Name:		Class:	

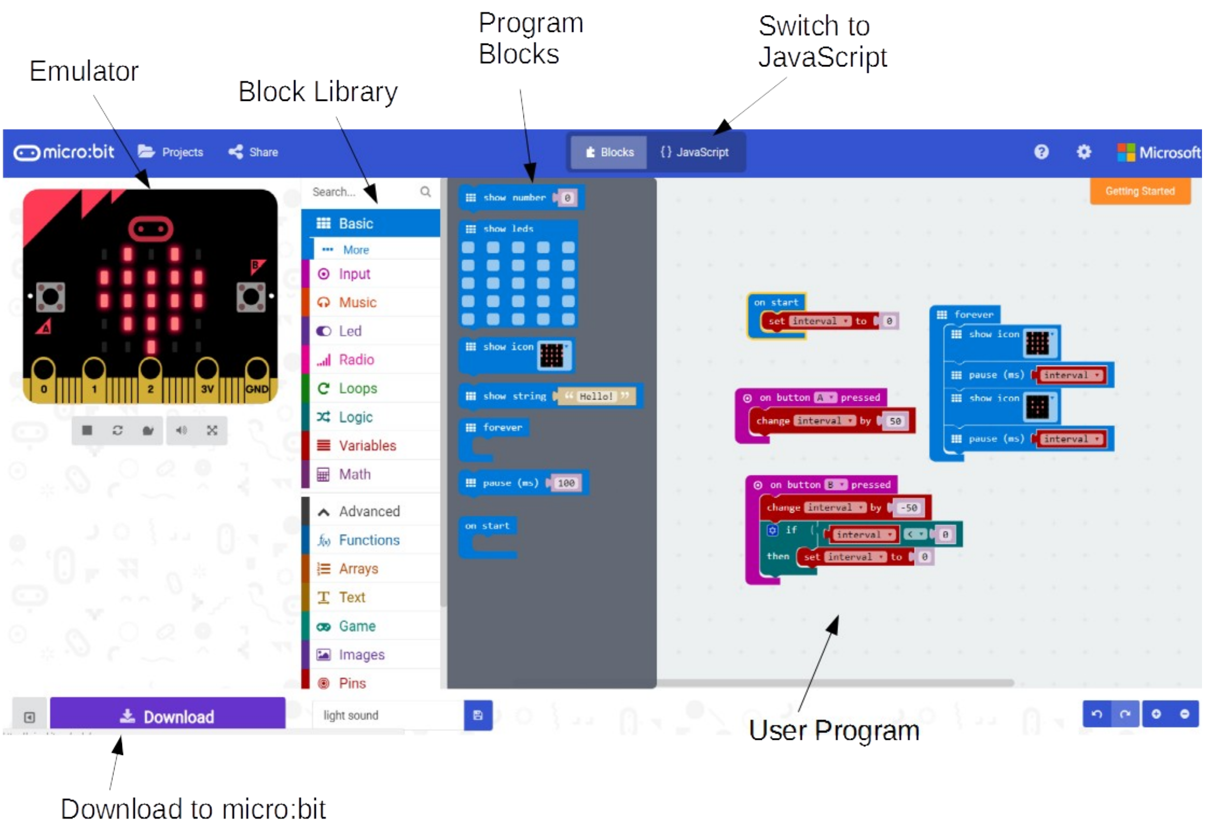
micro:bit Basics

What is a micro:bit?

The micro:bit is a small computer[1], created to teach computing and electronics. You can use it on its own, or connect it to external devices. People have used the microbit to make everything from games to automatic plant watering devices. It's up to your imagination!

How do you program the micro:bit?

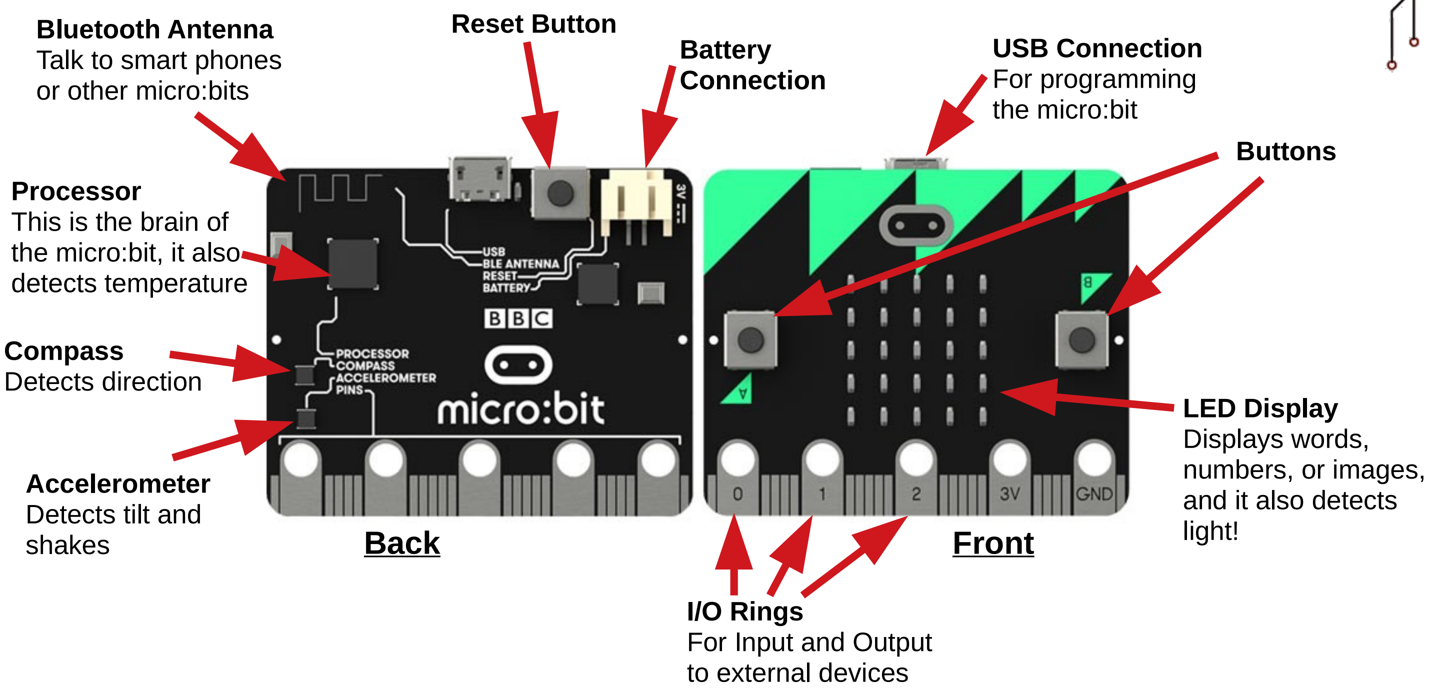
The basic programming interface, utilizes Block Programming and Javascript[2]. It can be found at **https://makecode.microbit.org**



1 Because it's smaller and less powerful than a normal computer, it is also called a "micro-controller".
2 You can use other programming languages like Python too!

What can you program the micro:bit to do?

The micro:bit itself is has enough core memory (256 KB) to hold pretty complex programs, but don't expect to download music files for playback (needs MBs).



