Instructions:

CO$_2$ MINI KIT

FOR MICRO:BIT   V1A

another bright idea!

MONK MAKES

Instructions v1a

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INTRODUCTION

This board is based on the Sensirion SCD41 CO2 sensor. The CO2 Mini uses a microcontroller to provide a serial interface between the sensor and the BBC micro:bit through ring connectors.

Features include:

* Low power -- power comes directly from your micro:bit

* True CO2 0-5000ppm, temperature and relative humidity measurement

* RGB LED indicates CO2 level

If left on for a period of 24 hours, the CO2 Mini will calibrate itself assuming that the lowest reading over the 24 hour period should be 400ppm. So, in an empty room, at night when there is nowhere there, there is no one to breathe out and the CO2 level should drift down to around 400ppm.
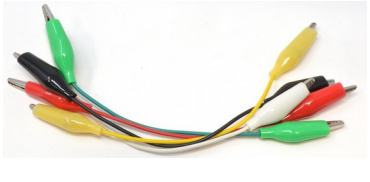
At shorter time scales, you can also manually calibrate the sensor to 400 ppm.

Please note that this product, while it has many of the same features as the MonkMakes CO2 for micro:bit is based on a completely different sensor and is not a direct replacement.

PARTS

Please note that a BBC micro:bit is NOT included in this kit.

Before you do anything else, check that your kit includes the following items:

CO2 Mini for micro:bit	
Set of alligator clip leads (5 leads)	

OPERATION

When the sensor first starts up, it goes through a self-test routine, turning the RGB LED red, green and blue in turn. The LED will then blink blue for a few seconds while the sensor stabilizes.

If there is a problem during the self test, then the orange LED in the MonkMakes logo will blink an error message. The number of blinks indicates the problem with the board. See the Troubleshooting section for more details.
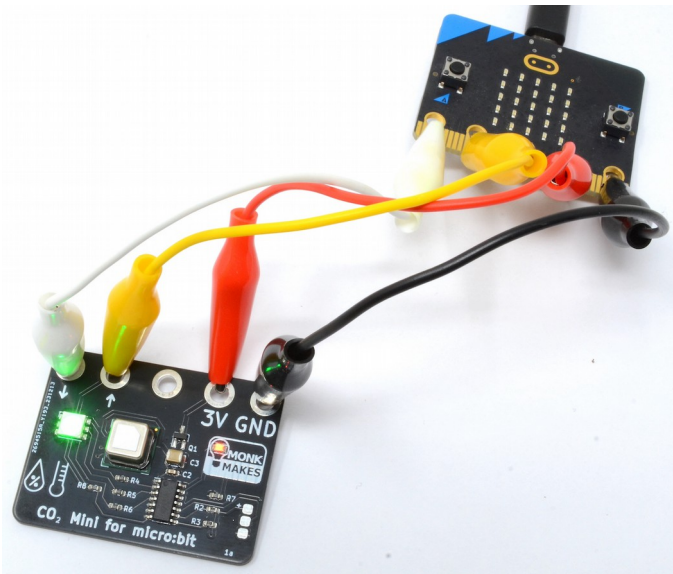
About Alligator Clips

When using the alligator clips to connect your micro:bit to the CO2 MIni for micro:bit board, you have to be a bit careful how you connect the clips at the micro:bit end. The best way is to connect the clips vertically as shown below.
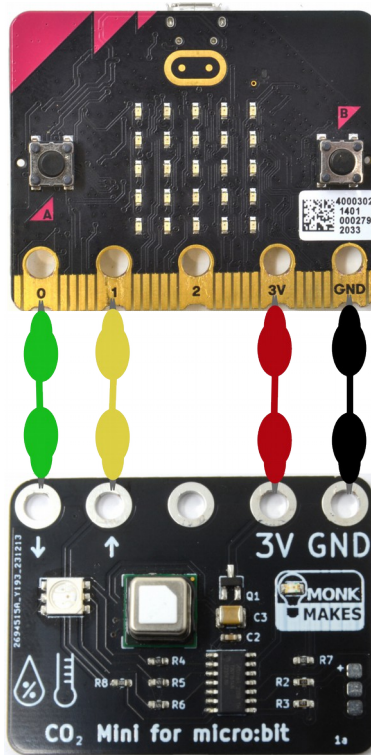

Connecting the alligator clips like this prevents any accidental connections between the large connectors with the holes in and the much smaller connectors (gold lines in the photo above)

Connect the micro:bit to the CO2 Mini for micro:bit

Use four of the alligator clip leads to connect your micro:bit and CO2 Mini for micro:bit together.

