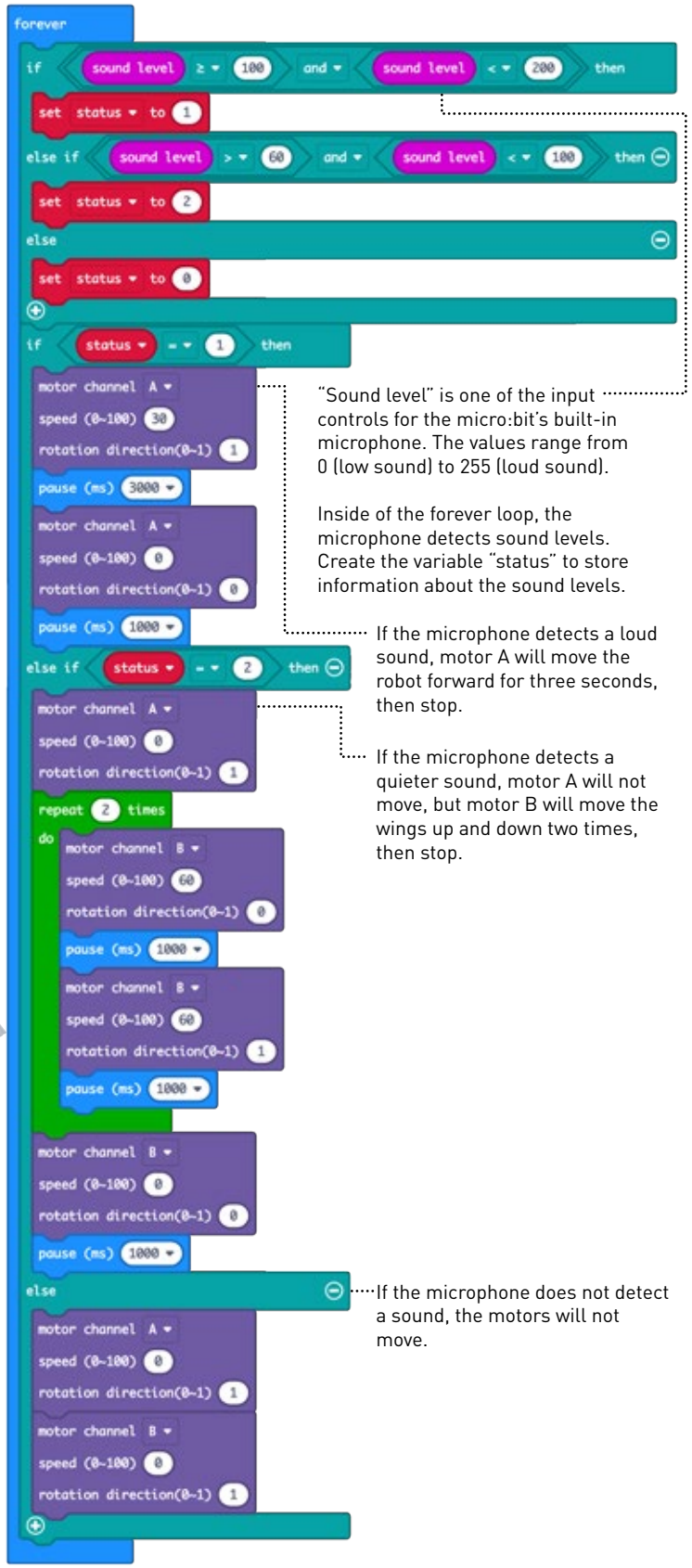
2. Leg length is a factor in stride length. Try varying the size and construction of your robot's legs — is there a setup that moves more efficiently than the others?

3. Add more inputs and/or outputs to the robot.

4. Turn the bionic bot into an obstacle-avoiding robot using the ultrasonic sensor.

SAMPLE PROGRAM FOR PROJECT 12

This program enables the robot to perform different actions based on the sound level detected by the microphone, providing basic interactive behavior with the environment.



"Sound level" is one of the input controls for the micro:bit's built-in microphone. The values range from 0 (low sound) to 255 (loud sound).

Inside of the forever loop, the microphone detects sound levels. Create the variable "status" to store information about the sound levels.

If the microphone detects a loud sound, motor A will move the robot forward for three seconds, then stop.

If the microphone detects a quieter sound, motor A will not move, but motor B will move the wings up and down two times, then stop.

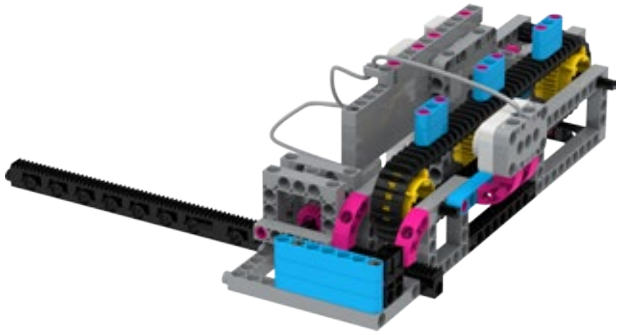
If the microphone does not detect a sound, the motors will not move.

PROJECT 13: CONVEYOR BELT

Learning Target:

I can program a factory operation.

PROJECT 13 ONLINE CONTENT



Full assembly and coding steps can be found online.

GO FURTHER!

1. Create a way to deliver the items onto the belt.
2. Modern manufacturing relies on many robotic applications. Model one of the manufacturing processes of a product you use in your everyday life.

SAMPLE PROGRAM FOR PROJECT 13

When this program is run, the conveyor belt moves. As you place items on the conveyor belt, the ultrasonic sensor counts the items that pass by, and after three items have passed, the cart automatically moves the items to the next area of the production line.

```
on start
set ON/OFF to 0
set Count to 0
motor channel B
speed (0-100) 15
rotation direction(0-1) 1
pause (ms) 100
motor channel B
speed (0-100) 0
rotation direction(0-1) 1
```

This program relies on three variables: "ON/OFF", "Count", and "Distance".