There are also 20 General Purpose Input/Ouput (GPIO) pins provided for interfacing with external devices like:

- speaker/microphone
- LEDs
- motors
- pumps
- external sensors using raw digital or analog[3]

Three of those pins (Pin 0, Pin 1, and Pin 2) are exposed as large rings than can be easily accessed with an alligator clip or 4mm plug.

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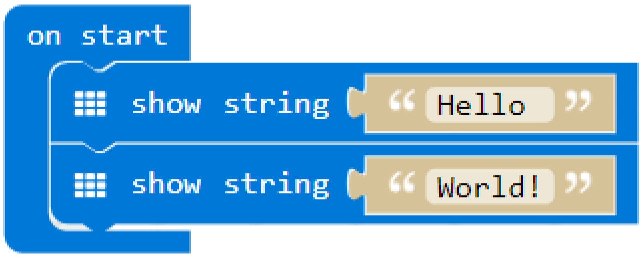
3 Some electronic devices also uses special modes of communications such as UART, I2C, or SPI. We won't be using them in this programme, but ask the trainer if you're interested to know more!

Activity 1: micro:mojis Movie

Sequencing

Movies are made using a sequence of images, while computer programs are made using a sequence of instructions. In both cases, the sequence must be in the correct order to work correctly! Try the program below, then try making your own micro:bit movie now!



What happens if you change the order?

Programming the micro:bit

After writing your program, you can run in in the simulator, but it's more cool to have your program running on the micro:bit. To transfer the program to the micro:bit, follow these steps:

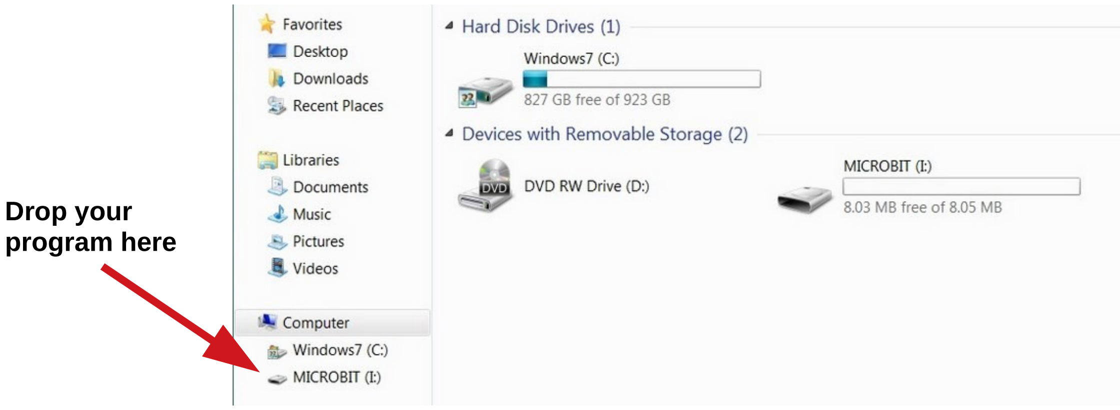
Step 1: Visit **https://makecode.microbit.org** to create your program.

Step 2: Connect your micro:bit to your laptop.

Step 3: Click the "Download" button in the programming page.

Step 4: Click on the next to the downloaded file, and choose "Show in folder".

Step 5: Drag and drop your program onto the micro:bit.



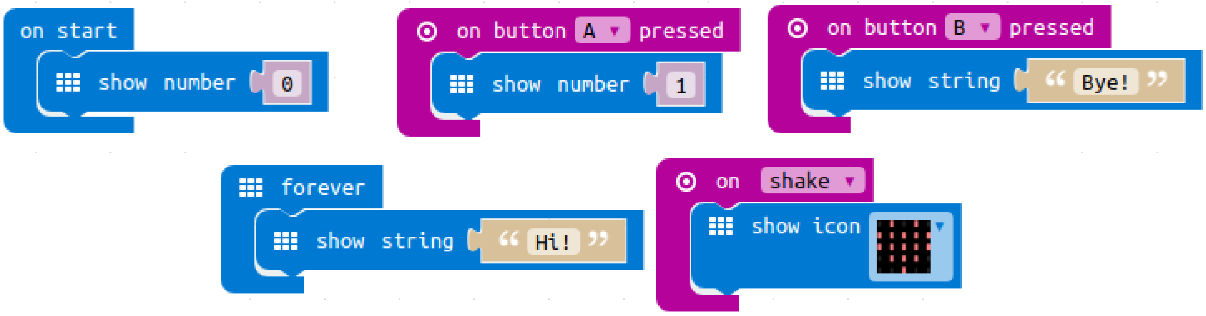
Tips and Tricks!

After creating your program in blocks, click the "Javascript" button and add an interval to your icon functions.

```
basic.showString("Hello", 100)
basic.showString("World!", 100)
```

The "100" indicates that the text should show for 100 milliseconds before moving. Try different values and see what happens!

Starting a Program

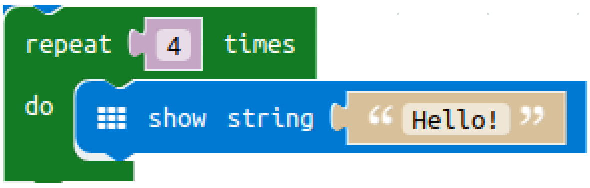


There are many ways to start a micro:bit program **"on start"** will run the program once when the micro:bit is powered up, and **"on button A pressed"** will run the program once when button A is pressed. Can you figure out what the other starting method shown above does? Try it out and write your findings here:

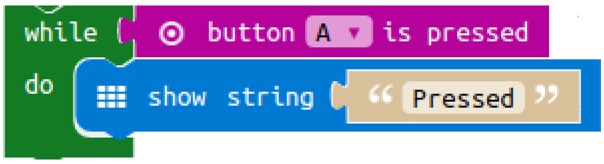
Starting Method	How does it work?
on button B pressed	
forever	
on shake	

Loops

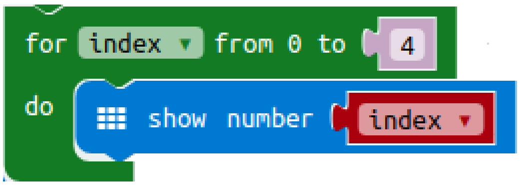
When we need to repeat something many times, use a loop!



Repeats something a certain number of times. In this example, it shows "Hello!" 4 times, but you can change the number and what it does to whatever you want.



Repeats something as long as a condition is true. In this example, it will show "Pressed" as long as button A is pressed.



Repeat something a certain number of times, and set a variable to the number starting from zero. In this example, it will repeat 5 times, and each time it will show a number from 0 to 4.

What did we learn?

- The micro:bit is a small computer that can be programmed to do many different things such as games or watering plants. It's up to your imagination!
- Sequences: Program instructions needs to be in the correct order.
- Starting a Program: The micro:bit can start a program in many ways, such as when it is powered up or when the button is pressed.
- Loops: Use loops to repeat something many times.