Use the alligator clip leads to connect your micro:bit to the CO2 Mini.

It's a good idea to use the red lead for 3V, black for GND for the other two colors chose whatever you like.

Note that there is no connection between pin 2 of the micro:bit and the CO2 Mini board.

Once the CO2 Mini is receiving power from the micro:bit, the RGB LED will light up, even without any program running on the micro:bit. If it's green, the CO2 level is low, orange – medium and red high.
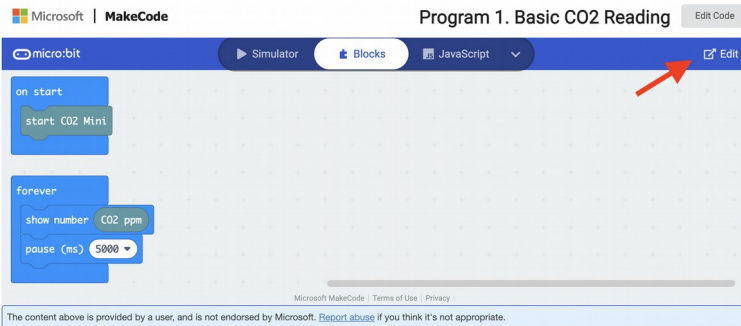
PROGRAM 1. BASIC CO2 READING

Code Link:
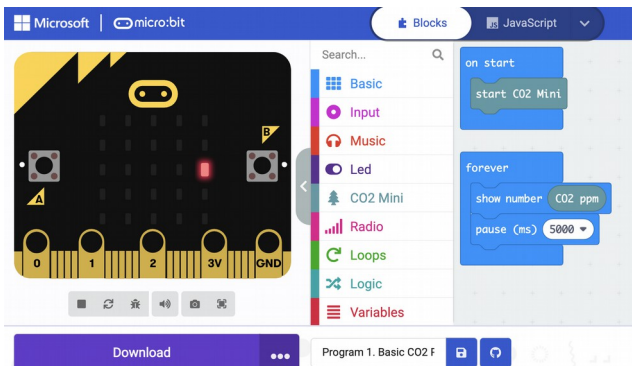**https://makecode.microbit.org/_gs6R6Rcx45qF**

This program displays the CO2 reading in parts per million, refreshing every 5 seconds.

Breathe on the sensor to increase the CO2 readings.

When you click on the code link above, the makecode system will open a window that looks like this:

Here, you can preview the program, but you can't change it or, more importantly, put it on you micro:bit, until you click on the **Edit** button indicated. This will open the normal makecode editor and you can then upload the program onto your micro:bit in the normal way.

Note that the micro:bit simulator in the editor can't get readings from the real sensor and will just show readings of -1.

PROGRAM 2. KITCHEN SINK

Code Link: https://makecode.microbit.org/_VJRHbYJw9fKs

This program is designed to illustrate all the features of the CO2 Mini sensor. It starts by reporting the firmware version of the CO2 Mini and then turns the CO2 Mini's LED off for two seconds.

Pressing button A displays the CO2 reading, the temperature and the humidity.

Pressing button B sets the altitude adjustment for the sensor to 1000 metres.

Pressing A and B together resets all the CO2 Mini's settings to their default values.

```
on start
    start CO2 Mini
    show string "Firmware version:"
    show number firmware version
    pause (ms) 2000
    LED off
    pause (ms) 2000
    LED on
```

```
on button A pressed
    show string "co2:"
    show number CO2 ppm
    pause (ms) 1000
    show string "temp:"
    show number temperature
    pause (ms) 1000
    show string "humidity:"
    show number humidity
```

```
on button B pressed
    show string "Setting altitude to 1000m"
    altitude 1000
```
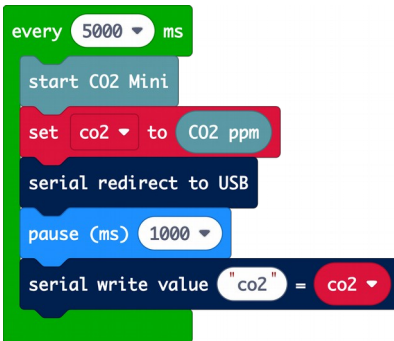
```
on button A+B pressed
    factory reset
```