The position of the cart is controlled by motor B. Since its position may move slightly when the power is turned on, this bit of code corrects the cart's position.

```
on button A pressed
set ON/OFF to 1
```

```
on button B pressed
reset
```

When button B is pressed, the code will run a reset function which starts the program over. The "on start" code will run again, and the motor will stop.

```
every 50 ms
set Distance to trig pin P14 echo pin P15 unit cm
```

The data is sent by the ultrasonic sensor every 50 milliseconds, reducing the likelihood of sending incorrect distance information.

```
forever
serial write value "x" = Check
show number Count
if ON/OFF = 1 then
motor channel A
speed (0-100) 60
rotation direction(0-1) 0
if Distance ≥ 2 and Distance ≤ 4 then
set Check to 1
else if Check = 1 and Distance ≥ 6 then
set Check to 0
change Count by 1
pause (ms) 1000
else if Count ≥ 3 then
motor channel A
speed (0-100) 60
rotation direction(0-1) 0
pause (ms) 1000
motor channel B
speed (0-100) 15
rotation direction(0-1) 0
motor channel A
speed (0-100) 0
rotation direction(0-1) 0
pause (ms) 1500
motor channel B
speed (0-100) 0
rotation direction(0-1) 0
pause (ms) 5000
motor channel B
speed (0-100) 15
rotation direction(0-1) 1
pause (ms) 1500
motor channel B
speed (0-100) 0
rotation direction(0-1) 1
set Count to 0
else
motor channel A
speed (0-100) 0
rotation direction(0-1) 0
motor channel B
speed (0-100) 0
rotation direction(0-1) 0
```

The serial allows the micro:bit to send data to an external computer.

When "ON/OFF" is set to 1, motor A is activated and the conveyor belt moves.

Ultrasonic sensor detects an item.

Afterwards, if the ultrasonic sensor does not detect an item, "Check" is set back to 0, and "Count" increases by 1. (The sensor detects presence followed by absence.)

Once "Count" reaches 3, the belt stops. Motor B is activated to deliver the cart to another station. Then "Count" is set back to 0.

If "ON/OFF" is not set to 1, both motors will be stopped.

TIP

IT'S IMPORTANT TO LEAVE SOME SPACE BETWEEN THE ITEMS. OTHERWISE, THE ULTRASONIC SENSOR MIGHT NOT DETECT THEM AS SEPARATE OBJECTS.

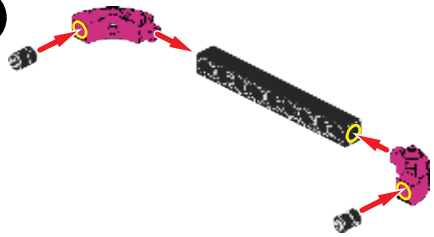
PROJECT 14: ROBOTIC ARM

Learning Target:

I can program a robotic arm with three degrees of freedom.

PROJECT 14
ONLINE CONTENT

1



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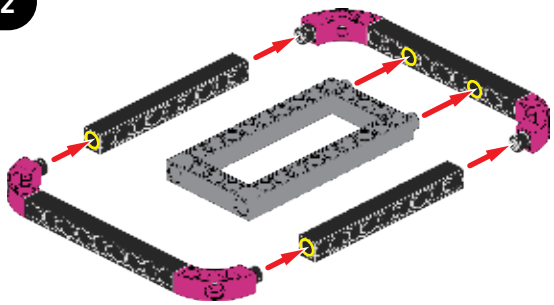

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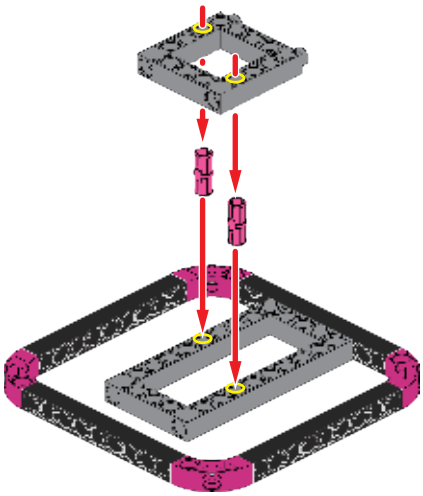

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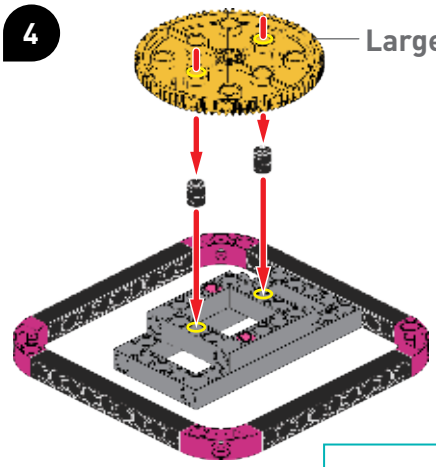

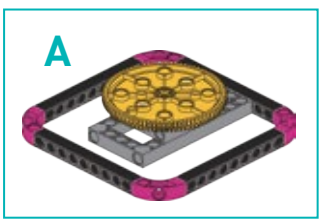

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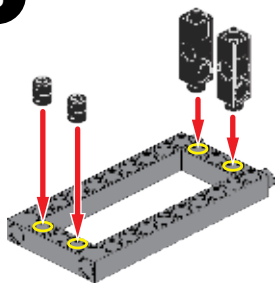

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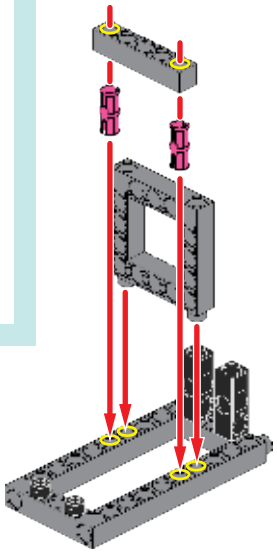

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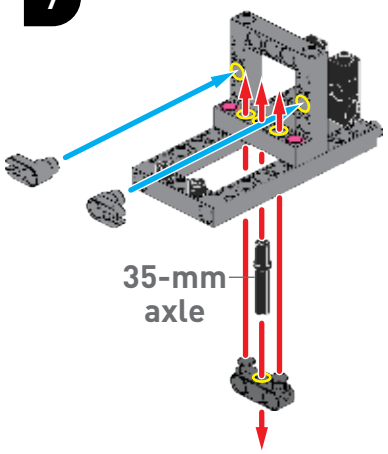

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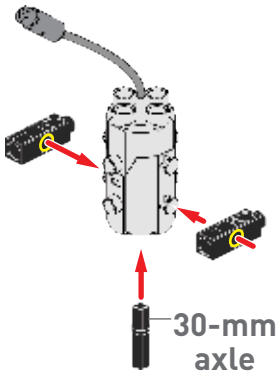

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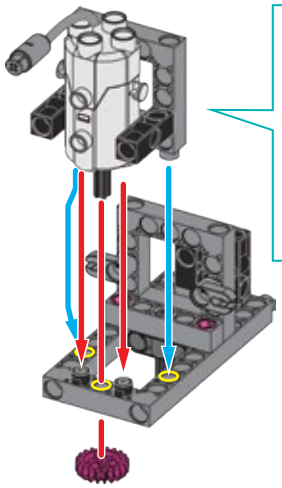

