UCL Micro:bit Robotics Documentation

Release 0.1

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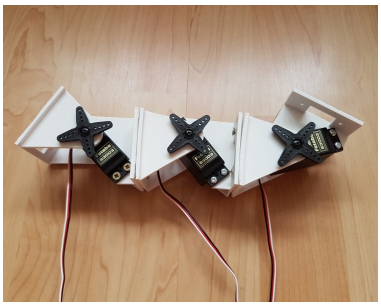
Sep 25, 2018

Contents

This project is designed to give students an introduction to robotics with a robot inspired by the natural world. There's no need to know how to code before diving in but we can assure you that once you have tried it, you won't want to stop. The project was designed by Professor Stephen Hailes, a robotics expert and dedicated educator. You will use the micro:bit to make the robot move. Professor Stephen Hailes has written a servo motor library for the micro:bit to make this easier.

The robot is a caterpillar (or maybe a snake, depending on the motion style) which was designed by Dr Juan González-Gómez. In this guide we assume that you have already 3D printed and built your robots.



Caterpillar robot designed by Dr Juan González-Gómez

CHAPTER 1

Building Your Own Robots

If you are starting from scratch, take a look at Dr Gómez's instructions for making and building the units for the robot. The latest design is here. You can also use the older design, found here.

Note: You will need to set the angle of the motors to 90 degrees when the robot is flat on the table.

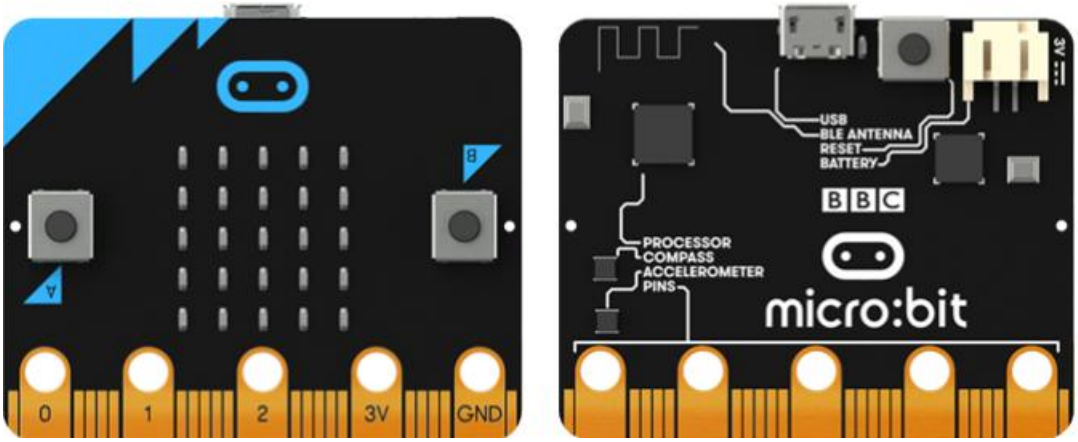
CHAPTER 2

Contents

2.1 Micro:bit - Getting Started

The BBC micro:bit is a tiny computer that you can use to create all kinds of projects from robots to musical instruments – the possibilities are endless. There are a myriad of features that you can use in your designs:

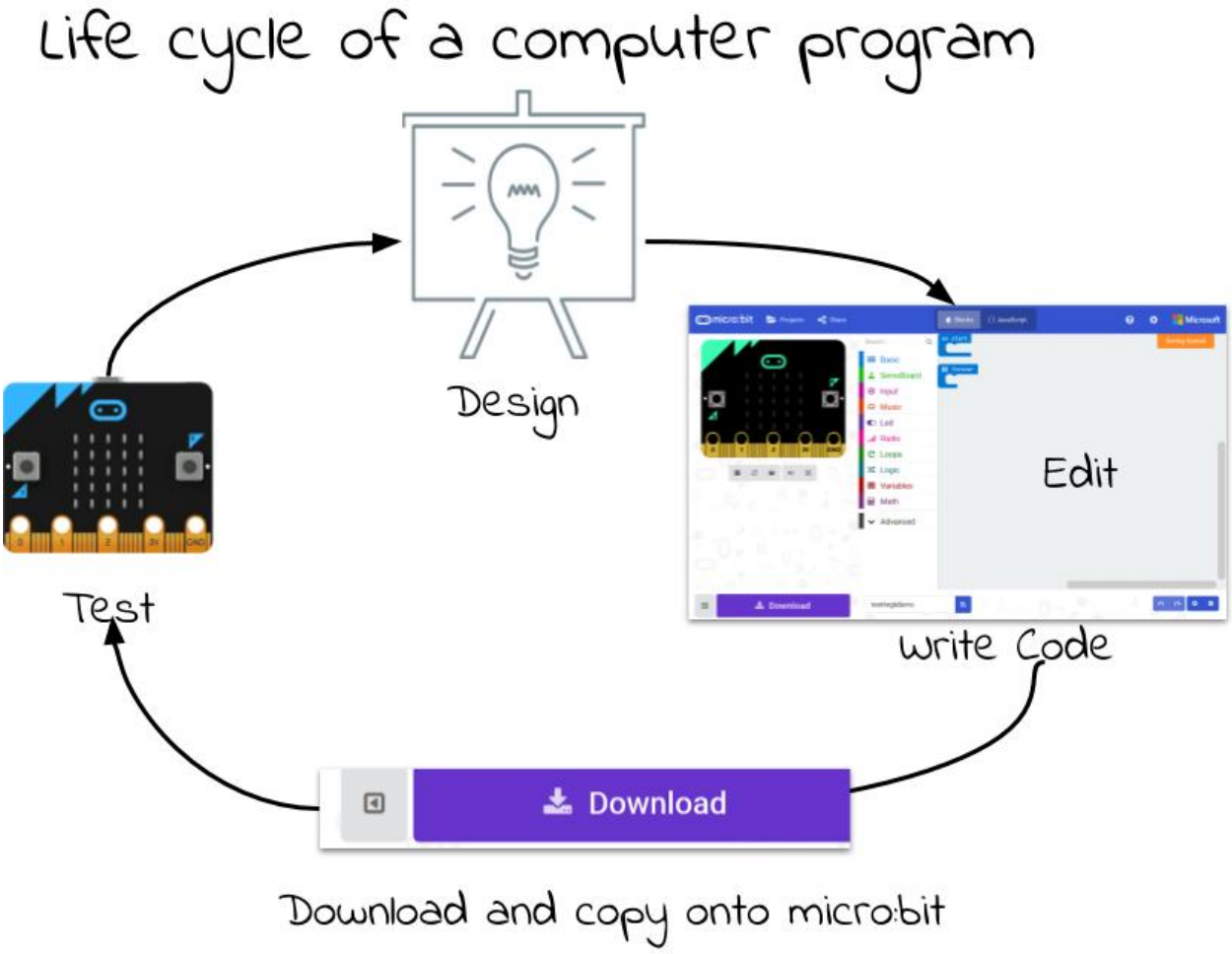
- 25 red LED lights that can flash messages.
- Two programmable buttons (A and B) that can be used to tell the micro:bit when to start and stop things.
- A thermistor to measure the temperature.
- A light sensor to measure the change in light.
- An accelerometer to detect motion.
- A magnetometer to tell you which direction you're heading in.
- A radio and a Bluetooth Low Energy connection to interact with other devices.



Let's create your first micro:bit program; after that, well we've listed a few ideas but it's really up to you.

2.1.1 Your First Program

Coding using the micro:bit is composed of these 4 steps. You can expect to go around the loop quite a few times before you get your code working.