PROGRAM 3. DATA LOGGING CO2

**Code Link: https://makecode.microbit.org/_F4EUrUDr25dE**

Although the CO2 Mini shares the micro:bit's serial connection with USB, you can still use it to send data to your computer through the micro:bit when it's connected to USB.

Here is an example that sends the CO2 values over USB, so that you can view how the CO2 level changes, in real-time, and log the data to a CSV file that can be opened in a spreadsheet.
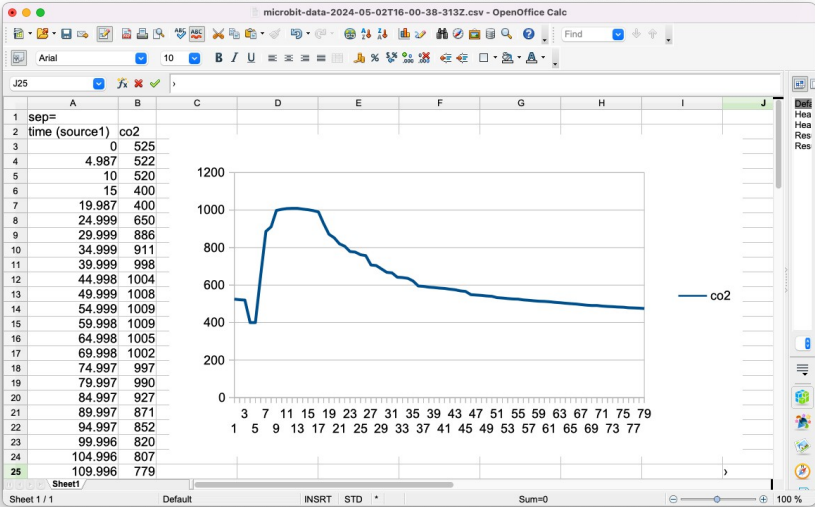

Once the program is uploaded, using a paired micro:bit, click on the **Show data Device** button and you will see something like this.
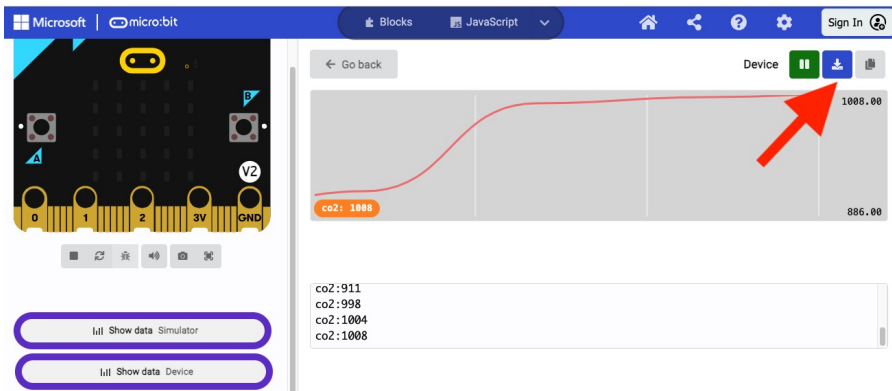
When you have collected enough data, you can download the CSV file by clicking on the blue download icon indicated above.
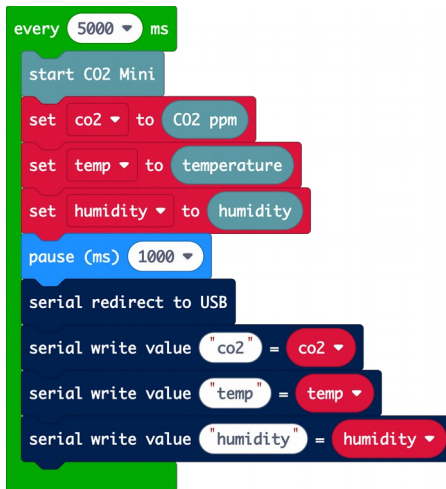
You can then open the file in a spreadsheet such as OpenOffice, plot charts or do other analysis on the data.
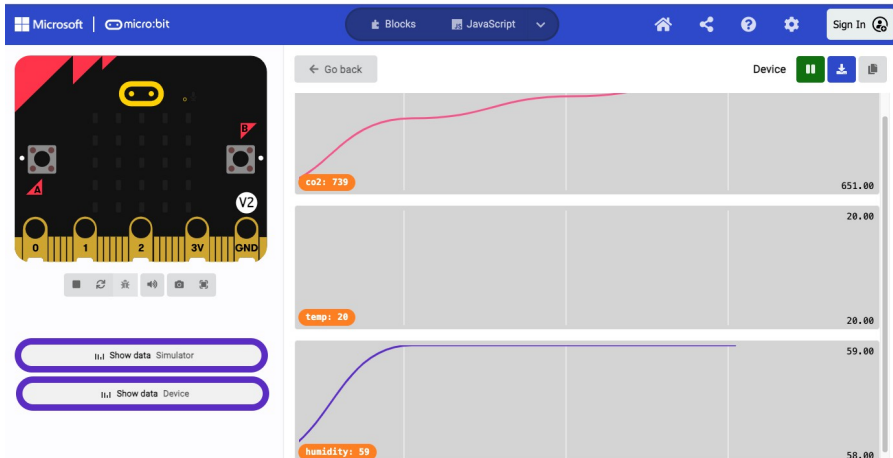
PROGRAM 4. DATA LOGGING CO2, TEMPERATURE AND HUMIDITY