Activity 2: Mood Projector

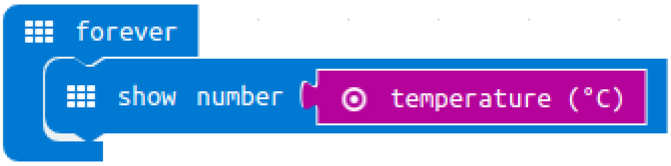
Mood Rings

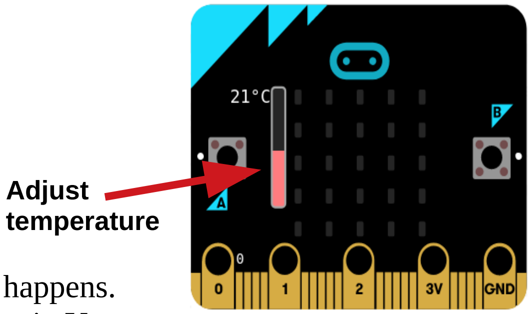
Mood Rings are a fashion accessory invented in the 1970's. They utilize the temperature-sensitive Liquid Crystals to change color depending on the temperature.[4] Using the micro:bit, we are going to make something even cooler.

Test Program

Before we start on our actual mood projector program, it is always good to test things out first. This helps us to make sure that the micro:bit is working fine and that we are programming it correctly.

Try the following program:





Adjust the temperature on the simulator and see what happens. Try loading the program onto the micro:bit and running it. You can make the temperature change by rubbing your fingers together and pressing it onto the processor chip on the back of the micro:bit.

> **Challenge!**
> If the temperature is 21ºC, the display will show "2" and "1" repeatedly. This makes it hard to tell if the measured temperature is "21" or "12". Can you think of a way to solve this?

Programming (Mood Projector)

We want the micro:bit to display a different message depending on the temperature. Use the previous test program and the actual micro:bit (...not simulator) to choose 5 different temperatures.

> Don't choose temperatures that are too high or too low! You may not be able to achieve it. (eg. if you choose 100ºC, you won't be able to achieve it unless you put the micro:bit in boiling water!)

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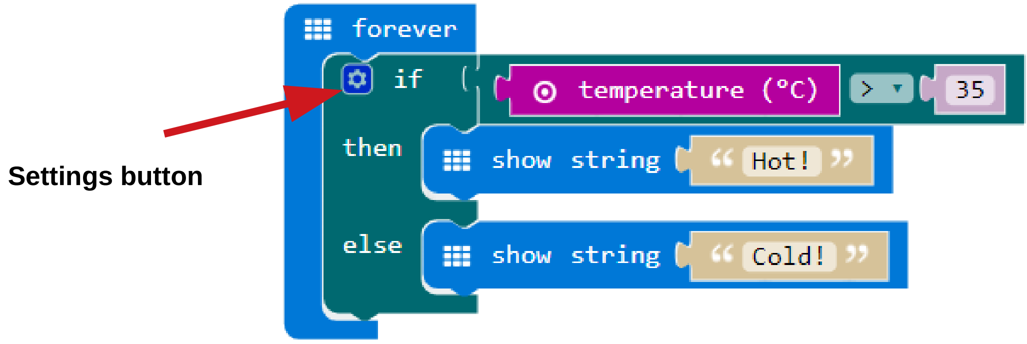
4 It's called "mood ring" because some people thinks that it changes color based on a person's mood, but it really just depends on the temperature.

Try out the sample program provided below. The sample program only checks for one temperature. Can you modify it to check for all 5 temperatures and display a different message for each? (Hint: You can use the settings button to add more if... else... conditions)



Try using icons instead of text messages. You can choose any icons you like or design your own.

Challenge!

Can you make the different messages appear only if you are pressing the "A" button? If you are not pressing button "A", the screen should remain blank.

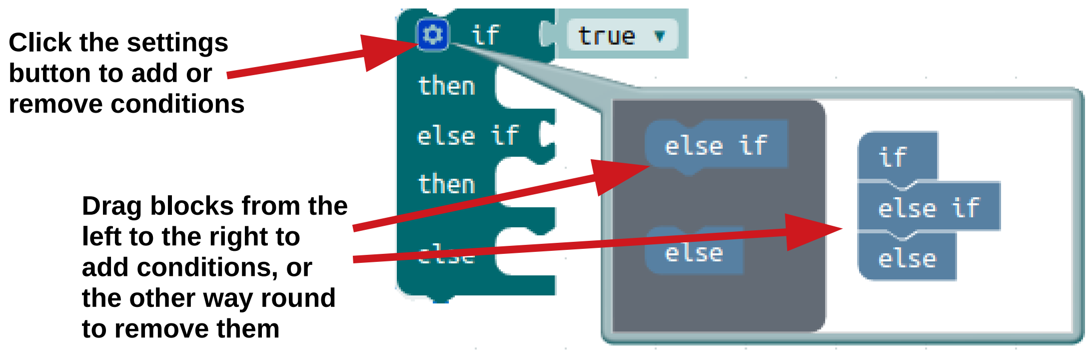
Conditionals

We use conditionals when we need to make a choice between various actions.

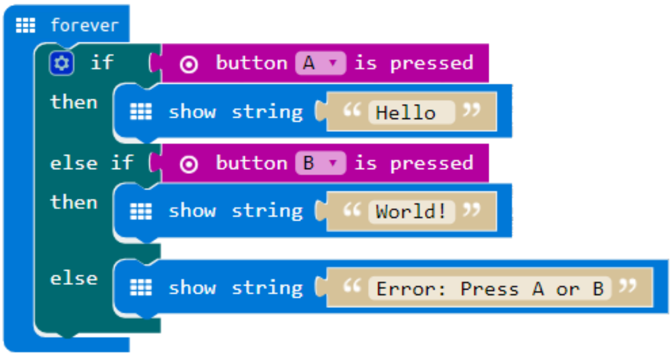
For example...

IF I am not feeling well ← **If this is true...**
THEN Visit the doctor ← **...then do this...**
ELSE Go to school ← **...else do this instead.**

In micro:bits, condition looks like this...

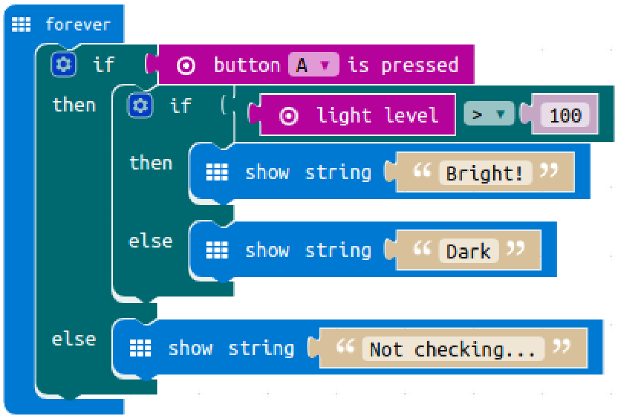


Examples of conditions in micro:bit...



Can you figure out what this program does?

Conditions can also be embedded inside each other...

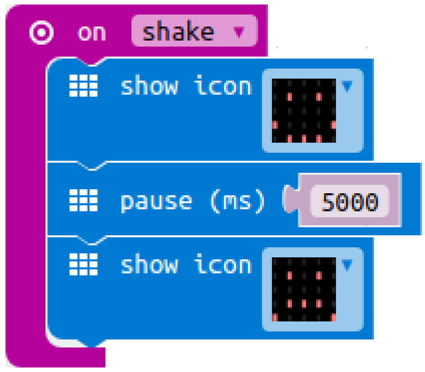


What about this one? Try it out and answer the following questions.

