BBC MICRO:BIT WORKSHOP

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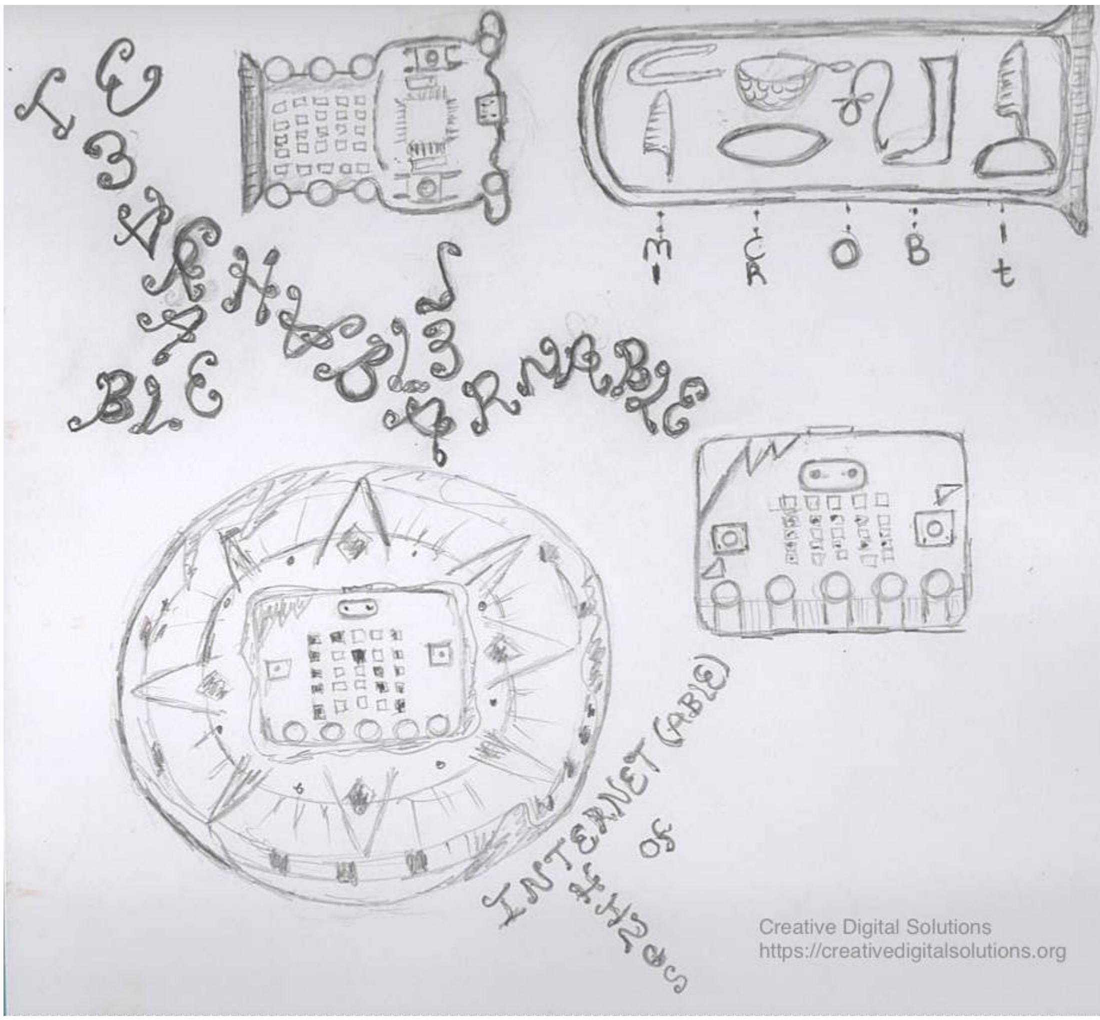


GETTING STARTED - BBC MICRO:BIT

Designed to more inclusive to get a wider range of people interested in digital electronics and processing

1. BBC micro:bit https://www.microbit.co.uk/
2. Micro Python programming
   a. Mu Python Editor https://codewith.mu/#download
   b. (Micro)Python guide https://www.microbit.co.uk/python-guide
   c. BBC micro:bit MicroPython latest documentation: https://microbit-micropython.readthedocs.io/en/latest/index.html