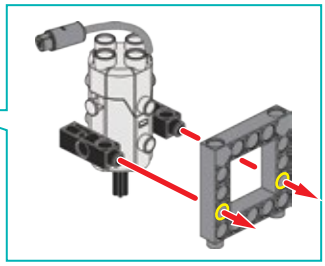

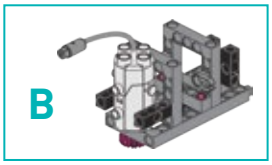

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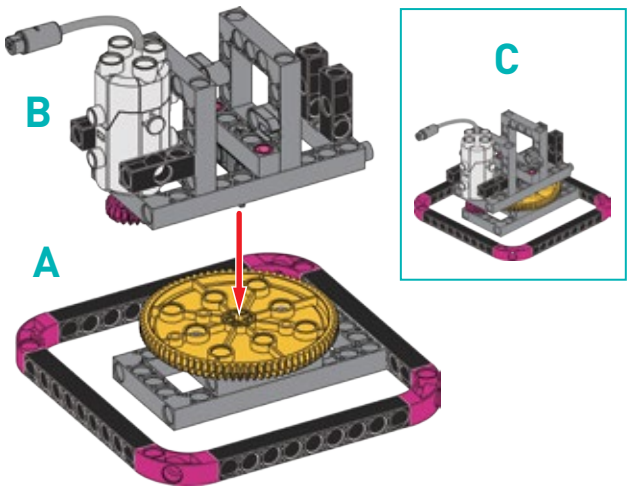

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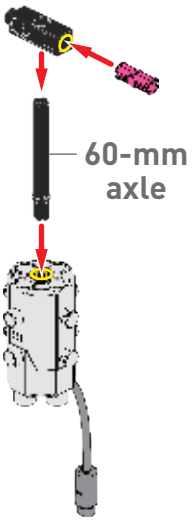

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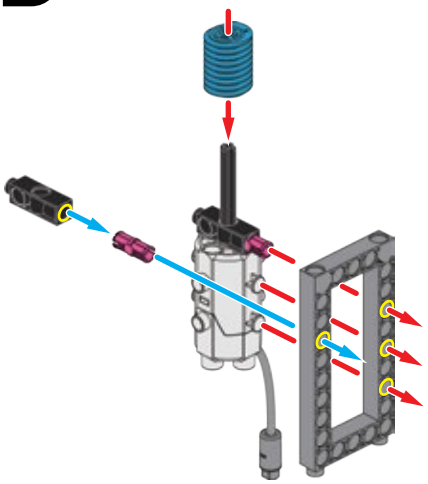

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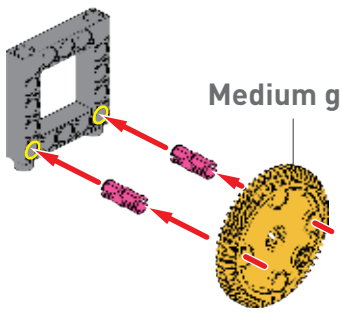

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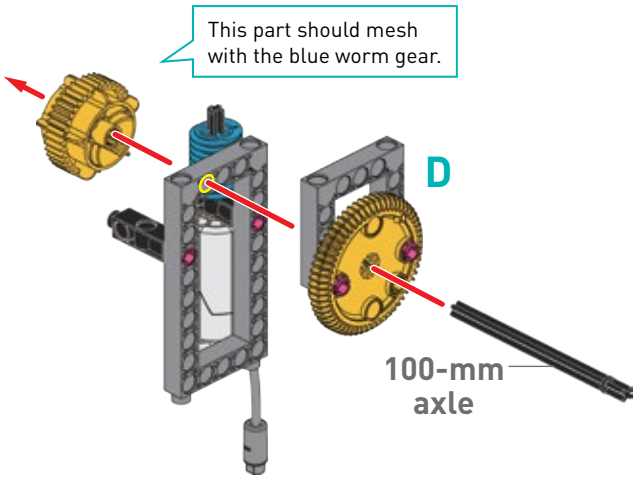

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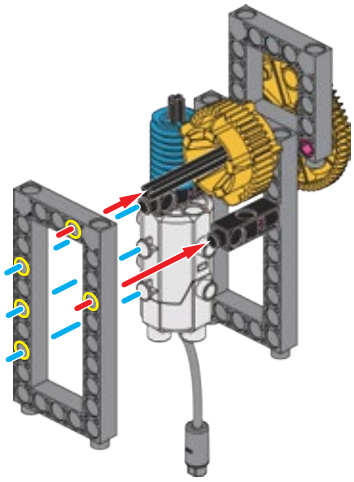

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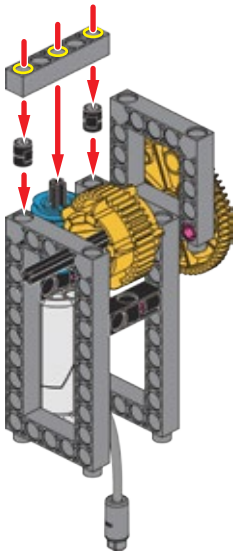

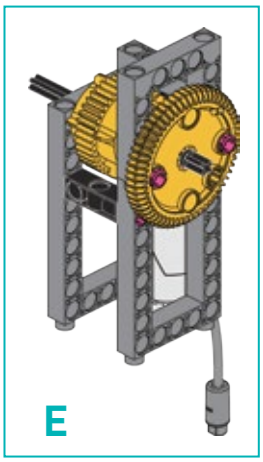

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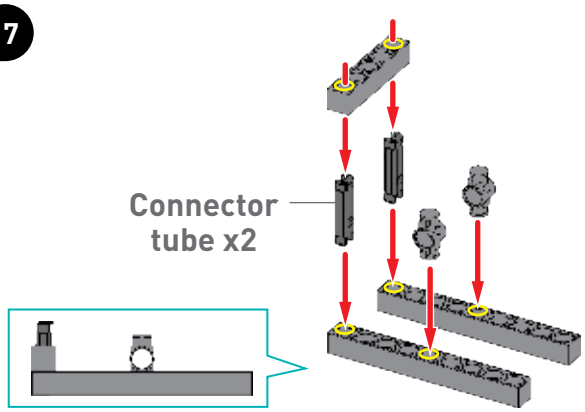