What happens when...	**Words shown on display**
micro:bit is in a bright place and no button pressed	
micro:bit is in a bright place and button A is pressed	
micro:bit is in a dark place and button A is pressed	

Programming (Fitbit)

Besides the temperature sensor, we can also use the accelerometer in the micro:bit to detect movement. Try the following program.



There are many different options besides “shake”. Try them out and see if you can figure out what they do!

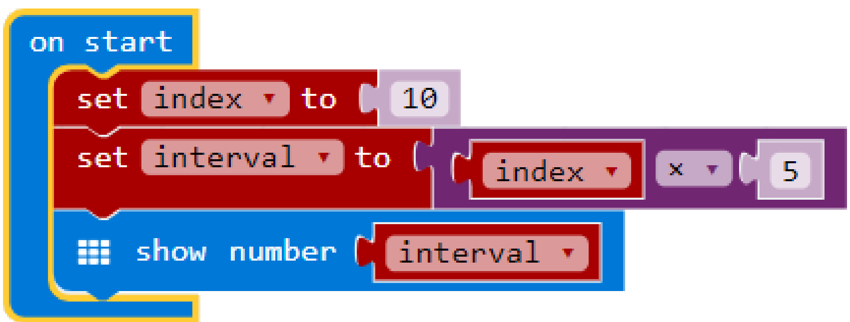
Bonus Challenge!
The example program has a problem! Even if you shake the micro:bit continuously, it will show the sad face for a short while every 5 seconds. Can you figure out why? Can you fix this problem?

Variables

Variables are used to store information. For example, it can store...

- How many times you pressed button A
- Game score
- Which button you pressed (A or B)
- Temperature detected by the micro:bit

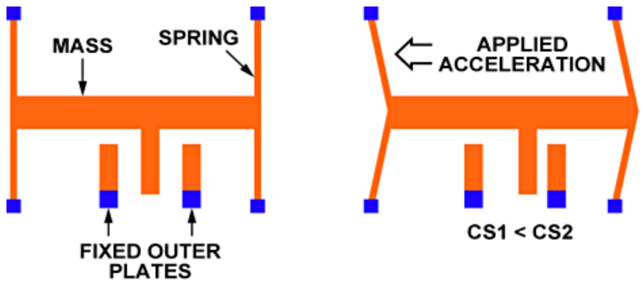
You can name a variable anything that you like, but it’s best to choose a name that helps you remember what the variable is storing (Eg. If you are storing game score, you may want to name your variable “Score”).



Try out this program. Can you figure out how it works?

Accelerometers

Accelerometers works using an extremely tiny moving mass that's built inside a chip. As the mass moves, it gets closer to one plate and further from the other. This changes the capacitance which is then measured and converted into an electrical signal.



The accelerometer in the micro:bit can be used to detect movement (eg. shake). It can also detect the direction of gravity, allowing it to know which way you tilt it.

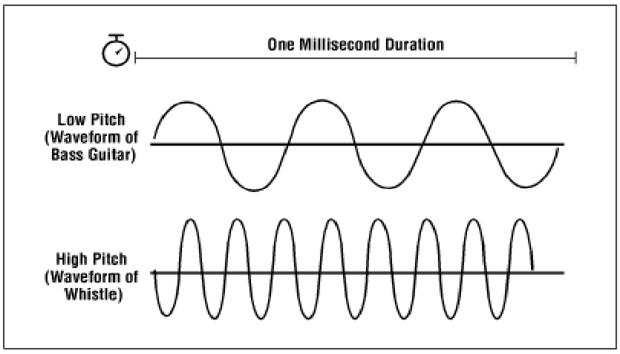
What did we learn?

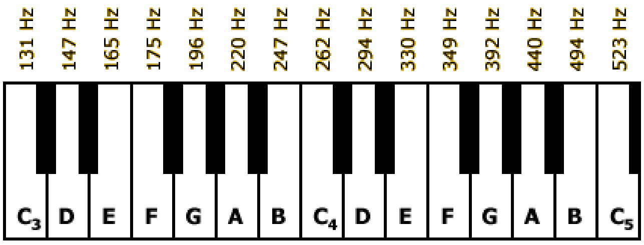
- Temperature: The processor at the back of the micro:bit can measure temperature.
- Accelerometer: The built-in accelerometer can measure shakes and tilts.
- Conditionals: Conditions allows the program to choose between different actions.
- Variables: Variables can store information such as game score or temperature.

Activity 3: Light and Sound

ABC of Music

Sound is what our ears and brain interpret from air particles vibrating and pushing against our eardrum. Air particles moving in a wave with short periods, or high frequencies sound like a high-pitched tone, and vice versa. When we play music, we use seven alphabets from A to G called "notes" to represent each tone. In the micro:bit, these notes are repeated 3 times in groups called "Low", "Middle", and "High".





The duration to play a musical tone is measured by "Beats". We can play a note for one beat, two beats, half a beat, etc. The duration of each beat depends on the "Tempo", and this is set in "Beats Per Minute (BPM)". A music set at 60 bpm, will play 60 beats in one minute, or 1 beat per second. When we set the tempo in micro:bit, it applies to all notes (...until you set a new tempo).

Applies to all the following notes

What is this song? Try it out!

Challenge!

What music can you make? Make a simple song on your own and play it on your micro:bit. If you're done with that, work with a friend to make a song that uses two micro:bits!