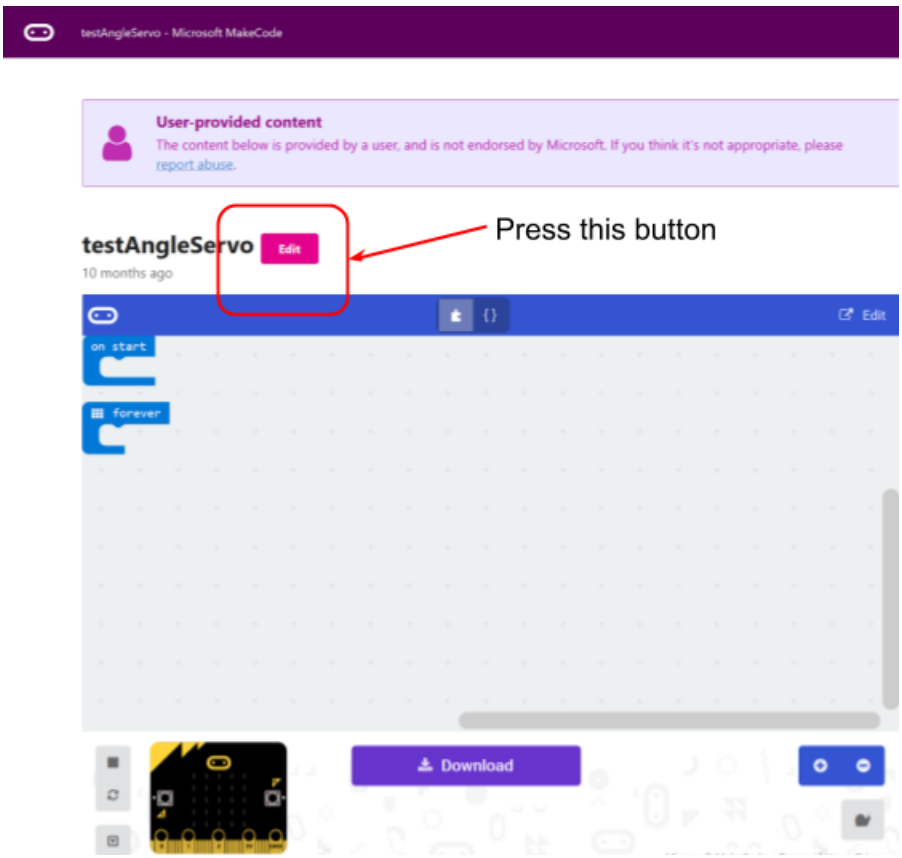


Design the Code

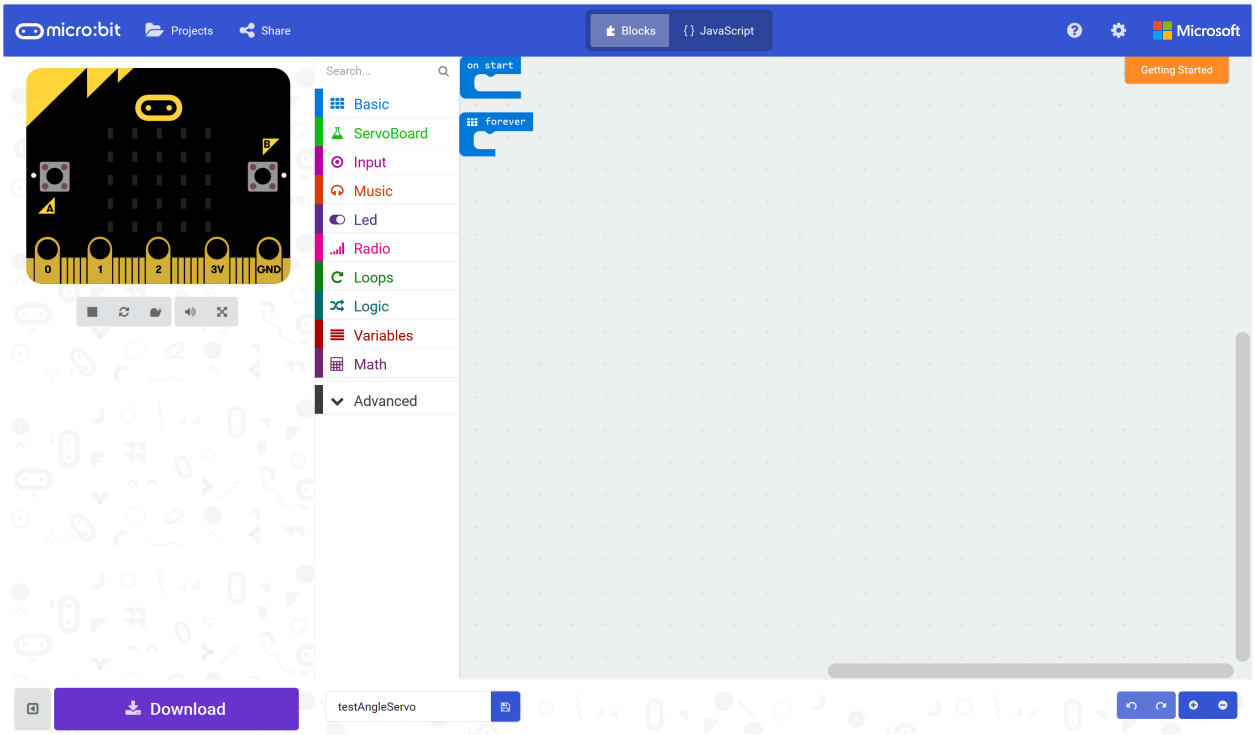
First of all you are going to write a program to display the message "Hello UCL!" followed by an image on the display of your micro:bit. There's not much planning and design to do here, but just so that you understand what a plan might look like:

Write the Code

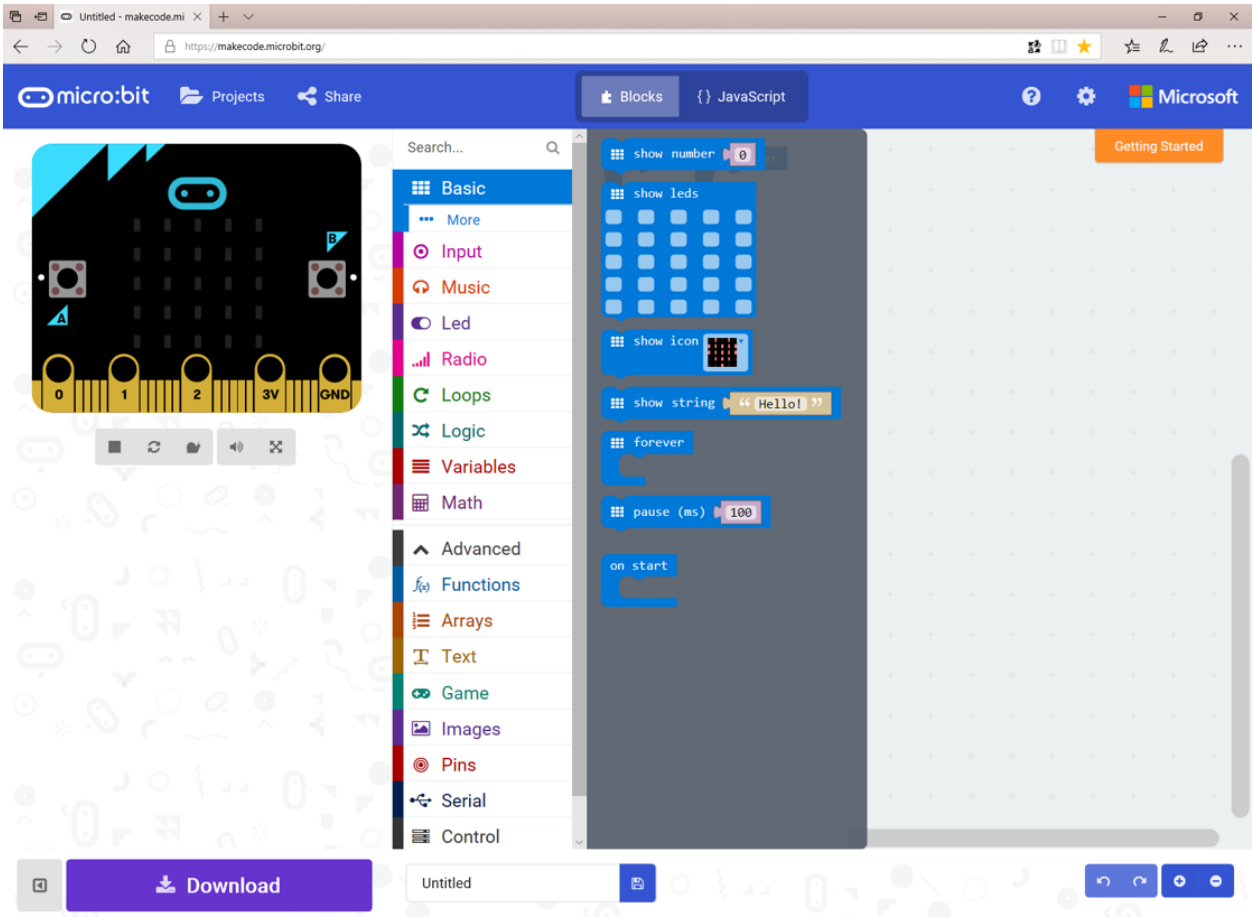
We will be programming the micro:bit using Microsoft's makecode programming environment with some added software to drive the motors. To start coding, open a browser, and go to this URL: https://goo.gl/nKmyrn. When you see the screen below, press the `Edit` button.