1. Small enough (1/2 a credit card in size) to take anywhere

2. Simple enough for beginners to experiment with and get started with to create and explore ideas

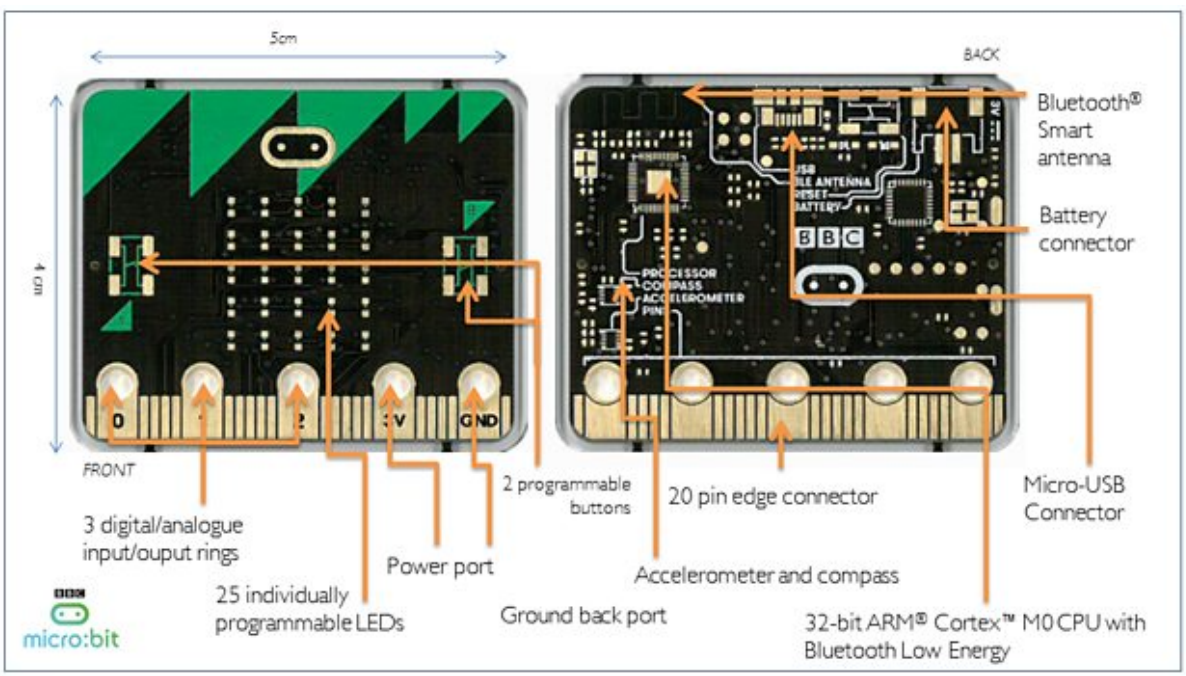
3. Extensible, flexible and adaptable to enable advanced ideas to be designed and crafted

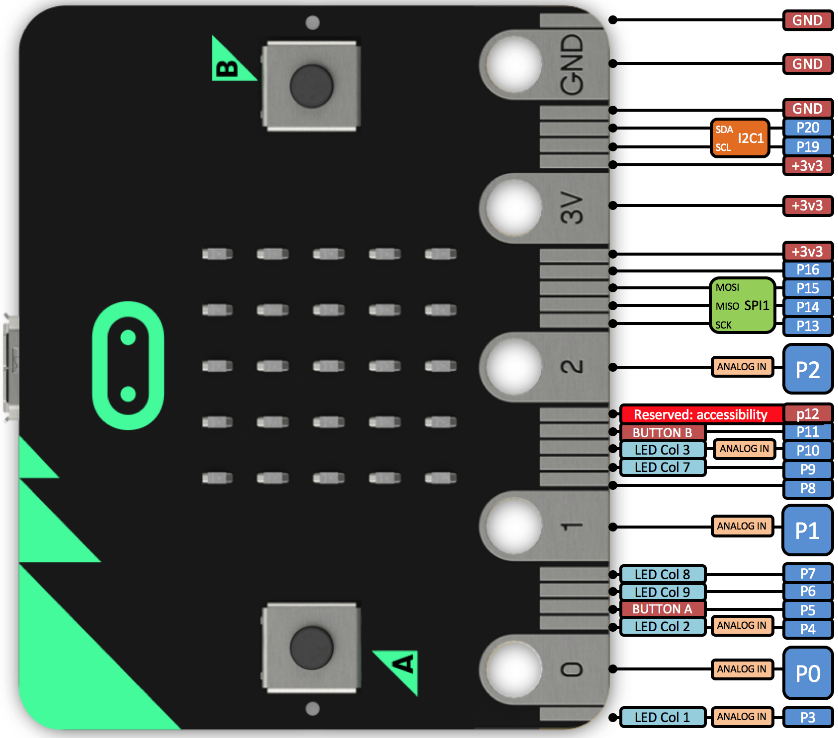
4. Sustainable in both cost and imagination - low cost extensible device to create interesting applications & experiments