Code Link: https://makecode.microbit.org/_C3w0vJhY6cMc

We can extend the previous example to also log temperature and humidity, with this code:

MAKECODE EXTENSION

The CO2 Mini uses a Makecode extension to provide a set of blocks for the CO2 Mini. The previous example programs already have the extension installed, but if you are starting a new project, you will need to install the extension.
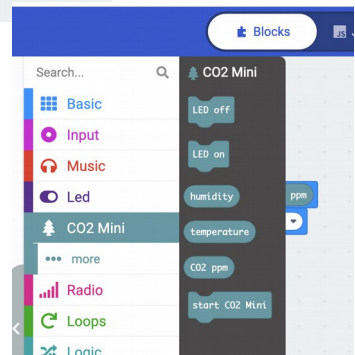
To do this:

* Go to the makecode for micro:bit website here: https://makecode.microbit.org/

* Click on **+ New Project** to create a new makecode project – give it whatever name you like

* Click on the **+ Extension** and in the Search area paste the following web address: https://github.com/monkmakes/co2_mini_makecode_extension

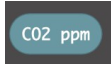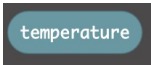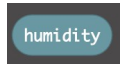This should bring up a single search result.
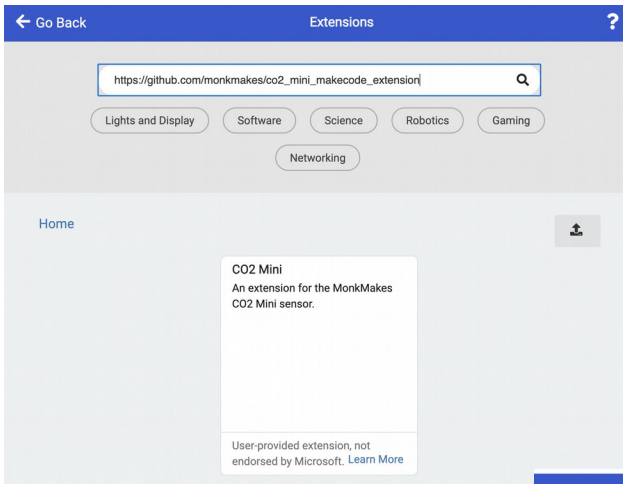
* Click on the CO2 Mini extension and it will be installed.

* Click on ← **Go Back** and you will find that some new blocks have been added to your list of blocks under the category CO2 Mini.