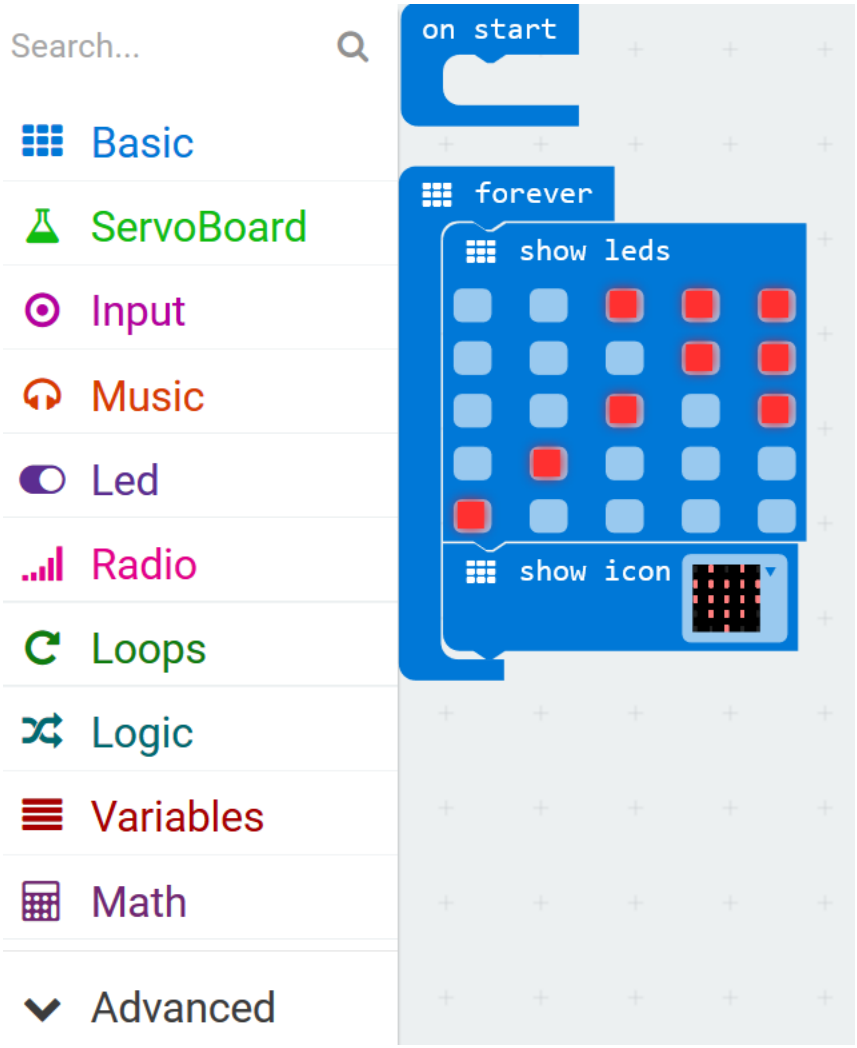
You should see a screen like the one below and you are now ready to make the micro:bit, and eventually your robot, do something.



Choose one or more of the blocks in the `Basic` menu by dragging one of the blocks onto the main canvas.



Place it into the `forever` loop like this:



What is happening here? Look at the simulator on the left hand side. Anything that you put in the `forever` loop will repeat over and over again.

Upload the Code

Final checks. Is your micro:bit connected to your computer? Yes? Then press the `Download` button. Drag the file that's downloaded onto the micro:bit which will appear as a device in your File Explorer.

Make a change

What else can you do? Try it out. You have written your first program, carry on and see what else you can do with the micro:bit. There are lots more resources online.

2.2 Crawling Robot

2.2.1 Aims

We're going to build a crawling robot that's inspired by a snake or a caterpillar but how does a crawling animal move? Take a look at these YouTube clips:

Click on the picture below:

BBC How Snakes Move

Caterpillar on the move (Lampe, 2013)

Or this one:

Hairy Caterpillar, Caterpillar Moving (HowToDrawCartoons, 2011)

You can see from the videos that a wave passes along the caterpillar so we'll try to make our robot mimic that.

For this project, the robot we are going to build will only have 3 body segments, we're going to need some power to move each segment and we will use a motor, called a servo motor to do this. We'll control the motors using a program written on a micro:bit. In the next section, we'll find out about motors.

2.3 Servo Motors

Let's begin by taking a look at the servo motor. There are two types of servo – the first type is one where you can choose an angle to which the arms should rotate; the second goes round and round at a speed you set. We're going to use the first type shown here:

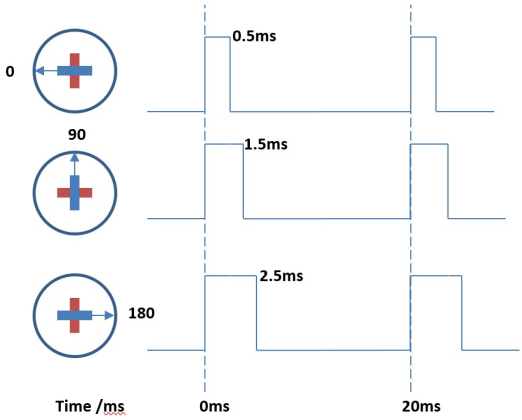
Futaba S3003 servo motor

Servos are used all over the place in both daily life and in robotics. A servo might retract the tray of a DVD player or might be used in radio controlled vehicles and aeroplanes to control the rudder of a boat, or the ailerons - the moveable flaps on the wings of a plane.

An animation of an airplane rolling via its ailerons (NASA, 2013)

2.3.1 Pulse Width Modulation (PWM)

The angle of the arms on the motor is controlled by sending the motor small electrical pulses. This technique is called a pulse width modulation (PWM). Look at the diagram below: a pulse of 0.5 milliseconds (ms) will cause the motor to set the rotor to 0°. A longer pulse of 1.5 ms will set the rotor to 90° and a pulse of 2.5 ms will move the rotor to 180°.



The length of the electical pulse determines the rotor position.

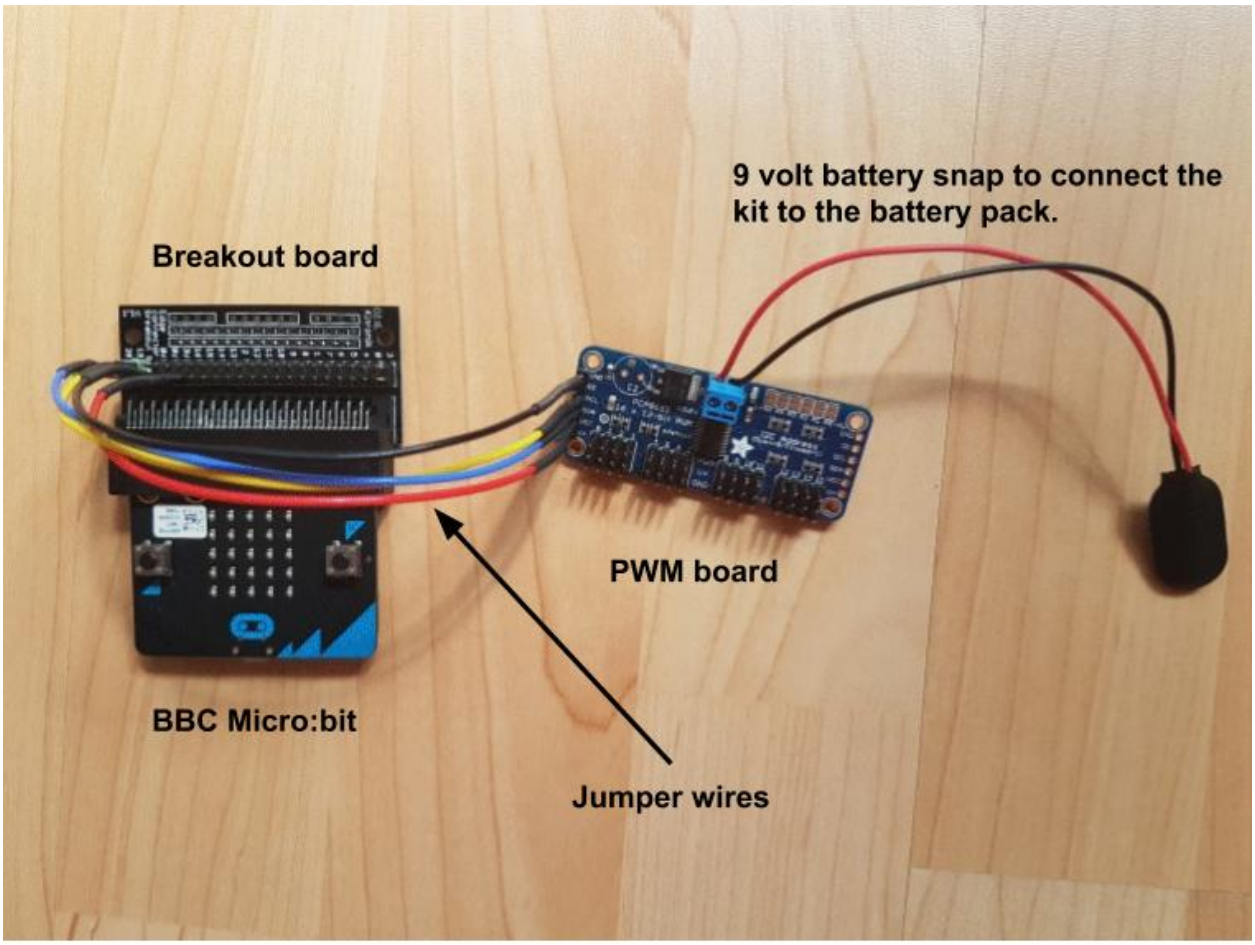
In the next section, we'll learn how to connect the motors to the micro:bit.