5. Able to support both formal and informal education

6. Be fun, innovative and creative to use, and,

7. Be usable by just about anyone who wants to explore technology and create something personally purposeful.

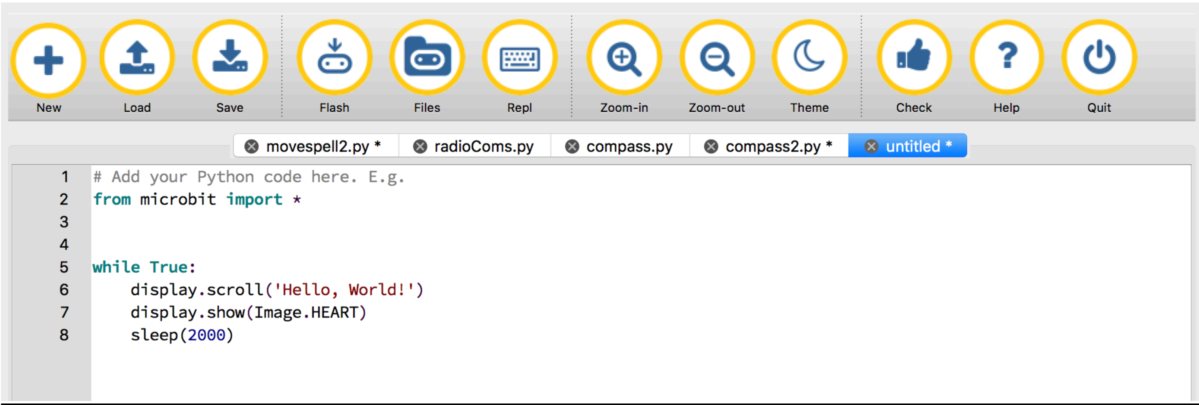




How to power your micro:bit

1. Via a Micro USB to normal USB lead, same one as used for charging up an Android phone
2. Via a battery cable attached to a 2 x AAA Battery holder terminated with a JST-PH connector to plug into the Micro:bit, costs about £2
3. **Don't use both, use 1 or the other to power the Micro:bit**

WRITING YOUR FIRST PROGRAM



What does the code mean?
Program is in a loop to repeat itself forever
1st action is scroll text
2nd action display an image
3rd action is sleep - a delay in mS

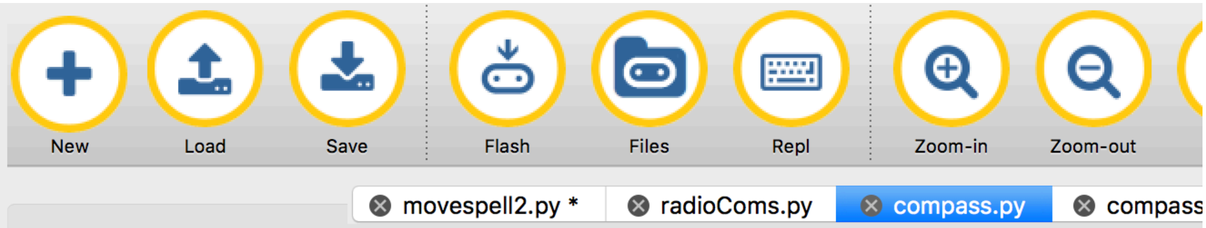
Input pin and push-button as simple actuators

```
from microbit import *

while True:
  if button_a.is_pressed():
#   if pin0.read_digital():
#   if pin0.is_touched():
    display.show(Image.HAPPY)
  else:
    display.show(Image.SAD)
```

1. Controllers, control other hardware devices that change the state of the physical environment via actuators
2. What does the code mean?
3. The program allows us to use 3 different actuators to change the default sad face to a happy face
4. Either by pressing button a
5. Or by something conductive between pin 0 and 3V = take care not to short-circuit pin 0 to 3V use something that has a resistance
6. Or by touching pin 0 with respect to ground – body is acting as a large capacitor to create a circuit

SENSING DIRECTION: COMPASS




```
from microbit import *


# Start calibrating
compass.calibrate()

# Try to keep the needle pointed in (roughly) the correct direction
while True:
    sleep(100)
    needle = ((15 - compass.heading()) // 30) % 12
    display.show(Image.ALL_CLOCKS[needle])
```

1. What does the code mean?
2. If you don't understand a line of code, look it up in the micropython guide, link was given earlier
3. Some sensors need to be calibrated (or configured) before use, e.g., compass, else the sensor data may produce is meaningless data
4. There after, when the 3 pixels on the micro;bit display line up that '3 dot line' points to north

Further Investigations

- How can you tell the compass is working correctly? Can you estimate where North should be, i.e., based upon landmarks?
- What happens if you comment out the calibrate line of code
- Does a phone map app that uses a compass require calibration?