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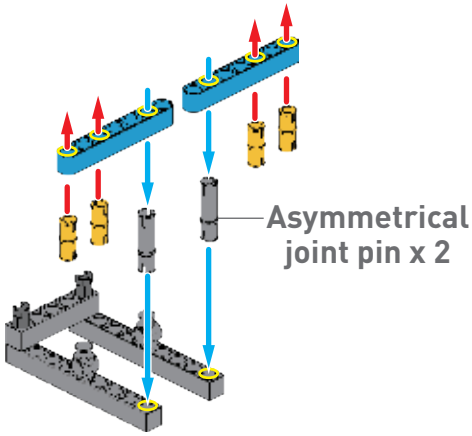

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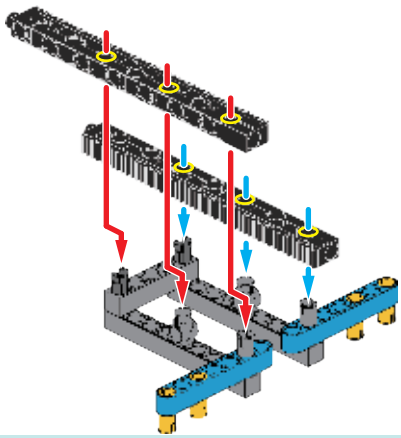

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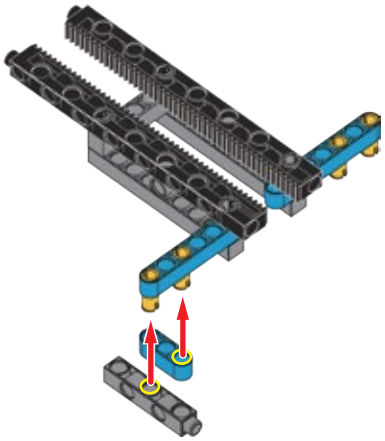

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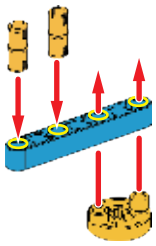

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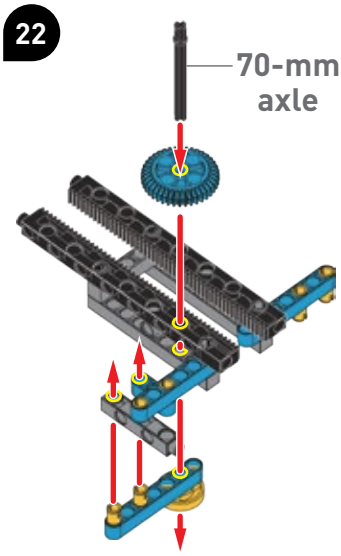

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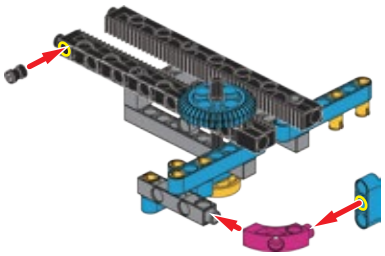

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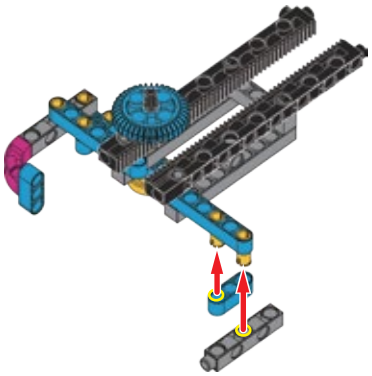

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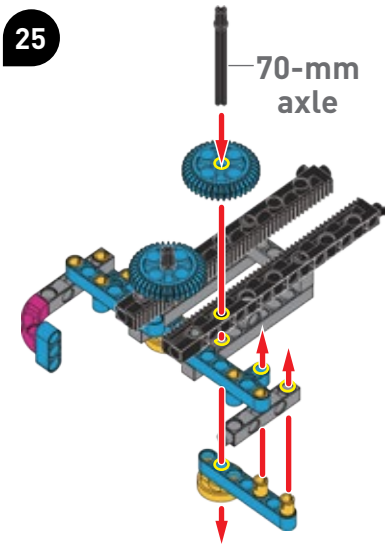
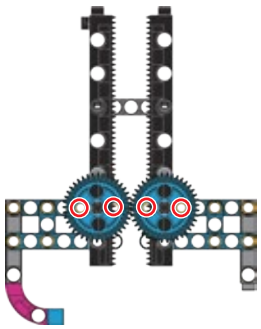


Make sure the holes are lined up as shown.



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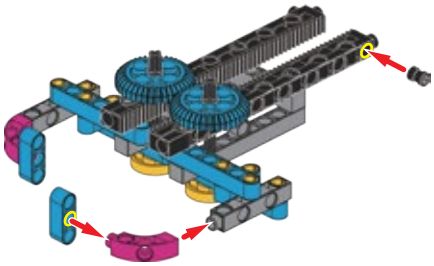

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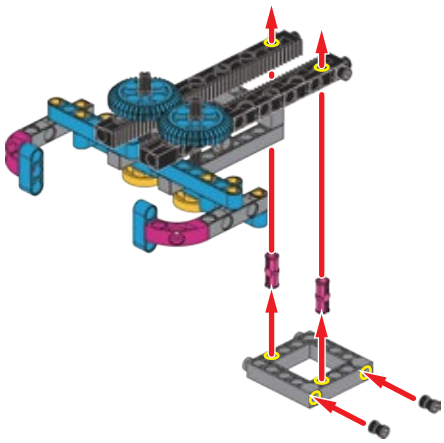

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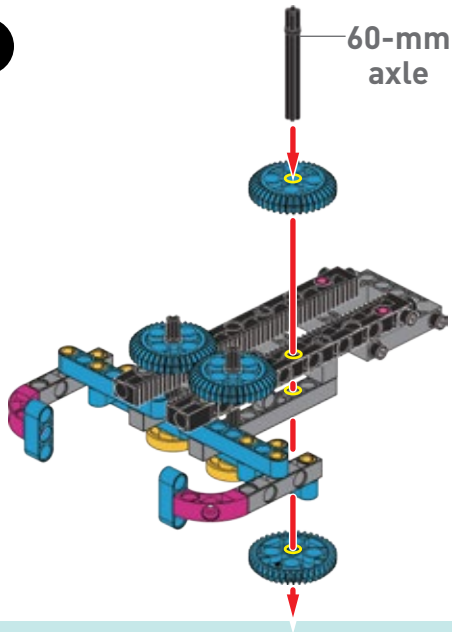