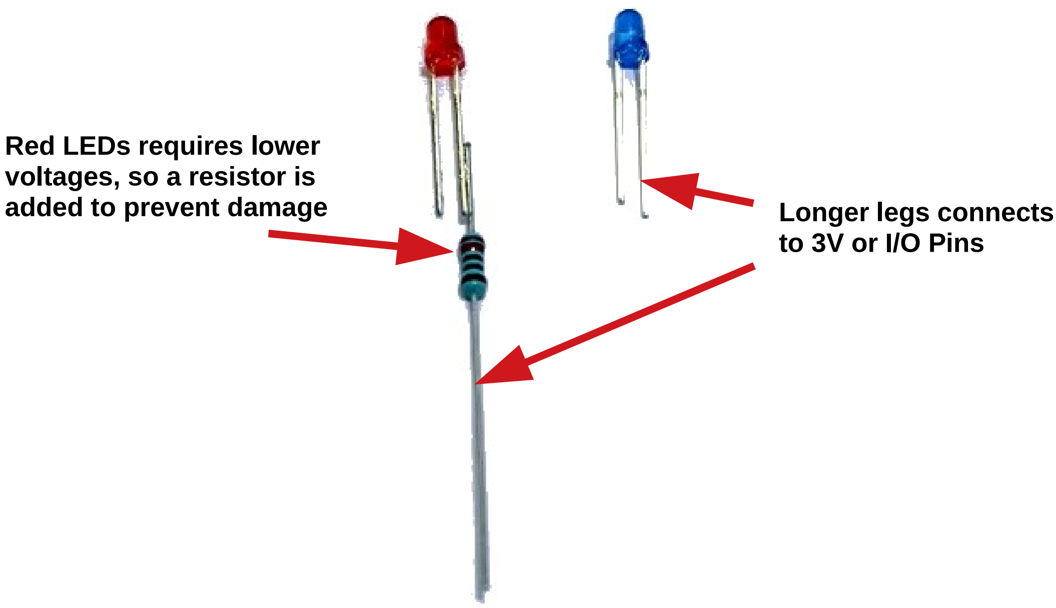
Piezoelectric Speakers

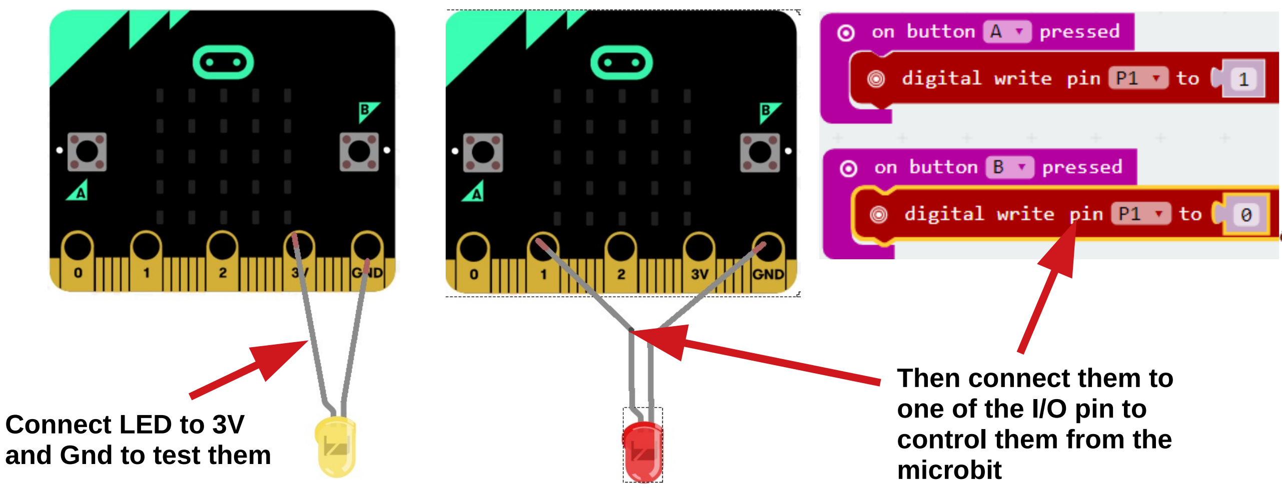
The micro:bit doesn't come with any built-in speakers, so to produce sound, we need to connect an external speaker. For this programme, we will be using a piezoelectric speaker. The piezoelectric crystal changes shape when a voltage is applied, so by changing the voltage, we can make the speaker vibrate and generate a sound!

When connecting the piezoelectric speaker to the micro:bit, connect one end to ground "Gnd" and the other end to I/O pin 0 – the music output. These speakers are "non-polarized" - this means that it doesn't matter which end you connect to ground and which end to I/O pin 0.

Lights

The micro:bit comes with a red LED (Light Emitting Diode) display, but you can also connect external LEDs of different colors. Unlike the piezoelectric speaker, LED are "polarized" devices; this means that you must connect the correct pin to negative (ground), and the correct pin to positive (3V or I/O Pins). Different colored LEDs works at different voltages, so some of your LEDs have resistors soldered on to prevent them from being damaged by the 3 volts from the micro:bit.

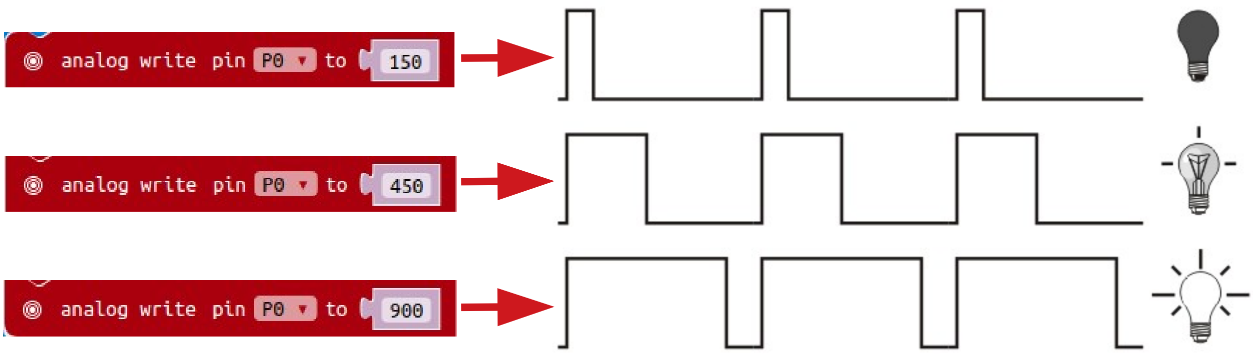




Challenge!
Can you make the LED blink without using the buttons? Try connecting two LEDs and make them blink alternately.

Analog Write

Besides simply turning the LED on and off, we can also control the LED’s brightness. The micro:bit cannot change the voltage that it supply to the I/O pins, but it can switch it on and off very rapidly. By changing the on and off duration, it can vary the brightness of the LED.

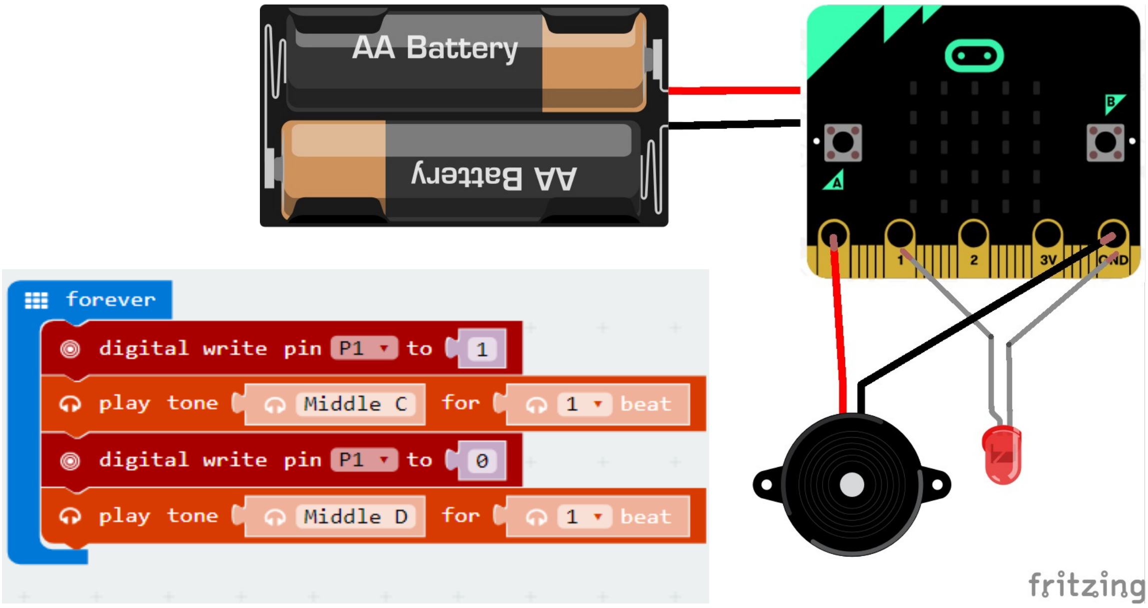


Signal Types

- Digital – Binary (0,1) or (0V, +3V)
- Analog – Range (0 – 1023) or (0V to 3V in 1024 steps)

Combining Lights and Sound

Try the following program and connection. Describe what happens when you power up the micro:bit



What happens? Write your observations below.