2.4 Constructing the robot

The robot is made from parts designed by Dr Gonzales-Gómez. Instructions for the latest design is here. You can also use the older design, here.

Although the micro:bit can drive up to 3 servo motors, we have decided to use a second board to connect the MicroBit to the servos, for two reasons:

- The micro:bit works on a 3.3V circuit but the servos work on a circuit of about 5V. This means that we can't just connect the two together anyway.
- We can connect up to 16 servos to the micro:bit using an interface board – we could make a very long snake or caterpillar.



High level view of the micro:bit, breakout board and PWM board

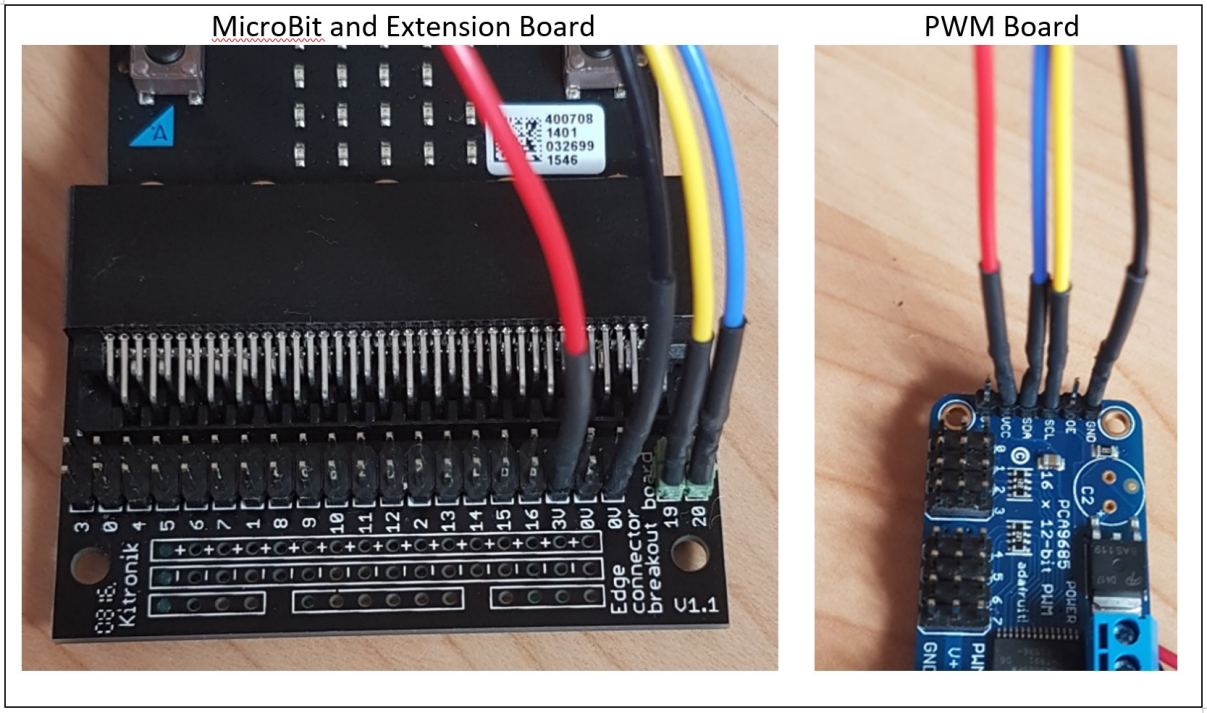
In this picture you can see that the micro:bit will plugged in to a breakout board which is connected, in turn, to a PWM board using some small wires. The PWM board communicates with the MicroBit using a special digital communications channel called I2C. We have written some code to hide these details from you so that you can focus on getting the caterpillar moving.

2.4.1 How to connect the parts

Follow the steps below to make the connections but please note:

DO NOT CONNECT THE BATTERY TO YOUR KIT UNTIL YOUR CIRCUIT HAS BEEN CHECKED

Step 1: Connect the micro:bit to the PWM board

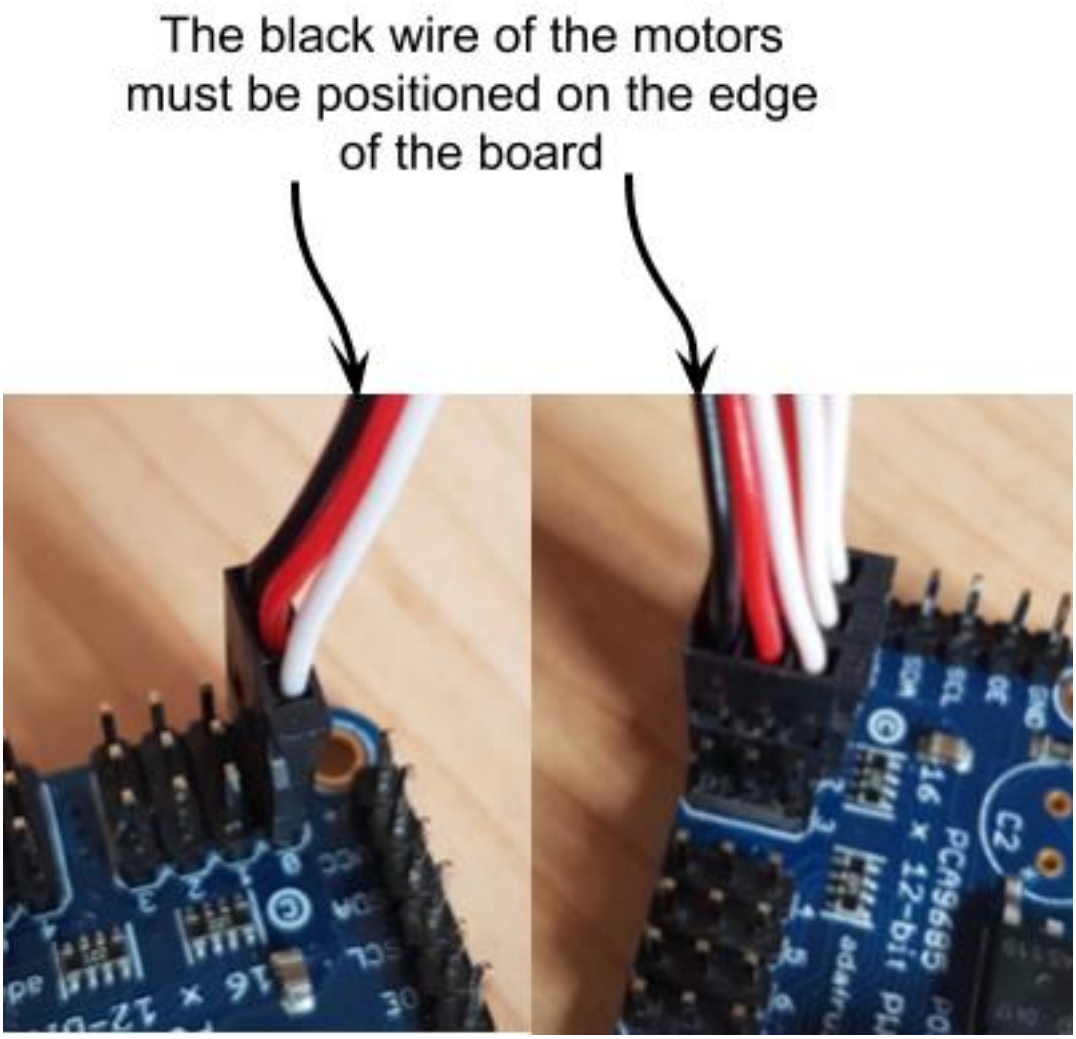


Connecting the micro:bit to the PWM board

You will need 4 female to female jumper wires and you must connect the right pins together. Use this table to match up the pins.