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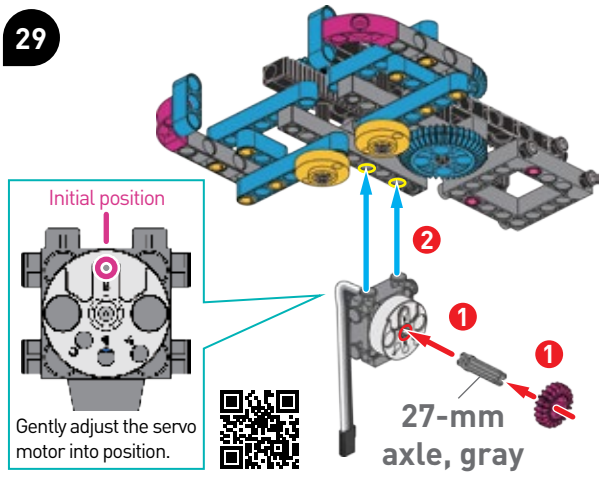

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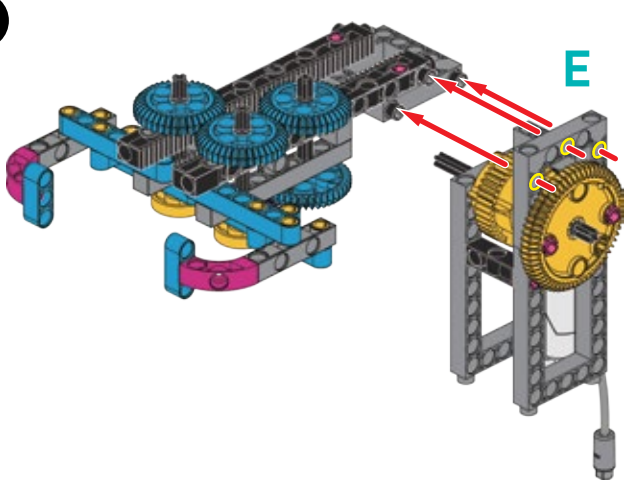

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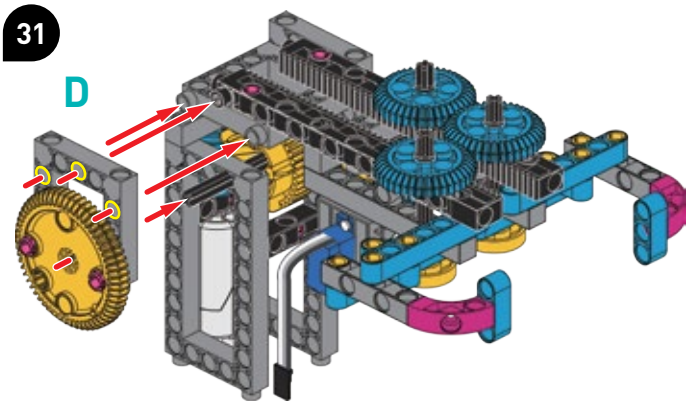

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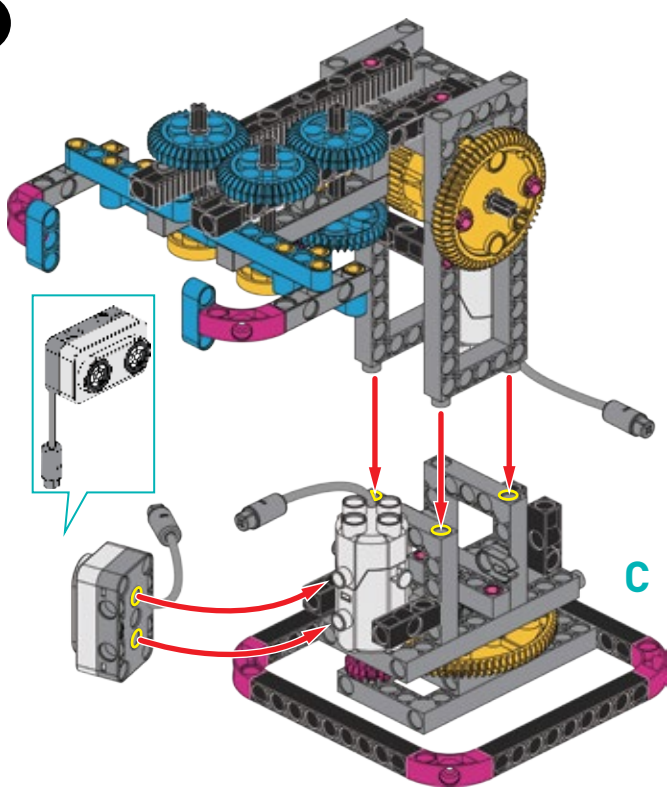

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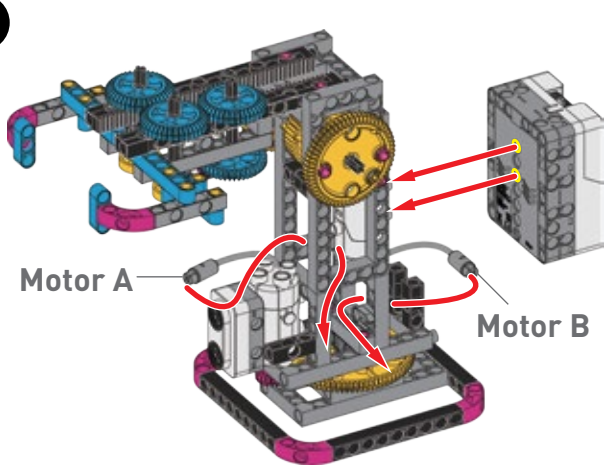

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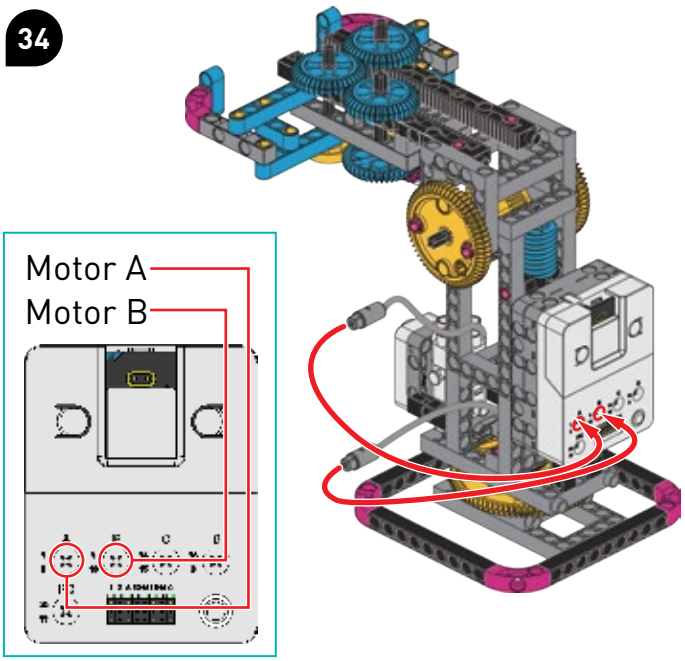