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Blocks Description

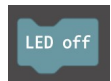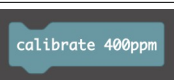| Block	Description
start CO2 Mini	This block is usually placed in your on start block and it redirects the micro:bit's serial port to talk to the CO2 Mini.
CO2 ppm	This block returns the CO2 concentration detected by the sensor in ppm (parts per million). Fresh air is usually about 400ppm. This sensor can measure concentrations as high as 5000ppm.
temperature	This block returns the temperature in degrees Celsius.
humidity	This block returns the relative humidity as a percentage.
LED on	If this block is used the CO2 Mini's built-in LED will display an indication of the CO2 level by changing color. Green if under 1000ppm, Orange if under 3000ppm and Red if over 3000ppm.
LED off	This block turns off the CO2 Mini's RGB LED.
Advanced Blocks	
set altitude	The NDIR (nondispersive infrared) sensor used in the CO2 Mini will give inaccurate results if you live at any significant altitude (more than a few hundred metres). For more accurate results use this block in your on start block. The default altitude is 0m.
calibrate 400ppm	When this block is invoked, the CO2 sensor recalibrates itself assuming that the CO2 level it is currently detecting is 400ppm.
factory reset	This block will remove any altitude or manual calibration settings, to return the sensor to it's original condition.

PYTHON

If you prefer to do your coding in Python, then you can download a Python module from here on GitHub.

https://github.com/monkmakes/co2_mini_micropython_module
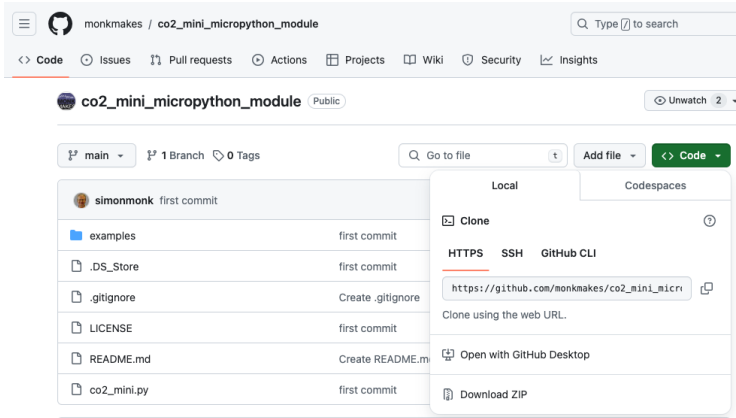
Click on the green **Code** button and then select **Download ZIP** and save the ZIP file somewhere convenient and then extract it. This will create a folder called co2_mini_micropython_module-main.

Now open a new browser tab and open the micro:bit Python editor here:
https://python.microbit.org/
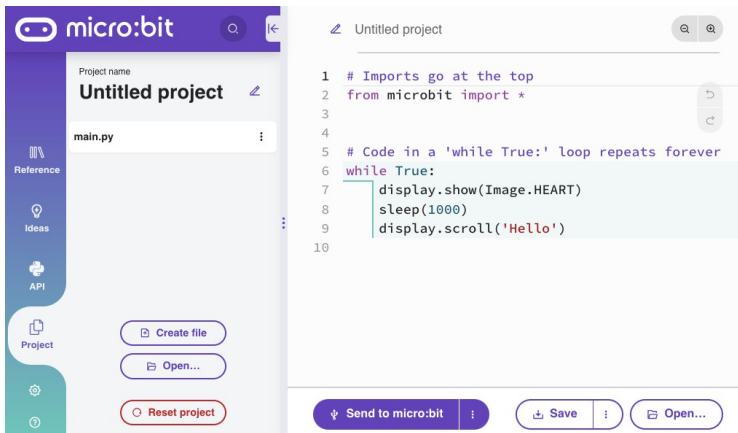
Next click on **Project** in the sidebar and then the **Open..** button and navigate to the folder you unzipped earlier. Within this folder, navigate into **examples** and then select **Kitchen Sink.hex**. This will load both the co2_mini module and the example program shown below.
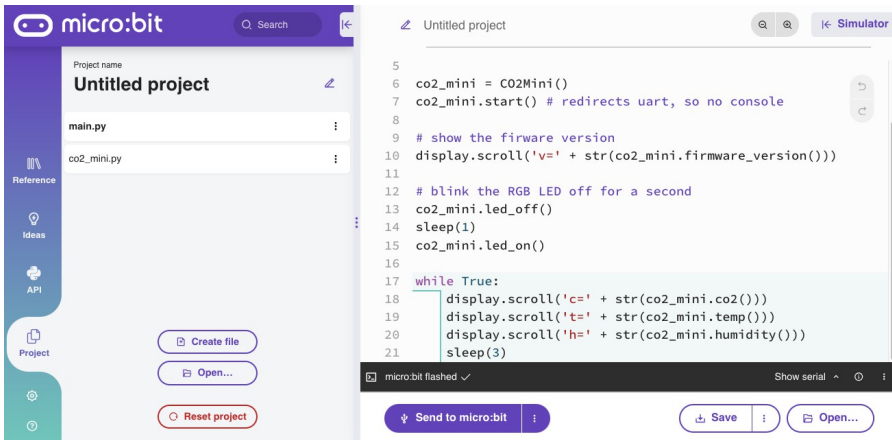
Click on **Send to micro:bit** to install the program and library onto your micro:bit.