____

____

What are your ideas to make the program better? Write your ideas here then try to create it!

____

____

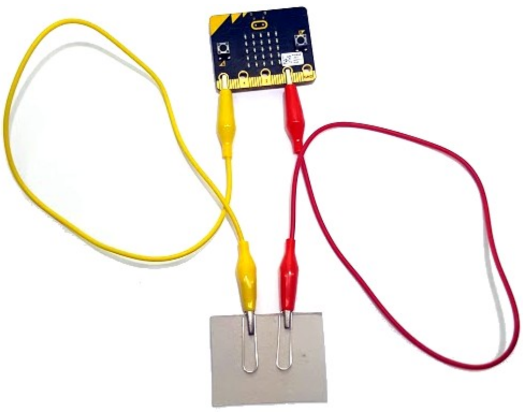
What did we learn?

- Music: Different tones are represented by characters. The speed of the music is controlled by the beats and tempo.
- Speakers: The micro:bit doesn't have a built in speaker, but you can connect a piezoelectric speaker to enable it to generate sound.
- Lights: LEDs are polarized devices; they need to be connected the right way!
- Analog: Analog write allows you to vary the power supplied to a component. This can be used to control an LED's brightness.

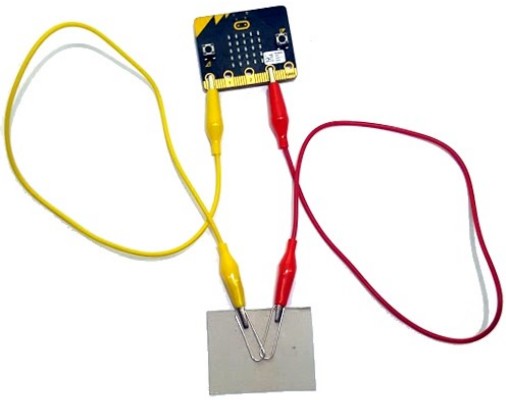
Activity 4: I Like To Move It

Switches

Besides using the two buttons on the micro:bit, you can also make your own buttons and switches. Here's one way of making an on-off switch using two paper clips and a piece of cardboard:

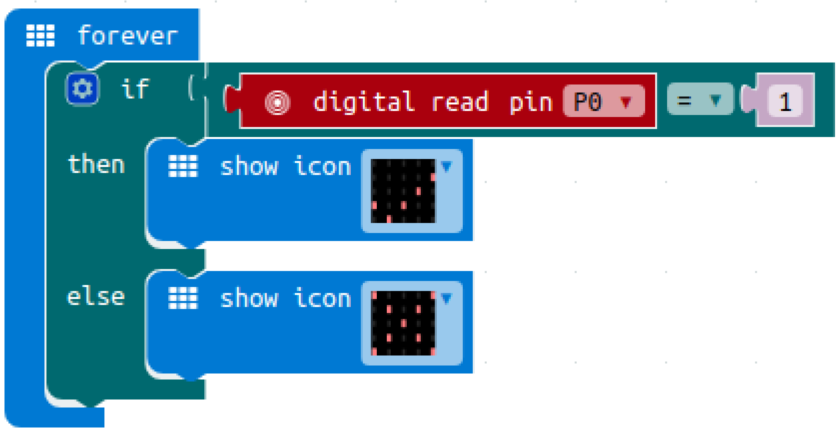


Paper clips not touching. Switch is off.



Paper clips touching. Switch is on.

To read the switch using the micro:bit, you can use the "digital read pin" block.

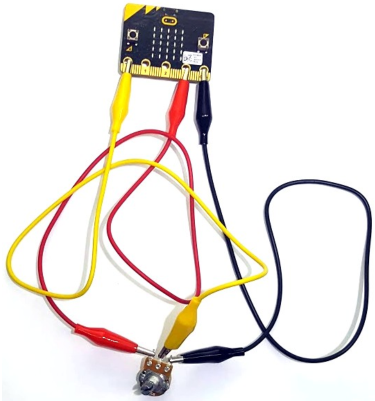


You can make switches using all kinds of materials. You'll need a conductive material such as aluminum foil or metal paper clips to connect the circuit, and a non-conductive material such as cardboard or plastic to support the conductors.

Challenge!
Try making your own unique switch. Paper clips are available in your component pack, and you can get aluminum foil and cardboard from your trainer if you need them.

Analog Read

Besides on and off, the micro:bit can also measure the voltage supplied to its I/O pins. In the earlier section on switches, we learned how to read on and off using "digital read". To measure voltages, we need to use "analog read". This will give us a value ranging from 0 (0 volts) to 1023 (3 volts). You can use a rheostat[5] to obtain a voltage in-between 0 to 3V. Try connecting the circuit below and reading from the micro:bit.

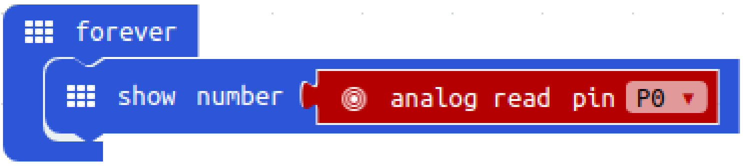


Connect the center pin on the rheostat to one of the I/O pins. The other two pins should be connected to 3V and Gnd.

Use this block to read the voltage, you should get an output from 0 to 1023.

Use this block to read an on-off signal. By default, you'll get a "1" (on) when the I/O pin is connected to 3V and a "0" (off) when it is not connected.

You can use a show number block to display the value you have read...



...but it's more interesting to use it to control on LED.

Read through the above program and try to understand it. How would you connect the LED and rheostat to make the program work? The first one has been filled for you.

Pin	**Connects to...**
Gnd	Short leg of LED and outer pin of rheostat
3V	
I/O Pin 0	
I/O Pin 1	

5 Also called a potentiometer or variable resistor

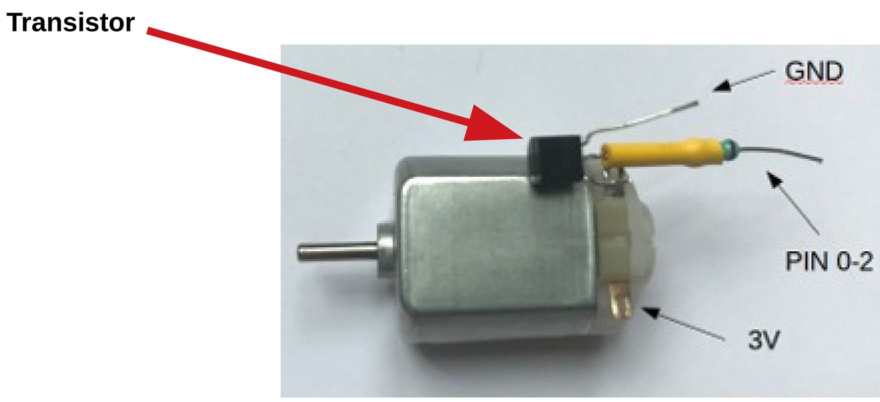
Challenge!
Can you make a blinking LED? And make the blinking speed controllable using a rheostat?