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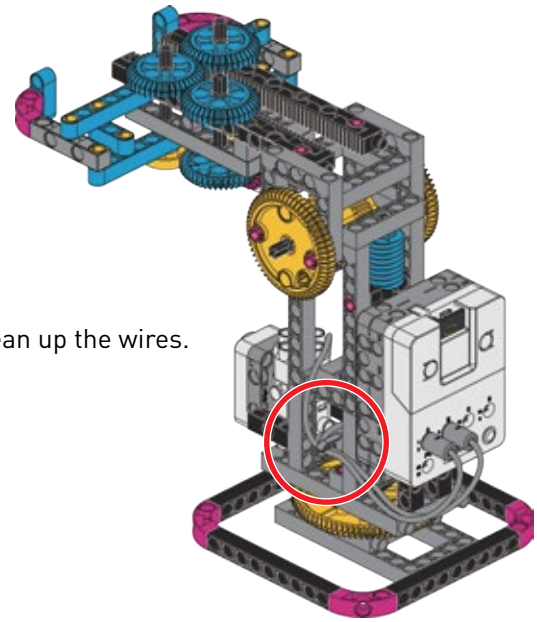
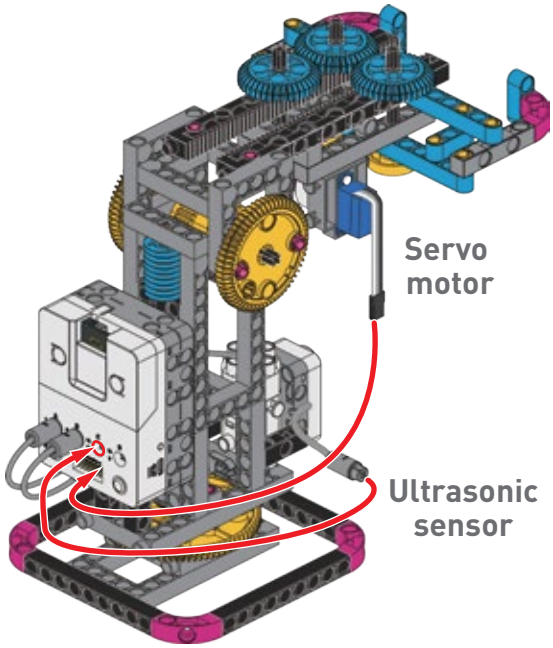
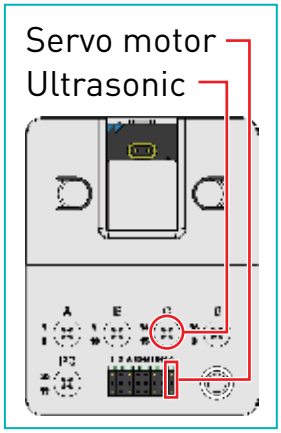


Clean up the wires.

36





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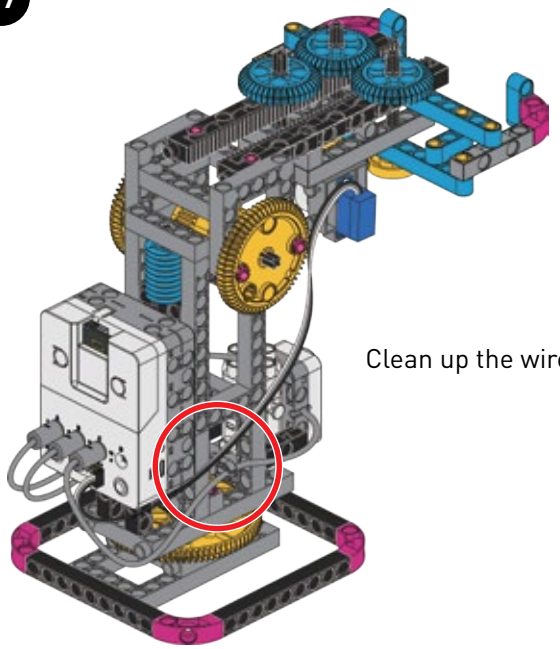
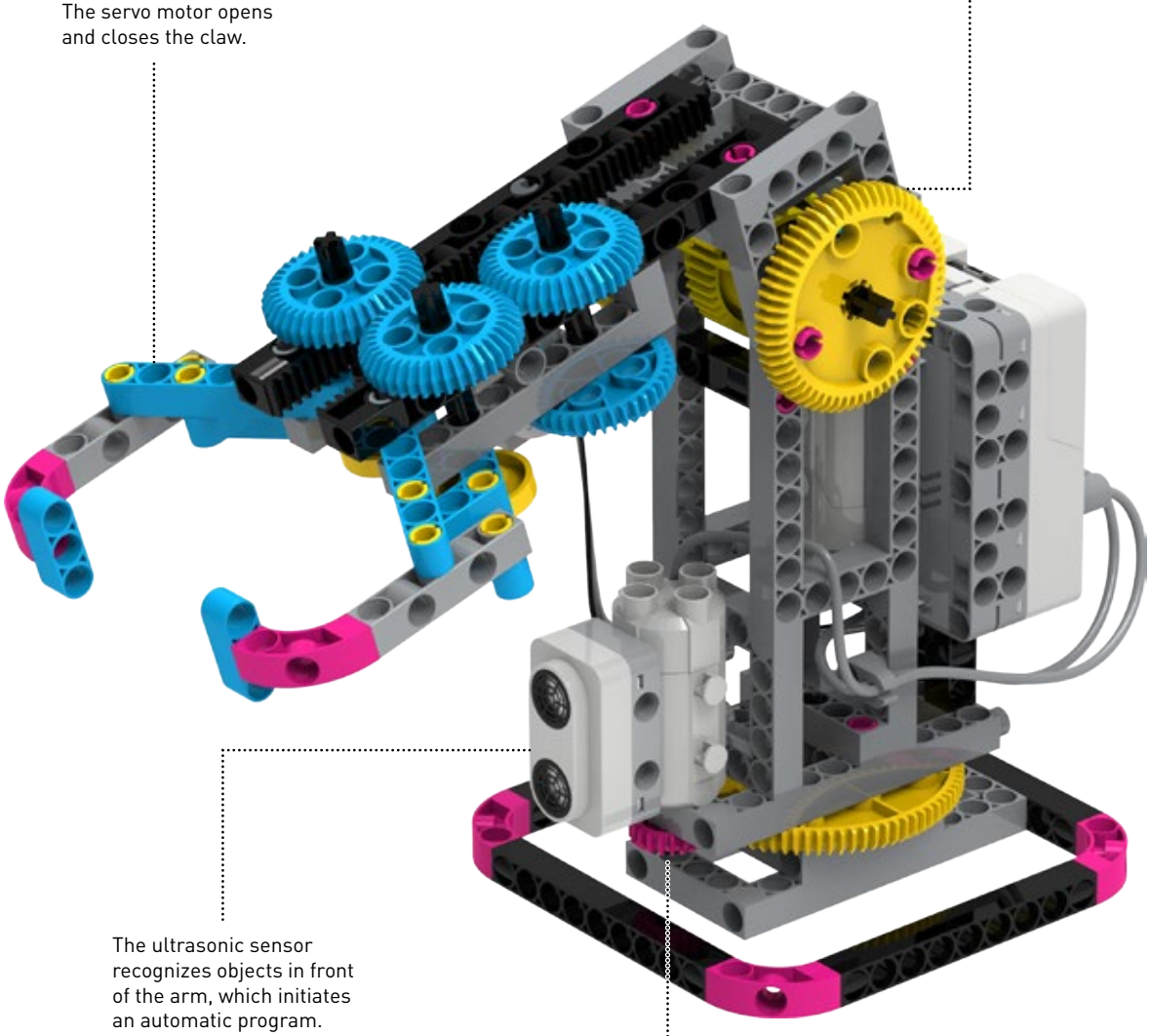