Connection Table		
Purpose of the pin	Micro:bit pin label	PWM board pin label
Power	3V	VCC
Ground	0V	GND
Clock Line	19	SCL
Data Line	20	SDA

Step 2: Plug the motors into the PWM board



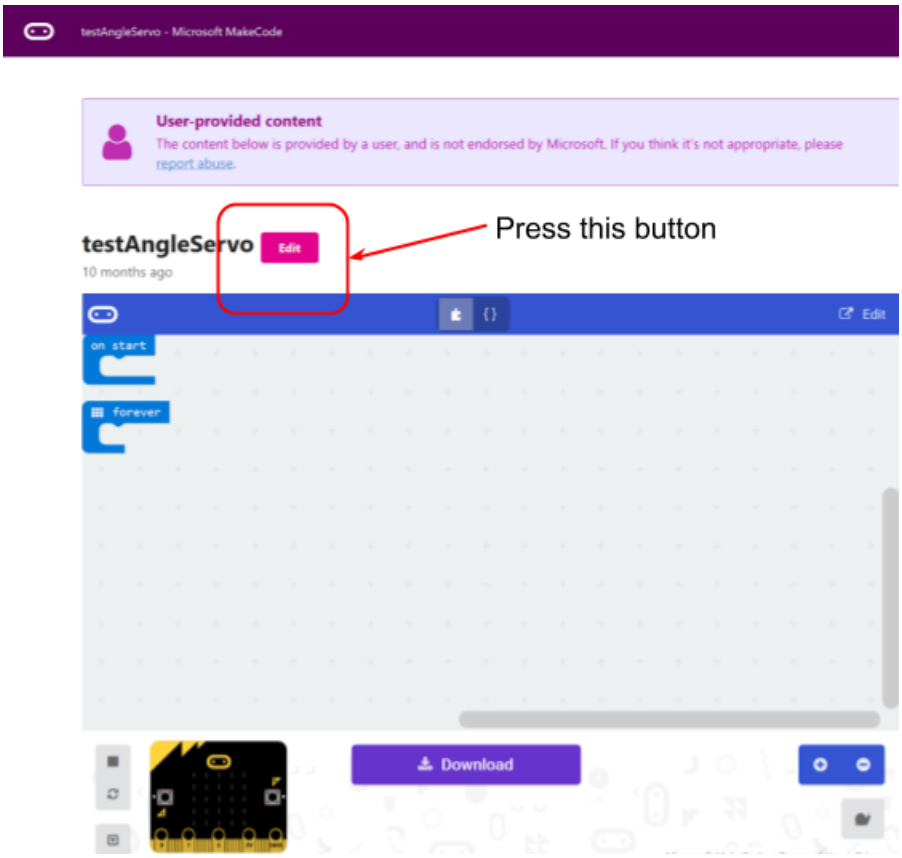
Plugging the motors into the PWM board

The servo motors should be connected to the PWM board this way round with the black wire on the outside of the board. You can see this clearly on the left where there is a servo connected in position 0. It's easier if you start at 0 and work up. You can start off by just connecting 1 motor and add more as you use them.

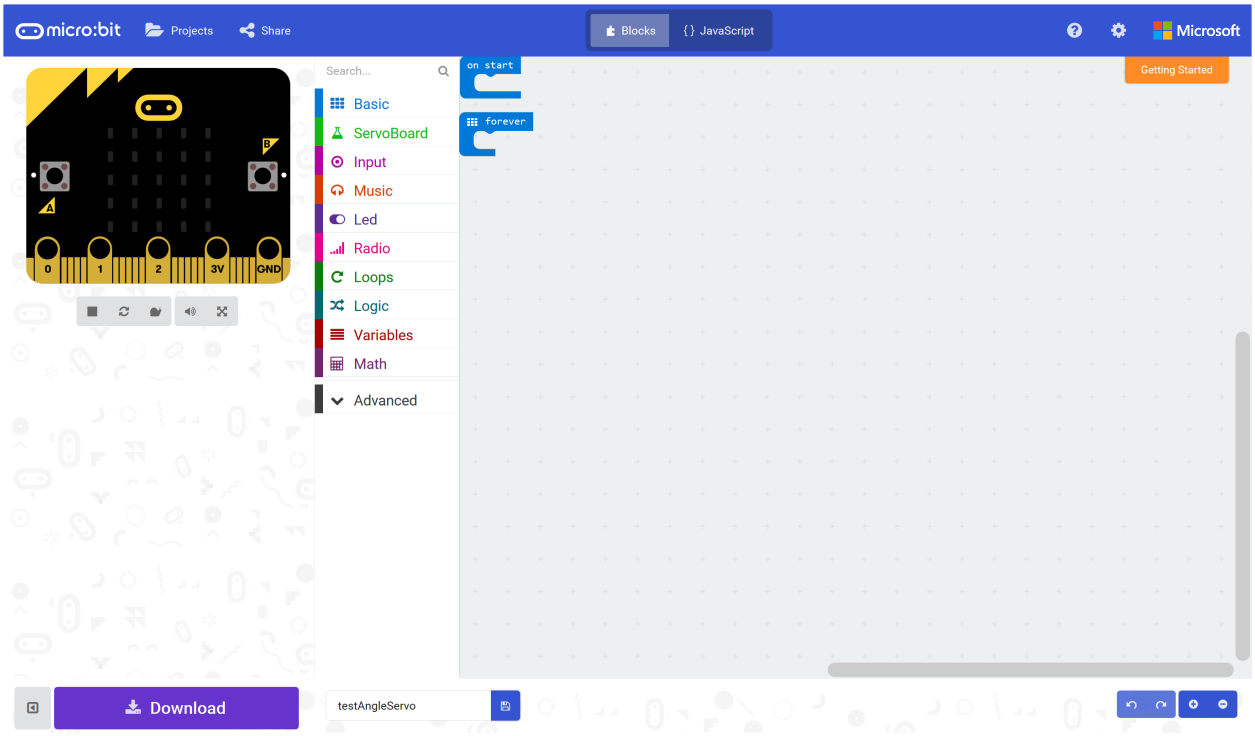
2.5 Get ready to code

We will be programming the micro:bit using the makecode programming environment with some added software to drive the motors. Open a browser, and go to this URL: https://goo.gl/nKmyrn

When you see the screen below, press the `Edit` button.



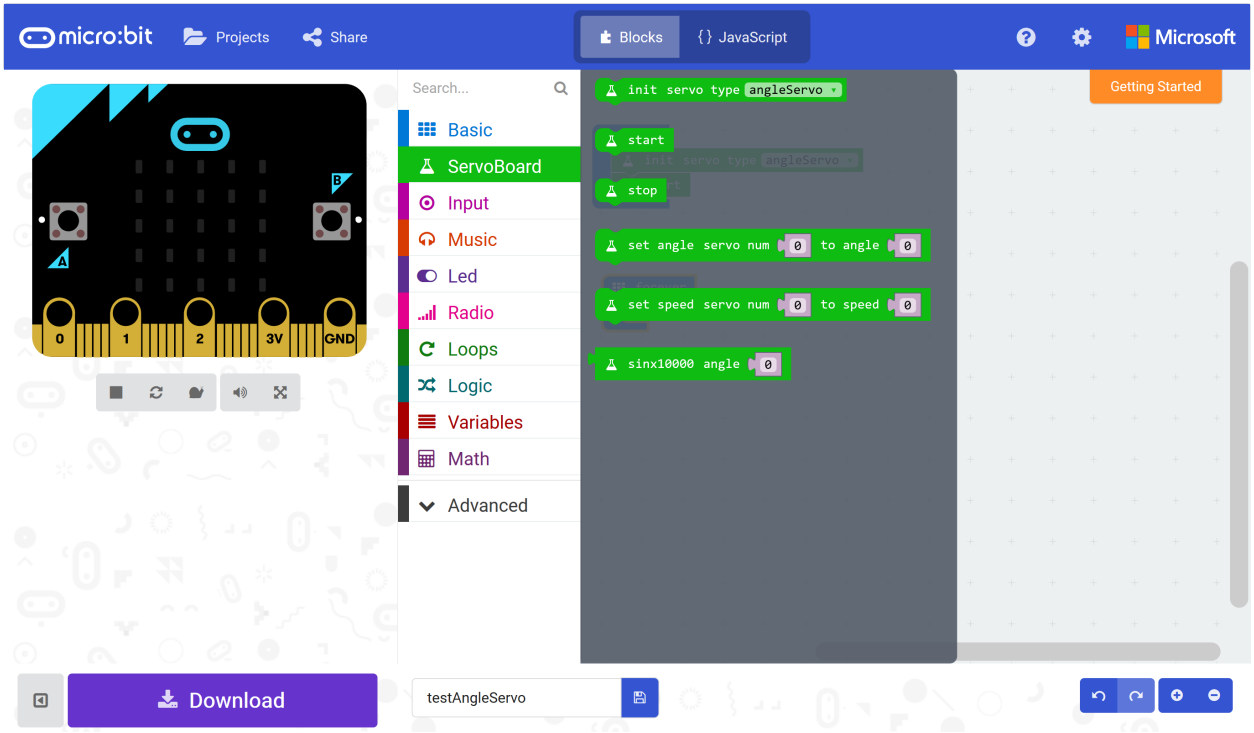
You should see a screen like the one below and you are now ready to make the micro:bit, and your robot, do something.