When it runs, the program will first display the CO2 Mini's firmware version, and then blink the RGB LED off for a second before repeatedly reporting the CO2, temperature and humidity.

The methods available in the Python library mirror the blocks in the makecode version. You can see them if you click on the file co2_mini.py.

CO2 AND HEALTH

The level of CO2 in the air we breathe has a direct influence on our well-being. CO2 levels are of particular interest from a public health point of view as, to put it simply, they are a measure of how much we are breathing other people's air. We humans breathe out CO2 and so, if several people are in a poorly ventilated room, the level of CO2 will gradually increase. As will the viral aerosols that spread disease.

Another important impact of CO2 levels is in cognitive function – how well you can think. The following quote is from the National Centre for Biotechnology Information in the USA:

"at 1,000 ppm CO2, moderate and statistically significant decrements occurred in six of nine scales of decision-making performance. At 2,500 ppm, large and statistically significant reductions occurred in seven scales of decision-making performance" Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3548274/

The table below is based on information from https://www.kane.co.uk/knowledge-centre/what-are-safe-levels-of-co-and-co2-in-rooms and shows the levels at which CO2 can become unhealthy.

Level of CO2 (ppm)	Notes
250-400	Normal concentration in ambient air.
400-1000	Concentrations typical of occupied indoor spaces with good air exchange.
1000-2000	Complaints of drowsiness and poor air.
2000-5000	Headaches, sleepiness and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present.
5000	Workplace exposure limit in most countries.
>40000	Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma, even death.

TROUBLESHOOTING

Problem: The amber power LED on the CO2 Mini for micro:bit is not lit.

Solution: Make sure that your micro:bit itself is receiving power and that the GND and 3V connections of the micro:bit are connected to the GND and 3V connectors of the CO2 Mini.

Problem: When a program is running, the orange LED in the MonkMakes logo of the CO2 Mini blinks repeatedly.

Solution: This indicates an error with the board and the number flashes indicates the error. Try disconnecting and reconnecting the power to your micro:bit, but if the problem persists, make a note of the number of LED blinks in each cycle and contact support@monkmakes.com

Problem: The amber power LED on the CO2 Mini for micro:bit is lit, but my program is only seeing CO2, temperature and humidity readings that are all -1.

Solution: This indicates that your micro:bit is not communicating with the CO2 Mini. There can be several reasons for this.
* The wiring may be misconnected. Take all the alligator clip leads off and reattach them.
* There may be a faulty alligator lead. Try swapping each lead out in turn for a spare.
* You may have forgotten to put the s**tart CO2 Mini** block in the **on start** block of your program.

Problem: Sometimes the readings freeze and communication seems unreliable.

Solution: Try and use short alligator leads like the ones supplied and keep them away from potential sources of electrical interference, such as power leads or leads to electric motors.

Problem: When I first run my program, the CO2 readings seem wrong, sometime 0 or -1.