Clean up the wires.

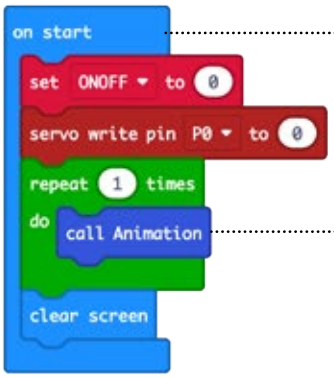
The robotic arm is able to move up and down, rotate around, and open and close its claw. When the ultrasonic sensor senses cargo in position in front of it, it can automatically pick it up and move it to another location.

Done!



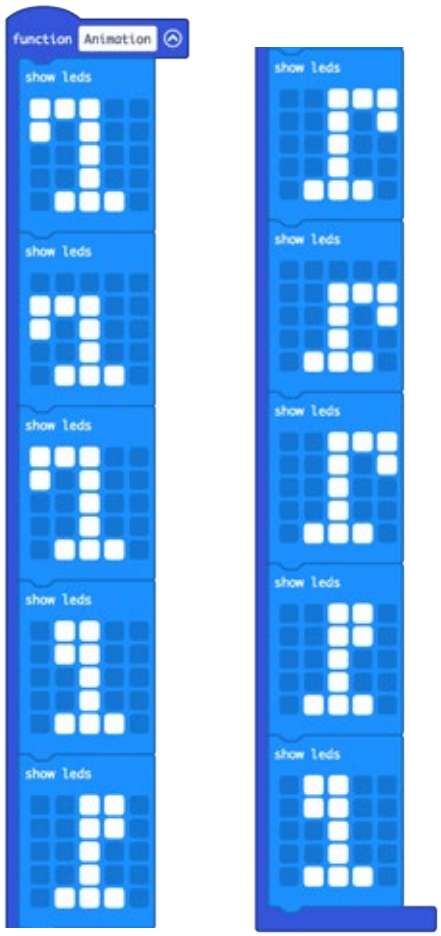
SAMPLE PROGRAM FOR PROJECT 14

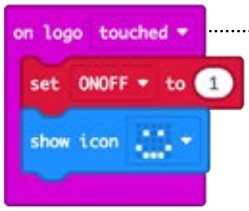
The robotic arm program uses three variables: "ON/OFF", where 1 indicates on and 0 indicates off, "Status", which signifies whether cargo is in the correct position in front of the ultrasonic sensor, and "Distance", which stores the distance detected by the ultrasonic sensor.



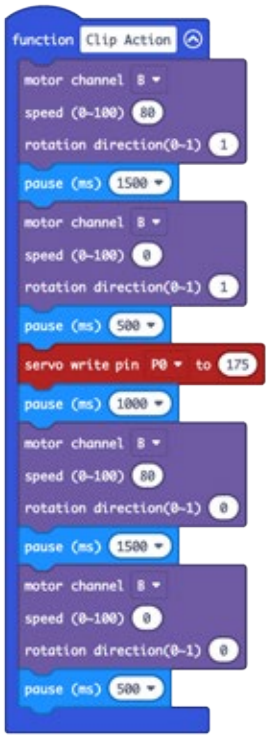
The robotic arm starts its initialization process.

The LED screen displays a short animation showing how the robotic arm moves.

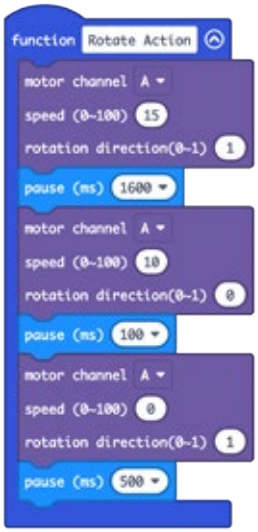




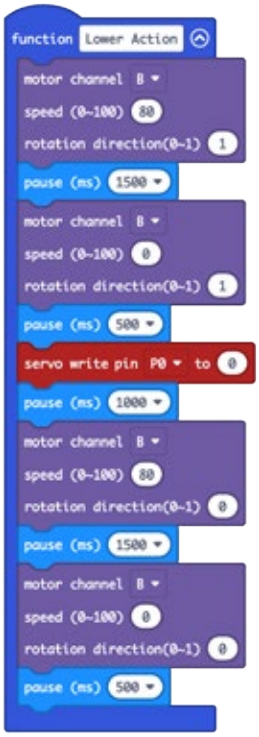
When the micro:bit's logo is touched, "ON/OFF" is set to 1, and the arm is ready to use.