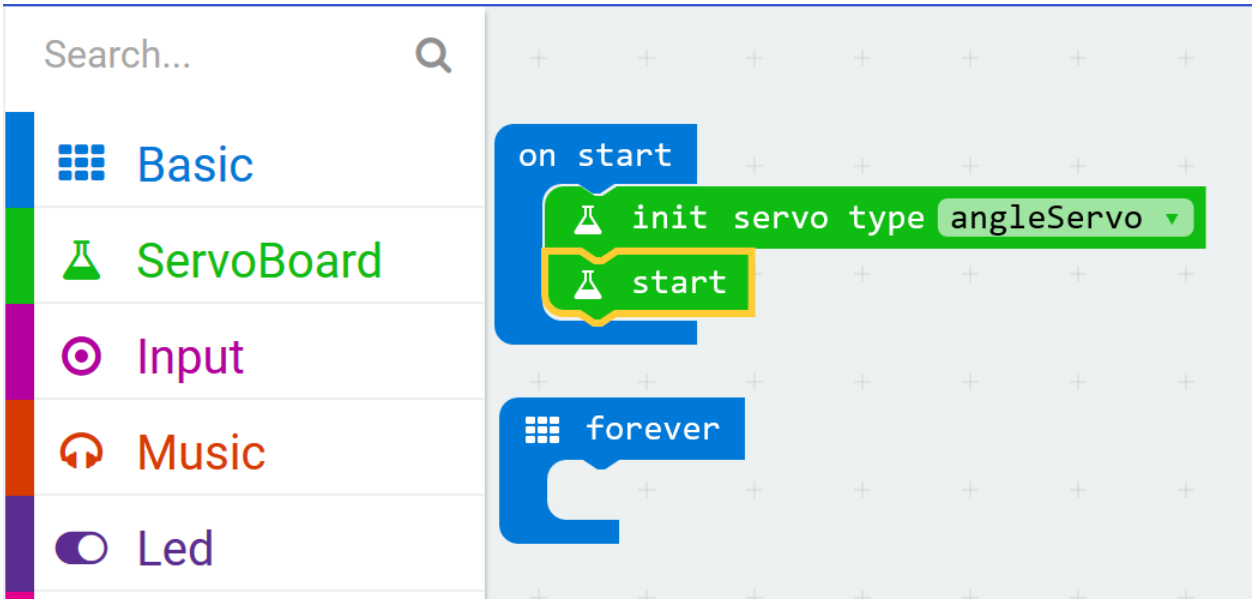
2.6 Moving motors

2.6.1 Set up the motors

Click on the `ServoBoard` menu so that you can see the blocks.

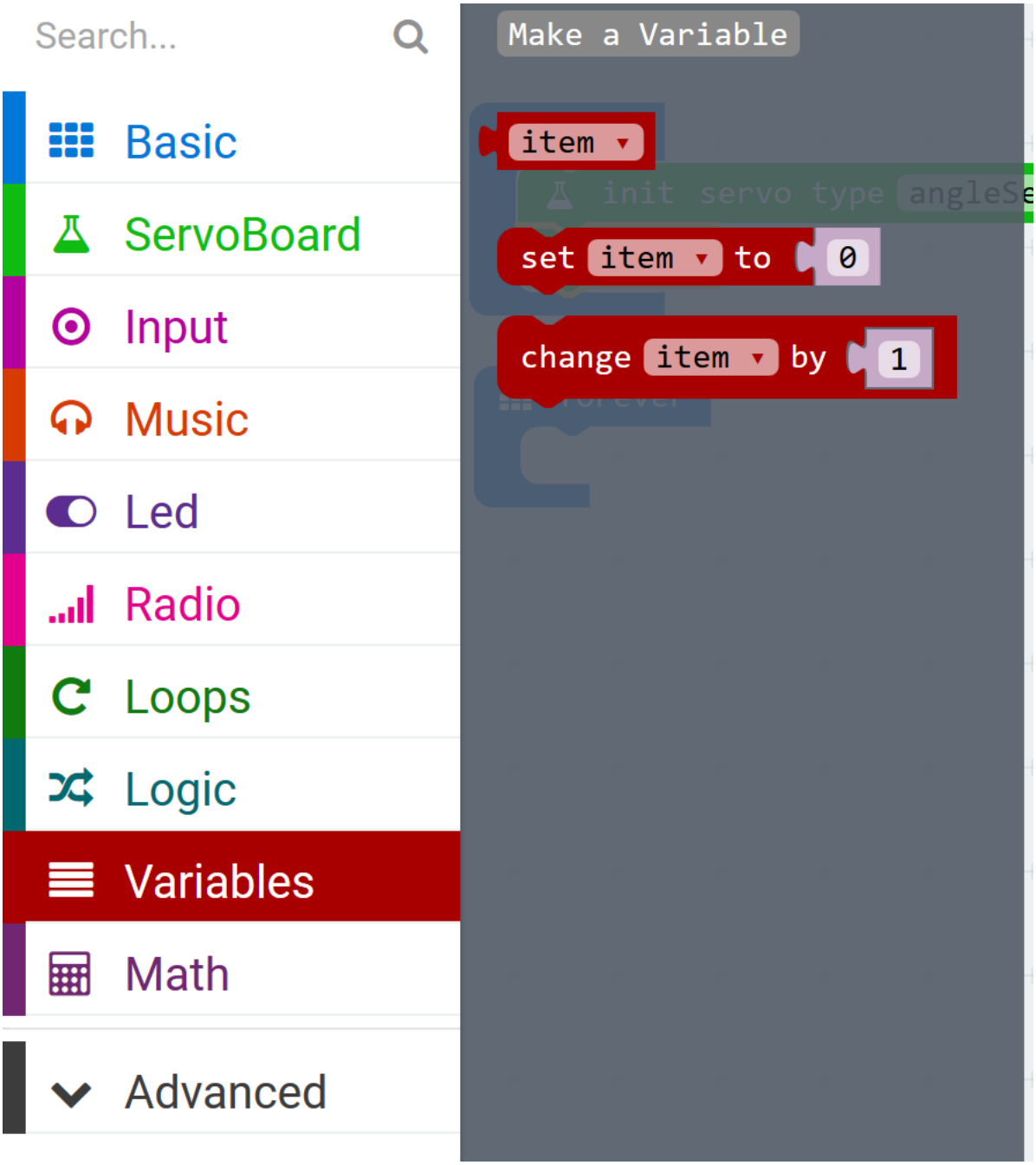


Now drag out the blocks that will set up the motors and place them in the `on start` jaws so that your code looks like this:



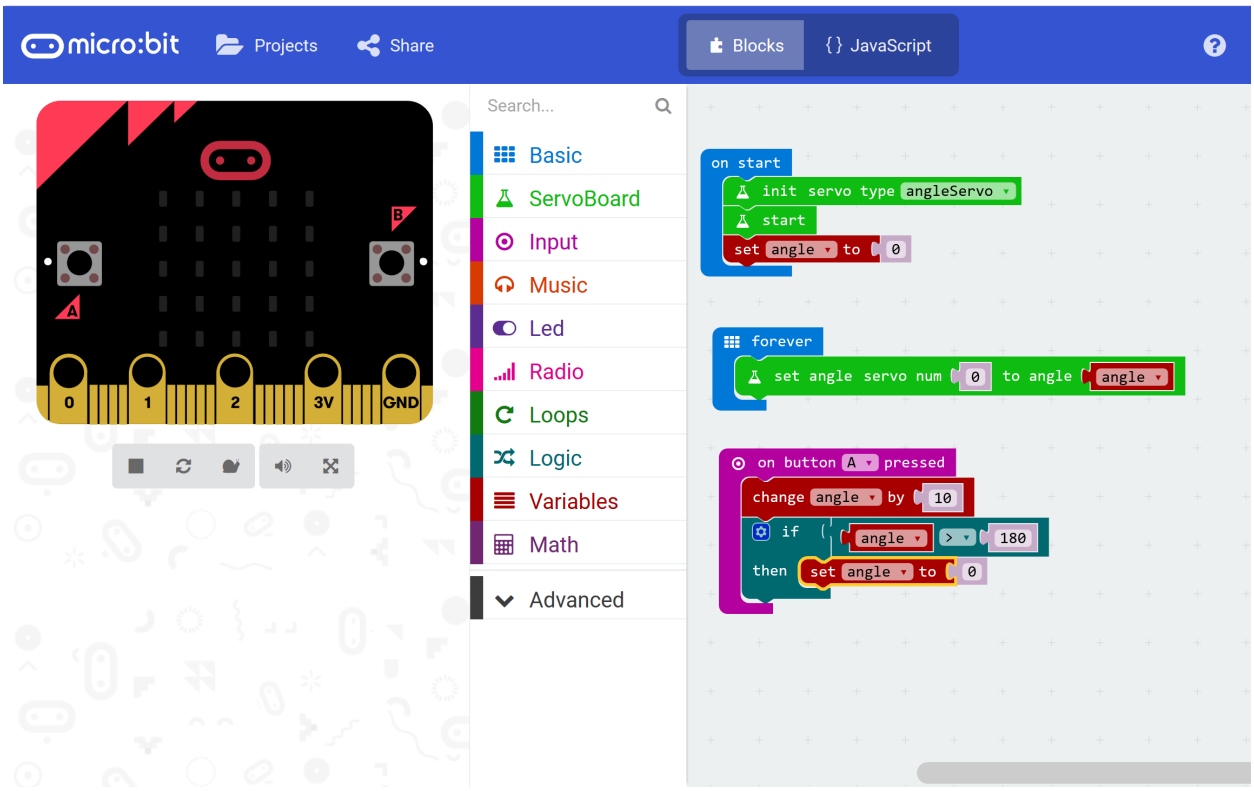
2.6.2 Make the motors move

Now we will add some code to move the motor every time that you press the button. First of all we will need to keep a counter, called a variable, in which we will store the current angle of the motor. You can do that by opening the `Variables` menu and choosing `Make a Variable`:



Name the variable `angle`.

Now you can add the rest of the code to change the angle of the motor.



What happens when the angle reaches 180°? Try it out.

2.7 Forward and Back

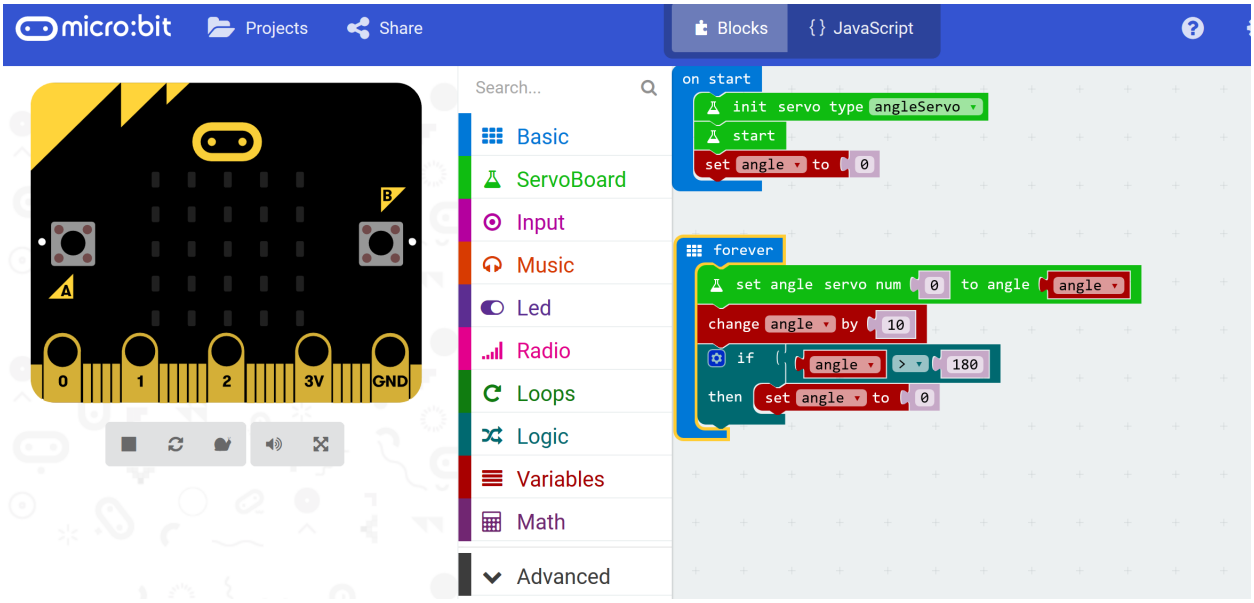
Well done, you have got the motor moving and you can see that it moves from 0° to 180° as you press the button. Now we need to change the code so that the motor moves without human intervention so that our caterpillar can crawl.

2.7.1 New code

We are going to move some of the code around using these steps.

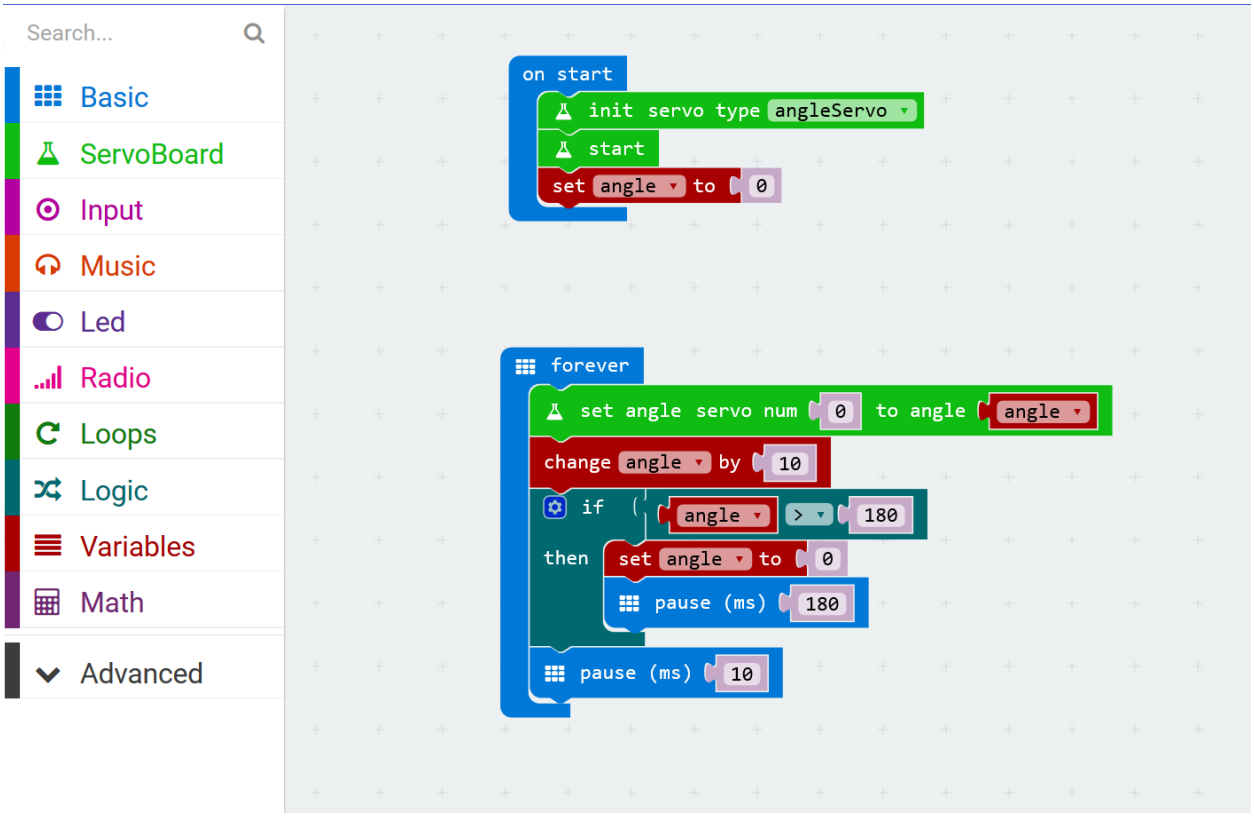
Step 1:

Any code that you put in the `forever` loop will keep repeating over and over as its name suggests. Move the code in the `on button A pressed` loop to the `forever` loop. Delete the `on button A pressed` loop. Your code should now look like this:



Step 2:

Now add a pause of 20 milliseconds at the end of the `forever` loop to give the motor a chance to move in response to the command from the micro:bit. You can see that we have added an extra pause of 180ms. This is because it will take the motor about 180 milliseconds to travel back from 180° to 0°.