SENSING THE DEGREE OF MOTION

```
from microbit import *
while True:
    reading = accelerometer.get_x()
    if reading > 20:
        display.show("R")
    elif reading < -20:
        display.show("L")
    else:
        display.show("-")
```

1. Several common devices know make use of motion sensors:
   a. Mobile phone knows which up to show the images on its screen
   b. Game controllers steer and move around in games
2. These use an accelerometer as this program example does to do this
3. Such Accelerometers work in 3 directions or along three axes:
   a. X - tilting from left to right.
   b. Y - tilting forwards and backwards.
   c. Z - moving up and down.
4. What does the code mean?
   a. Here's a very simple spirit-level that uses get_x to measure how level the device is along the X axis
   b. If we hold the device flat it should display -; however, rotate it left or right and it'll show L and R respectively.
5. Further investigations:
   a. How can we use this to step count – pedometer?
   b. How can we make this orientation independent to sense the degree of movement overall along any axes?

SENSING TEMPERATURE

```
from microbit import *
while True:
    temp = temperature()
    display.show(str(temp))
    #display.scroll(str(temp) + 'C')
    sleep(500)
```

1. Let's investigate the use temperature sensor so that you can keep a log of the temperature in different rooms.
   a. Think of the functions needed?
   b. Sense temperature –
   c. Anything else
2. Further investigations
   a. How do we cross-check, calibrate the temperature sensor to verify it measures correctly?
   b. How to link the physical world state to the wider context or conditions?, e.g., to relate the temp the location and time?
   c. How do we process / combine / aggregate / fuse multiple sensor measurements in nearby locations?

MICRO:BIT WIRELESS SUPPORT

Your micro:bit has a radio chip that can be used to transmit and receive messages. Wireless interaction is all about physics: radio waves (a type of electromagnetic radiation, similar to visible light) have some sort of property (such as their amplitude, phase or pulse width) modulated by a transmitter in such a way that information can be encoded and, thus, broadcast. When radio waves encounter an electrical conductor (i.e. an aerial), they cause an alternating current from which the information in the waves can be extracted and transformed back into its original form.

```
import radio
import random
from microbit import display, Image, button_a, sleep
# Create the "flash" animation frames. Can you work out how it's done?
flash = [Image().invert()*(i/9) for i in range(9, -1, -1)]
# The radio won't work unless it's switched on.
radio.on()
# Event loop.
while True:
  # Button A sends a "flash" message.
  if button_a.was_pressed():
    radio.send('flash')  # a-ha
  # Read any incoming messages.
  incoming = radio.receive()
  if incoming == 'flash':
    # If there's an incoming "flash" message display
    # the firefly flash animation after a random short
    # pause.
    sleep(random.randint(50, 350))
    display.show(flash, delay=100, wait=False)
    # Randomly re-broadcast the flash message after a
    # slight delay.
    if random.randint(0, 9) == 0:
      sleep(500)
      radio.send('flash')  # a-ha
```

See next example – how might you adapt your program

```
from microbit import *
import radio
radio.on()
radio.config(channel=19) # Choose your own channel number
radio.config(power=7) # Turn the signal up to full strength
my_message = "This is my message."
# Event loop.
while True: radio.send(my_message)
incoming = radio.receive()
if incoming is not None:
   display.show(incoming)
   print(incoming)
   sleep(500)
```

APPENDIX NOTES

Compass and accelerometer

Travelling and navigating the seas happened long before the invention of 'the compass'. Trading and innovation was exchanged between many cultures and communities. How did they manage without 'a compass', SATNAV or 'map technology' we take for granted today?

Throughout the history of navigation, latitude could be found relatively accurately using celestial navigation. Celestial navigation is the use of angular measurements (sights) between celestial bodies and the visible horizon to locate one's position in the world – on land as well as on sea.