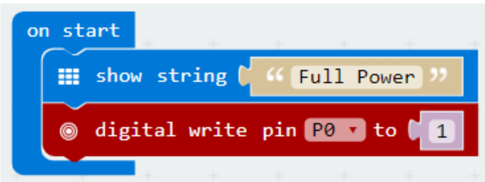
As an added challenge, make the micro:bit play a short song, and make the speed of the song controllable using a rheostat.

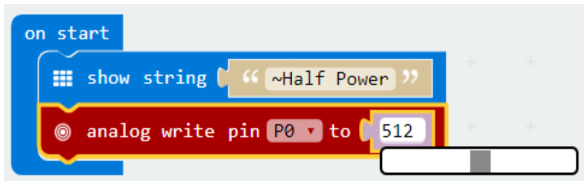
DC Motors

Direct Current (DC) is what you get out of a battery, while Alternating Current (AC) is what you get from the wall socket. Since the micro:bit uses DC power, we will only use DC motors with it. The motors convert electrical power from the micro:bit into rotational kinetic energy.

The DC motor requires more power than what the I/O pins can provide, so our motors are fitted with a transistor (...a type of switch), and we'll use the I/O pins to control the switch.



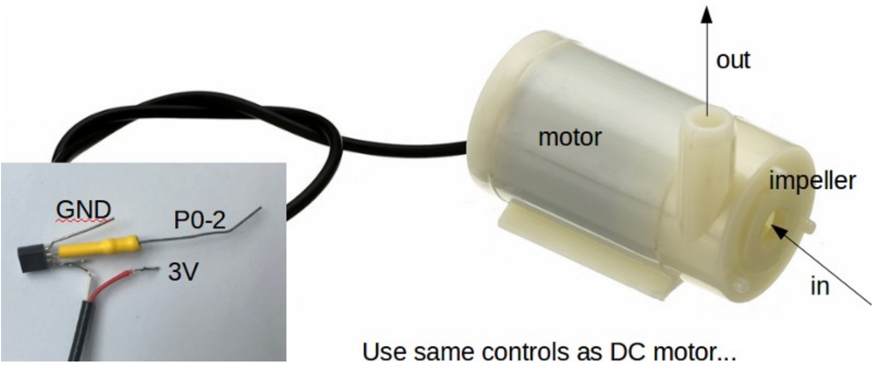




You can use either the "digital write" or the "analog write" blocks to control the motor. Using digital writes will only allow you to turn the motor on or off, while the analog write block will allow you to control the motor's speed.

Pumps

Pumps uses motors to move gas or liquid. There are many different types of pumps, and the one we are using is called a “centrifugal pump”. Centrifugal pumps are good for moving water, but they don’t work well for gases (eg. air). They also need to be submerged in the water to work effectively.



Use same controls as DC motor...

The motor inside the pump is a DC motor, so we’ll be controlling it the same way as the earlier DC motor.

WARNING!!!

- Laptops and water are not best of friends. They do not get along at all.
- When working with water, keep far away from any laptops, and I mean really far.

Servo Motors

Servo motors integrate a DC motor with gears, rheostat, and a control circuit. Unlike a DC motor where you can only control speed, with a servo motor, you can control position. You use a special command in micro:bit (servo write) to tell the servo what position you want it to be in, and the servo will turn accordingly.

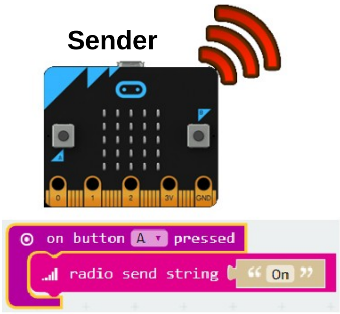
Servo Connections

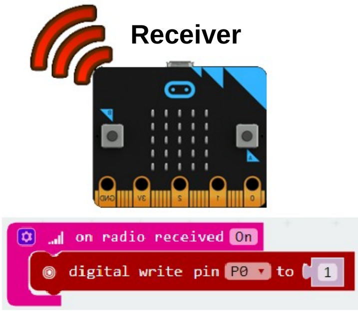
Brown :	Gnd
Red :	3V
Orange :	I/O Pins

Use values from 0 to 180 to control the position of the servo.

Radio / Bluetooth

You can use the Radio blocks to get micro:bits to talk to one another. This lets you use one micro:bit to control another (...like a remote control). You can also use it to detect other people around you (eg. make your micro:bit play a music when your best friend is nearby).





In this example, the sender sends a message when button A is pressed.

When the receiver receives the message, it writes to the output pin, turning on a motor or pump.

What else can you do? Think of something cool!

You can send many different types of message, and the receiver can do a different action depending on which message you send. The content of the message can be anything you want, but it has to be the same on both sides.

What did we learn?

- Switches: The micro:bit can read switches using its I/O pins.
- Analog Read: The micro:bit can measure voltages and return a value from 0 to 1023. We can create different voltages using a rheostat.
- DC Motors: A DC motor requires more power than what the I/O pin can provide. We'll need to use a transistor to switch it on and off.
- Pumps: Used for moving gases or liquids. The pump we have contains a DC motor inside, and is controlled in the same way as a DC motor.
- Servo Motors: We can control the position of a servo motor using special "servo write" commands.
- Radio / Bluetooth: We send messages from one micro:bit to another using the radio blocks. The receiver can be programmed to perform a particular action when it receives a message.

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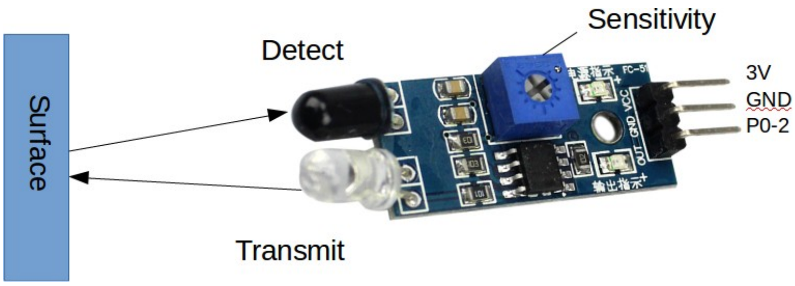
Activity 5: Sustainability

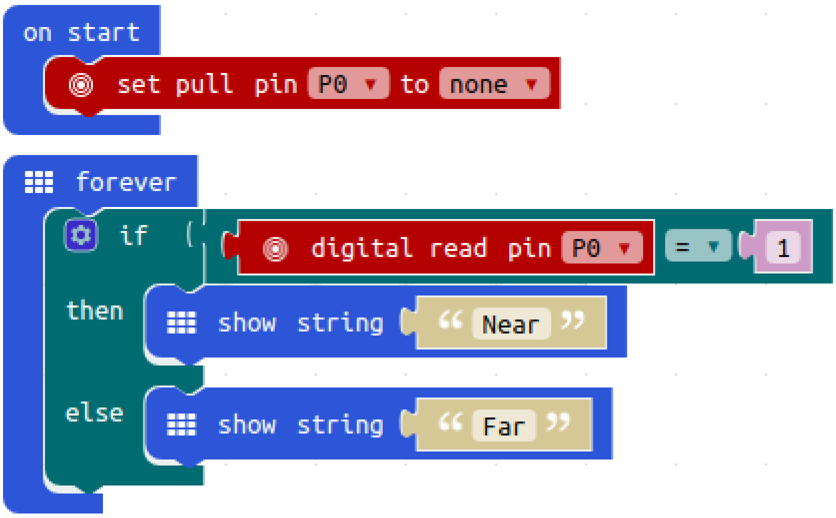
Infrared (IR) Proximity Sensor

The infrared sensor uses infrared light to detect is something is in-front of it. The micro:bit can read it using "digital read", but you'll need to set the pull for the pin to "none", otherwise the micro:bit will think that you are reading a normal switch and may give incorrect results.