Step 3:

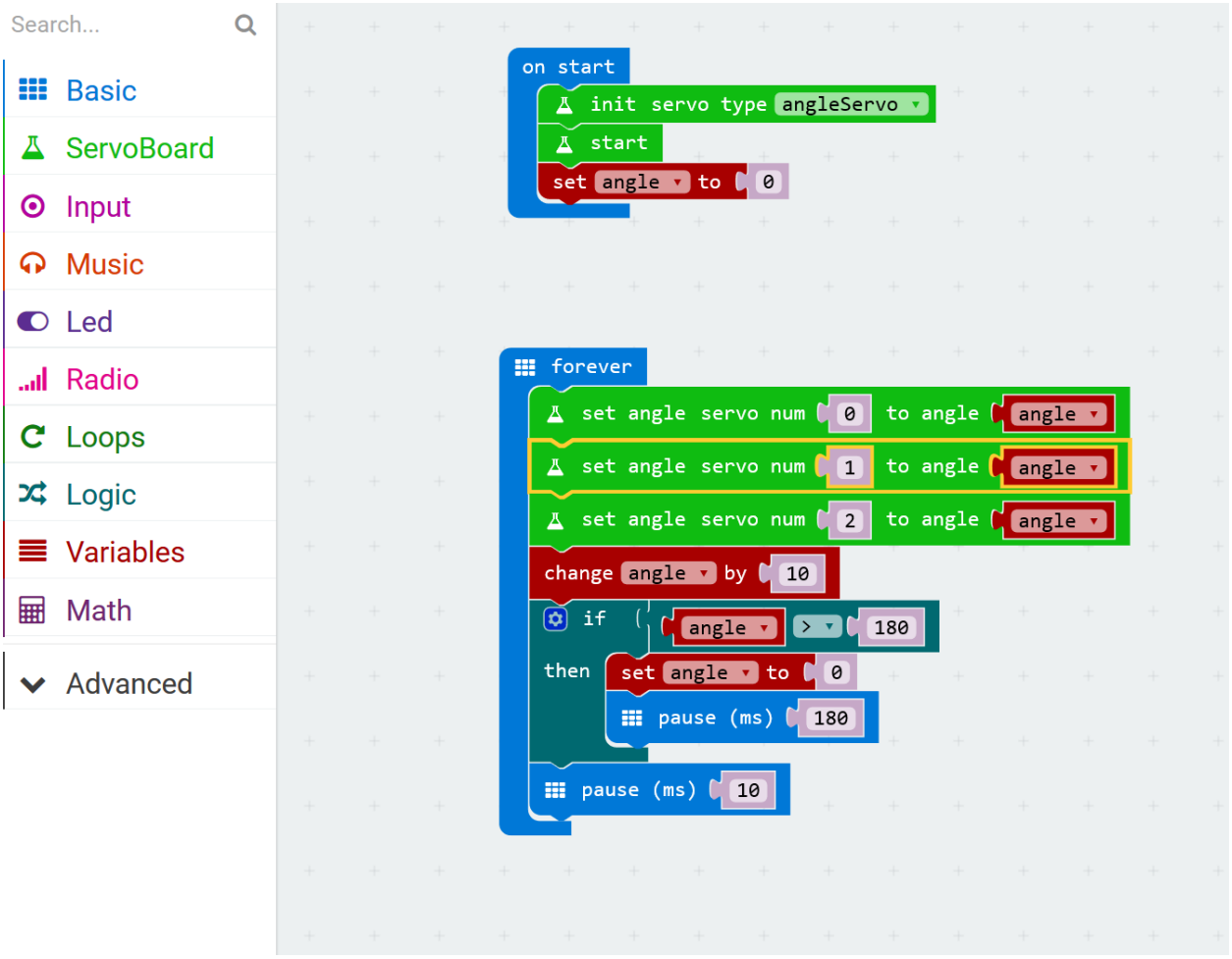
Try the program out. Upload your code to the micro:bit. Did it work? Keep experimenting until you are satisfied with the outcome.

2.8 More than one motor

You are now ready to move more than one motor. Make sure that you have all the remaining motors plugged in to the PWM board.

2.8.1 Servos 1 and 2

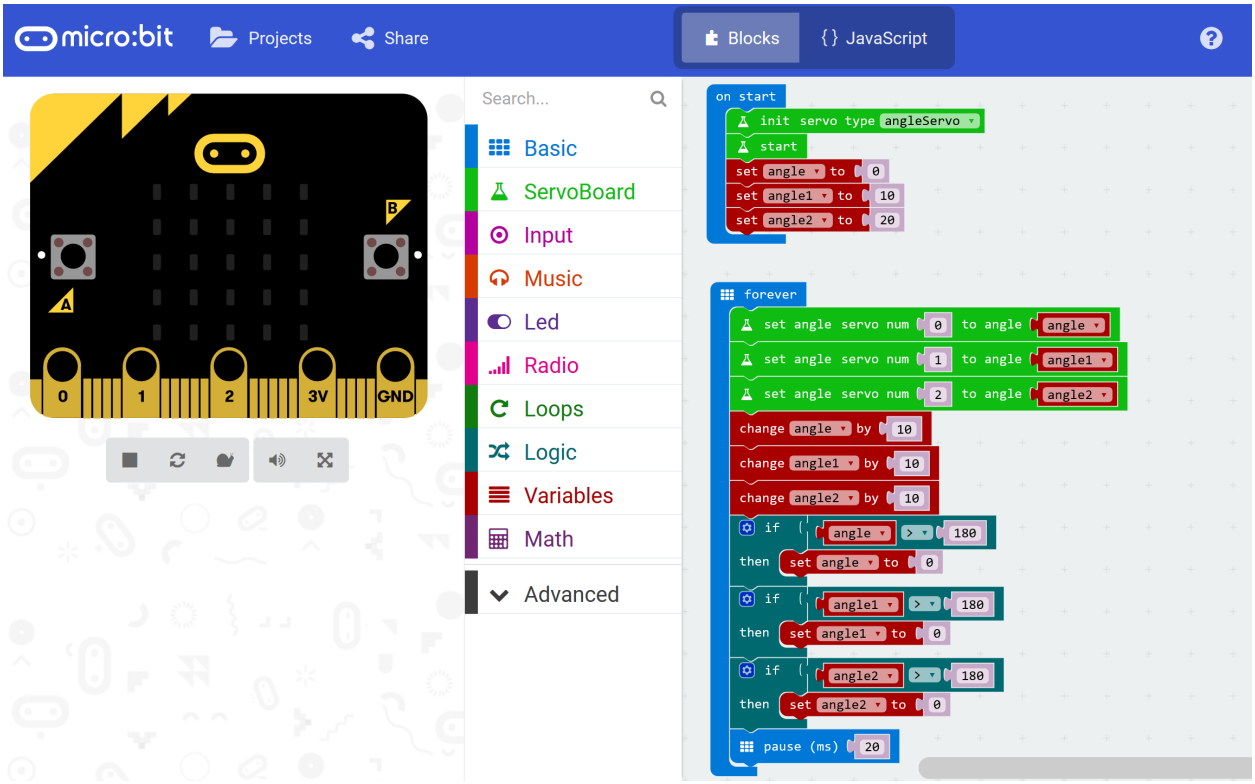
So far your code just moves the motor plugged into slot 0 on the PWM board. You should add code to move the other two motors as well, like this:



You will notice that all of the motors are moving together at the same angle. This is progress but the caterpillar is not going to move very far!

2.8.2 Is it crawling?

Now it's time for you to experiment. Make two more variables `angle1` and `angle2` and initialise the new variables in the `start` loop. Add more code to increase the value of `angle1` and `angle2` in the `forever` loop and don't forget to check whether the value of the angle is greater than 180°.



Try it out. Upload your code to the micro:bit. Did it work? Keep experimenting until you are satisfied with the way that the caterpillar crawls.

2.9 References

Ove Daae Lampe. (2013). Caterpillar on the move. [Online Video]. 2 September 2013. Available from: https://www.youtube.com/watch?v=fRVGWCSij_M. [Accessed: 28 April 2018]

HowToDrawCartoons. (2011). Hairy Caterpillar, Caterpillar moving. [Online Video]. 21 August 2011. Available from: https://www.youtube.com/watch?v=a9Km0edRFG4. [Accessed: 28 April 2018]

NASA (Glenn Research Center, NASA). (2006), [Public domain], via Wikimedia Commons, 10th February 2006. [Accessed: 28 April 2018].

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