However, longitude could only be estimated, at best. This was because the measurement of longitude is made by comparing the time-of-day difference between the mariner's starting location and new location. Even some of the best clocks of the early eighteenth century could lose as much as 10 minutes per day, which translated into a computational error of 242 kilometers (150 miles) or more.

In 1764, British clockmaker John Harrison (1693–1776) invented the seagoing chronometer. This invention was the most important advance to marine navigation in the three millenia that open-ocean mariners had been going to sea.

Finding out how a compass works! So how does a compass work?

Scientists understand that Earth's magnetic field has flipped its polarity many times over the millennia. In other words, if you were alive about 800,000 years ago, and facing what we call north with a magnetic compass in your hand, the needle would point to 'south.' This is because a magnetic compass is calibrated based on Earth's poles. The N-S markings of a compass would be 180 degrees wrong if the polarity of today's magnetic field were reversed. [1]

Reversals are the rule, not the exception. Earth has settled in the last 20 million years into a pattern of a pole reversal about every 200,000 to 300,000 years, although it has been more than twice that long since the last reversal. A reversal happens over hundreds or thousands of years, and it is not exactly a clean back flip. Magnetic fields morph and push and pull at one another, with multiple poles emerging at odd latitudes throughout the process. Scientists estimate reversals have happened at least hundreds of times over the past three billion years. And while reversals have happened more frequently in "recent" years, when dinosaurs walked Earth a reversal was more likely to happen only about every one million years.

Sediment cores taken from deep ocean floors can tell scientists about magnetic polarity shifts, providing a direct link between magnetic field activity and the fossil record. The Earth's magnetic field determines the magnetization of lava as it is laid down on the ocean floor on either side of the Mid-Atlantic Rift where the North American and European continental plates are spreading apart. As the lava solidifies, it creates a record of the orientation of past magnetic fields much like a tape recorder records sound. The last time that Earth's poles flipped in a major reversal was about 780,000 years ago, in what scientists call the Brunhes-Matuyama reversal. The fossil record shows no drastic changes in plant or animal life. Deep ocean sediment cores from this period also indicate no changes in glacial activity, based on the amount of oxygen isotopes in the cores. This is also

[1] https://www.nasa.gov/topics/earth/features/2012-poleReversal.html

proof that a polarity reversal would not affect the rotation axis of Earth, as the planet's rotation axis tilt has a significant effect on climate and glaciation and any change would be evident in the glacial record.

Earth's polarity is not a constant. Unlike a classic bar magnet, or the decorative magnets on your refrigerator, the matter governing Earth's magnetic field moves around. Geophysicists are pretty sure that the reason Earth has a magnetic field is because its solid iron core is surrounded by a fluid ocean of hot, liquid metal. This process can also be modeled with supercomputers. Ours is, without hyperbole, a dynamic planet. The flow of liquid iron in Earth's core creates electric currents, which in turn create the magnetic field. So while parts of Earth's outer core are too deep for scientists to measure directly, we can infer movement in the core by observing changes in the magnetic field. The magnetic north pole has been creeping northward – by more than 600 miles (1,100 km) – since the early 19th century, when explorers first located it precisely. It is moving faster now, actually, as scientists estimate the pole is migrating northward about 40 miles per year, as opposed to about 10 miles per year in the early 20th century.

While Earth's magnetic field can indeed weaken and strengthen over time, there is no indication that it has ever disappeared completely. A weaker field would certainly lead to a small increase in solar radiation on Earth – as well as a beautiful display of aurora at lower latitudes - but nothing deadly. Moreover, even with a weakened magnetic field, Earth's thick atmosphere also offers protection against the sun's incoming particles.

The science shows that magnetic pole reversal is – in terms of geologic time scales – a common occurrence that happens gradually over millennia. While the conditions that cause polarity reversals are not entirely predictable – the north pole's movement could subtly change direction. A reversal might, however, be good business for magnetic compass manufacturers.

<u>What about accelerometer?</u>

What is an accelerometer?
An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic - caused by moving or vibrating the accelerometer.

What are accelerometers useful for?
By measuring the amount of static acceleration due to gravity, you can find out the angle the device is tilted at with respect to the earth. By sensing the amount of dynamic acceleration, you can analyze the way the device is moving. At first, measuring tilt and acceleration doesn't seem all that exciting. However, engineers have come up with many ways to make really useful products with them. An accelerometer can help your project understand its surroundings better. Is it driving uphill? Is it going to fall over when it takes another step? Is it flying horizontally or is it dive bombing your teacher?