Solution: This is normal. The sensor takes some time to settle. Disregard any readings for the first minute after the sensor starts up.

Problem: I'm using Python but I cant use the Python Shell.

Solution: The CO2 Mini uses the micro:bit's serial interface, making the Python shell unavailable.
If you are trying to use trace to debug your program, you can scroll messages onto the micro:bit screen using **display.scroll('my message')**.

Problem: I'm using Python and the CO2 Mini RGB LED has gone off and no readings are coming back, but the Orange power LED in the MonkMakes logo is lit.

Solution: A side-effect of sharing the serial link between USB and the CO2 Mini, is that if an error occurs in your code, the error message will be sent to CO3 Mini, causing unexpected problems. For example, if the error message contains the letter 'l' the LED will be turned off. Worse, if it contains a 'k' the CO2 Mini will be recalibrated.

The solution is to fix the problem in your code and then disconnect the GND lead to the CO2 Mini to cycle the power to it.

micro:bit Programming

If you want to learn more about programming the micro:bit in MicroPython, then you should consider buying Simon Monk's book 'Programming micro:bit: Getting Started with MicroPython', which is available from all major book sellers.

For some interesting project ideas, you might also like micro:bit for the Mad Scientist from NoStarch Press.

You can find out more about books by Simon Monk (the designer of this kit) at: http://simonmonk.org or follow him on Twitter where he is @simonmonk2
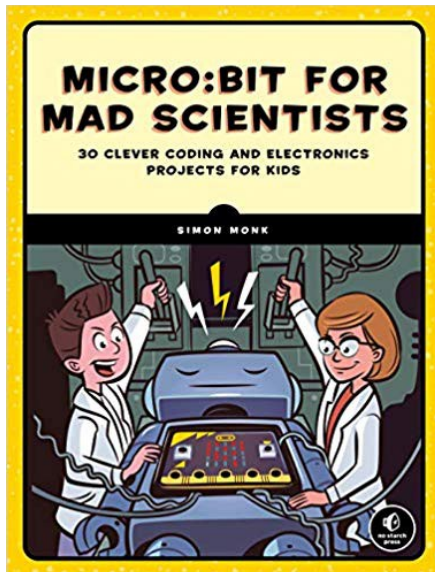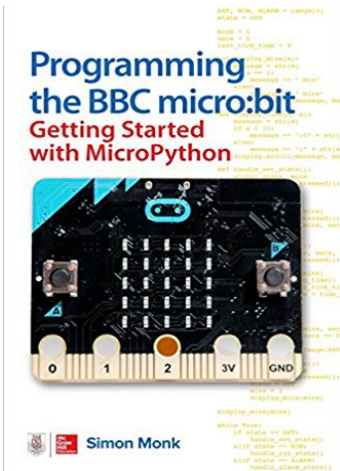
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For more information on this kit, the product's home page is here:
https://monkmakes.com/mb_slider

As well as this kit, MonkMakes makes all sorts of kits and gadgets to help with your maker projects. Find out more, as well as where to buy here:
https://monkmakes.com you can also follow MonkMakes on Twitter @monkmakes.
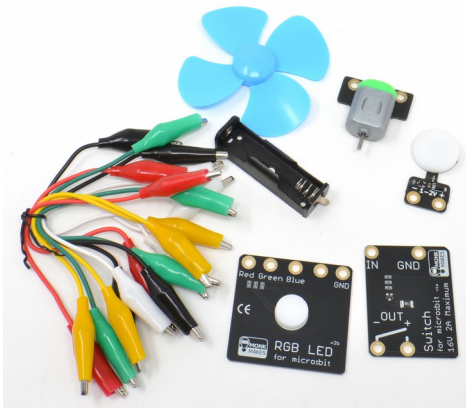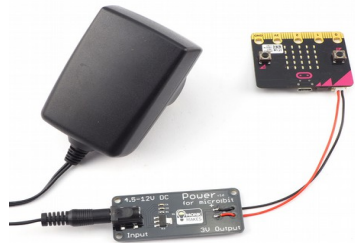
From left to right: Solar Experimenters Kit for micro:bit, Power for micro:bit (AC adapter not included), Electronics Kit 2 for micro:bit and 7 Segment for micro:bit.