Clip Action:
1. Arm lowers, stops
2. Claw closes
3. Arm raises, stops



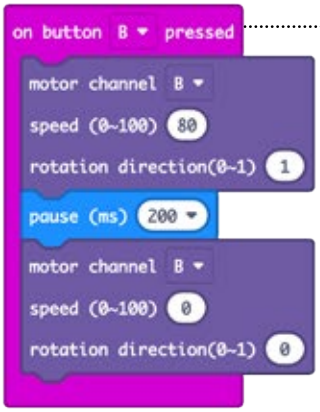
Rotate Action:
1. Arm rotates CCW
2. Arm slows
3. Arm stops



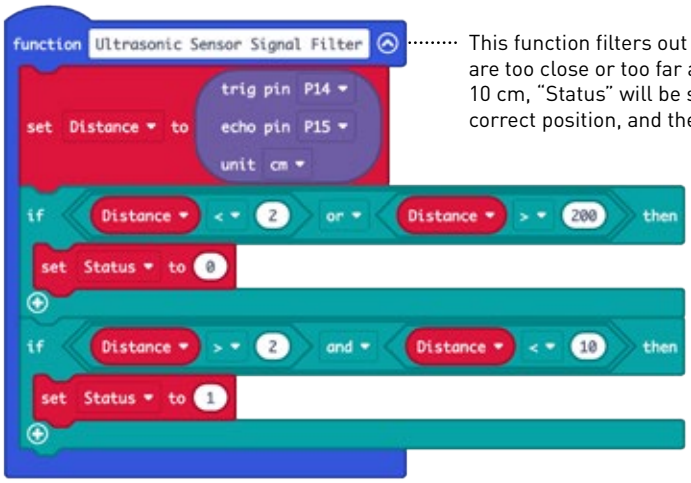
Lower Action:
1. Arm lowers, stops
2. Claw opens
3. Arm raises, stops

Return Action:
1. Arm rotates CW
2. Arm slows
3. Arm stops

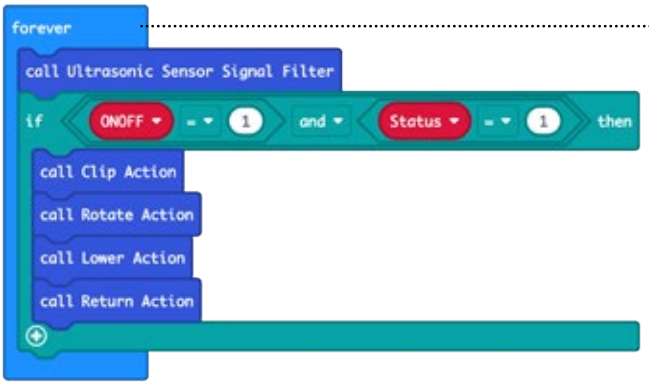
Button A raises the arm.



Button B lowers the arm.



This function filters out any readings from the ultrasonic sensor that are too close or too far away. If the detected distance is between 2 and 10 cm, "Status" will be set to 1, signaling that the cargo is in the correct position, and the robotic arm is ready to activate.



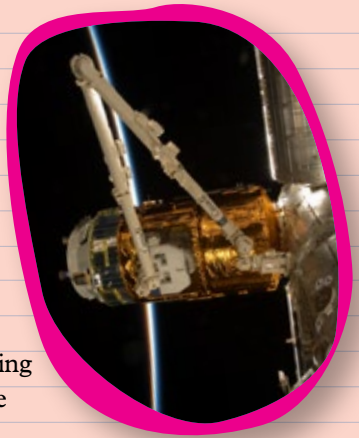
This short block is the code that brings everything together. The function "Ultrasonic Sensor Signal Filter" is always running. If the ultrasonic sensor senses cargo in front of it, it will run the other four functions in order: "Clip Action", "Rotate Action", "Lower Action", "Return Action"

GO FURTHER!

1. Change the program of the robot to complete another task.
2. Change the inputs that tell the arm what to do.
3. Redesign the arm to use a servo instead of a motor for its core motion. What are the advantages and disadvantages?
4. With a second micro:bit: program a remote control for your robotic arm.

SPACE ARMS

Robotic arms are mechanical, programmable devices that function with the dexterity of a human arm. Often robotic arms have several mechanical joints that ultimately move an **end effector**, which carries out the operation.



Since the early 1980s, a series of robotic arms called Canadarm has been an integral part of the International Space Station, launching satellites into orbit, assisting astronauts on spacewalks, and performing maintenance tasks on the station itself.

Design a tool

Humans have an inherent inclination to create tools that enhance convenience, efficiency, and problem-solving abilities, thereby making their lives easier. Explore and define a problem that you encounter in your everyday life, and develop a **tool** that addresses the problem.

Invent a game

Invent a simple **arcade game** that can be played using the micro:bit's built-in buttons or sensors. The game might foster friendship or encourage some healthy competition.

Make a smart device

The widespread adoption of technology, the Internet, and sensors has made it possible for everyday devices, home appliances, and furniture to become more intelligent. Make a **smart device** that enhances automation and simplifies daily living.

Create music

Electronic instruments are a key part of modern music. They allow for a great degree of customization, and produce unique sounds compared to their analog counterparts. Create a robotic **instrument** using the micro:bit's speaker and/or the mechanical elements of the kit.

Mimic an animal

Many modern machines draw inspiration from plants and animals. This is called **biomimicry.** Choose an animal known for a specific trait, and think about how their body moves. How could you create or alter a robot to operate more like that animal?

Build a buddy

Ever feel lonely? Snuggling a dog or cat can make you feel better, but sometimes you won't have access to a live pet. Build yourself your very own robotic companion.

YOUR PROJECTS ONLINE CONTENT

Now that you know how to build and program with the elements of Robotics Workshop, **where do you go from here?**

Here are six open-ended prompts to inspire your own creations. For each one, we have printable PDFs to guide your design thinking.

We want to see what you make!

Teachers and parents, tag us @thamesandkosmos using #roboticsworkshop.

Think outside the blocks!

We recommend building robots using other materials in addition to the parts included in this kit.

You might consider incorporating:

- paper or cardboard
- recycled materials
- scraps of fabric
- rubber bands
- markers, pencils, and crayons

The universal connector (part 45) also makes it possible to connect your Robotics Workshop parts to other plastic building parts you might have in your home or classroom, like LEGO.

Good to know!

You can order extra components for Robotics Workshop from our website.

Want more Robotics Workshop?

Check out the Sensor Expansion Pack:

- RGB LED
- Color Sensor
- 2x Versatile Infrared Sensors (for line tracking robots)
- Toggle Sensor
- Additional durable building parts
- 14 new projects with full assembly and coding instructions

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