Set this to let the micro:bit know that this is not a normal switch

If you need to adjust the detection distance, you can change the sensitivity using the blue rheostat. You'll need a screwdriver to adjust it, and can borrow one from the trainer.



Connect the IR sensor to the Gnd, 3V, and I/O Pin 0 of the micro:bit and try out the above program. It will display "Near" when something is near the IR sensor, otherwise it will show "Far".

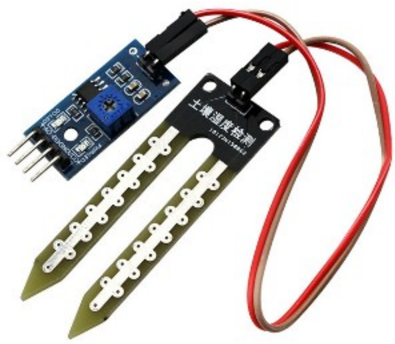
Challenge!

Using what you have learned about the IR sensor and other components, can you make one of the following?

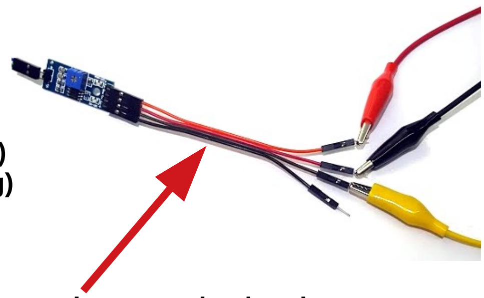
Automatic Door	Auto Lights
Electronic Mouse Trap	Auto Fan

Soil Moisture Sensor[6]

The soil moisture sensor detects the moisture level in soil by passing a small electrical current through it. The wetter the soil, the easier it is for the electrical current to pass through.



VCC	-	3V
GND	-	GND
D0	-	I/O Pin (digital)
A0	-	I/O Pin (analog)



Use these wires to make the pins easier to clip on to

The soil moisture sensor can be connected in two different modes; digital and analog. To use the digital mode, connect the pin labeled D0 on the sensor to your micro:bit I/O pins. To use the analog mode, connect the pin labeled A0 instead. In both cases, you'll also need to connect the VCC and Gnd.

When in digital mode, you'll need to set the pull for the pin to "none", otherwise the micro:bit will think that you are reading a normal switch and may give incorrect results.

Challenge!

I have a potted plant at home and I'm going to be overseas for a 5 days holiday. I'll like to have my micro:bit measure the soil moisture level in my pot and let me know what is the **lowest** value. Can you use the micro:bit to create a device that can do that? (Hint: you'll need to use a variable)

If the soil moisture level is below 500, I'll like the micro:bit to sound an alarm and send a message to my neighbor (...so that he can help water my plant). Can you modify your program to do that?

6 Also called a hygrometer.

Sustainability

The United Nations adopted 17 sustainable development goals. Theses are:

GOAL 1: No Poverty
GOAL 2: Zero Hunger
GOAL 3: Good Health and Well-being
GOAL 4: Quality Education
GOAL 5: Gender Equality
GOAL 6: Clean Water and Sanitation
GOAL 7: Affordable and Clean Energy
GOAL 8: Decent Work and Economic Growth
GOAL 9: Industry, Innovation and Infrastructure
GOAL 10: Reduced Inequality
GOAL 11: Sustainable Cities and Communities
GOAL 12: Responsible Consumption and Production
GOAL 13: Climate Action
GOAL 14: Life Below Water
GOAL 15: Life on Land
GOAL 16: Peace and Justice Strong Institutions
GOAL 17: Partnerships to achieve the Goals

There are many ways that the micro:bit can be used to help achieve sustainability goals. For example:

- Smart appliances: Reduce wastage of energy.
- Automated farming: Produce food with less manpower.
- Intelligent traffic lights: Reduce waiting time for cars and people.
- Smart solar panels: Turn towards the sun to maximize energy generation.

These are just some ideas. What are yours? You can sketch and write about your ideas in the space provided on the next page.

My ideas for a micro:bit device that helps sustainability

What did we learn?

- Infrared Proximity Sensor: This sensor detects objects by shining a beam of infrared light, and detecting how much gets bounced back. It can detect if something is near or far, but it cannot measure distance.
- Soil Moisture Sensor: This sensor works by passing a small electrical current through the soil. The wetter it is, the more current will pass through. It can detect if the soil is wet or dry, and it can also measure how wet it is.
- Digital Read: The micro:bit can use digital read to read from a switch and from an electronic sensor. Normally, the micro:bit expects a switch, but you can tell it that an electronic sensor is connected by using “set pull pin to none”.

Activity 6: Project Work 1

Step 1: Form a team of 3 to 4 students. In the space below, write the names of everyone in the team.

Team Member 1: ______________________________

Team Member 2: ______________________________

Team Member 3: ______________________________

Team Member 4: ______________________________

Step 2: Discuss in your team, what are the things you can create for a sustainable city using the micro:bit. **Every member must create a different device using the micro:bit. (Exception: Two students may work together to create a device that uses two micro:bits)**

Step 3: Write down your individual project idea in the space below.

What is my device called?

____

What does my device do?

____

____

____

____

How does my device contribute towards sustainability?

____

____

____

____

Step 4: Build and program your device. If you need cardboards, glue gun, or extra LEDs, you can get them from the trainer.

Step 5: Demonstrate your device to your teammates. Ask them…

What do they think is good about the device?

What they think didn't work well?

What are their ideas for improvements?

Remember; you don't have to agree with the comments from your teammates, but do thank them for trying to help.

Step 6: Make improvements to your device. You can use the comments from your teammates for idea, or perhaps you have some new ideas. Either way is fine.

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Activity 7: Project Work 2

Step 1: Complete your individual devices. Test and make sure it is working well.

Step 2: Work with your teammates to combine your individual devices into a sustainable city. Sketch out how the combined project will look like.

Step 3: Think about how each of these devices contribute towards sustainability and create a story of how a person living in the city would be helped by these devices as he or she go about their day.

My sustainable city story...

____

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____

____

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____

____

____

Step 4: Finally, as a team, present your story to the class!

The End!
That's the end of this micro:bit course! For more lessons and fun projects, visit…

https://microbit.org/

https://www.hackster.io/microbit/projects

https://codeclubprojects.org/en-GB/microbit/