Hi there.

Wanna code?

QUICK START GUIDE
FOR TEACHERS

• Tips and advice for getting to grips with the BBC micro:bit
• Step-by-step coding challenges with clear solutions
• Guidance on creating and sharing your own programs and tutorials

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PREVIEW
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• Tips and advice for getting to grips with the BBC micro:bit
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Computational thinking is the thought processes involved in formulating a problem and expressing its solution(s) in a way that a computer – human or machine – can carry out effectively. In 2006, I began to advocate that everyone, regardless of profession, of career, or of age, can benefit from learning how to think computationally[1]. With the BBC micro:bit, the BBC and its partners, including Microsoft, catalyze our realization of this dream. Children can learn how to think computationally by first formulating a problem and conceptualizing a solution. Then, by expressing their solution using a code editor, such as Microsoft TouchDevelop, and by compiling and running their programme on the BBC micro:bit, they can see their code come alive!

I commend the BBC and the UK for their leadership in the Make it Digital initiative. Teaching children at an early age the fundamentals of computing helps provide them with the programming skills and the computational thinking skills they will need to function in the 21st Century workforce. Programming the BBC micro:bit will teach children basic coding concepts, such as variables, types, procedures, iteration, and conditionals. Solving problems with the BBC micro:bit will expose children to computational thinking skills, such as abstraction, decomposition, pattern matching, algorithm design, and data representation. Students knowledgeable with these skills will be in high demand by all industrial, government, and academic sectors, not just information technology.

Most importantly, the BBC micro:bit will introduce children to the joy of computing. Making one’s personal device do whatever one wants is empowering. Programming the BBC micro:bit will tap into a child’s imagination and creativity. The device and programming environment provide a playful way to explore a multitude of computational behaviors.

I am thrilled to see this Quick Start Guide for Teachers, which is rich with examples that show how hands-on coding is easy and natural. Let’s have fun together!

Jeannette M. Wing  
Corporate Vice President, Microsoft Research  
25 May 2015

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Although every effort has been made to ensure that website addresses are correct at time of going to press, Microsoft cannot be held responsible for the content of any website mentioned. It is sometimes possible to find a relocated web page by typing in the address of the home page for a website in the URL window of your browser.

The contents of this Preview copy are as accurate as possible at the time of printing. Updates and changes will be made prior to release of the final edition.
The project aims to put digital creativity in the spotlight like never before, and to help build the nation’s digital skills, through an ambitious range of new programmes, partnerships and projects.

These include:

• A major partnership to develop and give a BBC micro:bit coding device to all year 7 children across the UK, for free, to inspire a future generation.

• A season of programmes and online activity involving the BBC’s biggest and best-loved brands, including Doctor Who, EastEnders, Radio 1, The One Show, Children in Need, BBC Weather and many more, including a new factual drama about the development of Grand Theft Auto on BBC Two and a documentary on Bletchley Park.

• The Make it Digital Traineeship to create life-changing opportunities for up to 5,000 young unemployed people; the largest traineeship of its kind.

• Partnerships with around 50 major organisations across the UK.

• A range of formal education activities and events, including Bitesize, Live Lessons and School Report.

The BBC micro:bit initiative

Back in the 1980s, the BBC Micro was used extensively in primary and secondary schools and was instrumental in inspiring a generation of technology pioneers. Nowadays, computing and digital technology can be found everywhere, but the emphasis seems to have shifted from the creation of technology to the consumption of it.

As part of the Make it Digital initiative, the BBC has collaborated with over 25 organisations to create the BBC micro:bit, a personal programmable device, which will be provided, free of charge, to every child in Year 7 across the UK.

It provides an exciting and accessible introduction to coding on a simple hardware platform. Its purpose is to enthuse, excite and empower a new generation of digitally-creative young people. This is why the BBC micro:bits are specifically designed for young people themselves to own.
**The micro:bit device**

The BBC micro:bit is a very simple computer. It is programmed by using another device (smart phone, tablet, PC, IPad etc.) to write the program, which is then compiled and downloaded onto the BBC micro:bit. The newly programmed BBC micro:bit can be disconnected and will run the program, just like other embedded devices, such as a digital watch, a GPS device or a pocket calculator.

The device has a display made up of 25 LEDs and some simple input controls that can be used in a number of ways. It is small enough to slip into a pocket or even wear.

The BBC micro:bit offers a gentle introduction to programming and making: switch on, program it to do something fun, wear it, customise it, and put new ideas into action. It can be programmed to show words or shapes, tell the time or play games.

It is designed to be a starting point to get young people interested in coding so they can move on to other, more sophisticated devices in future. The BBC micro:bit has an accelerometer, which can detect movement, and it can connect and communicate with other devices, including Arduino, Galileo and Raspberry Pi.

It offers a natural progression from screen-based programming using visual languages, and can lead on to more complex, text-based programming.

The BBC micro:bit also has Bluetooth Low Energy, allowing it to be part of the ‘Internet of Things’ – the extension of the internet beyond computers and smartphones to include other embedded systems, from fridges to cars, and even home central heating systems.

**Supporting learning**

The BBC and its partners recognise that a hands-on learning experience can help young people to grasp the computing curricula in ways that on-screen coding activities and traditional classroom learning cannot.

The BBC micro:bit can help learners to develop their understanding of physical technology and computing, offering the opportunity to apply complex thinking, analytical and problem-solving strategies.

Inspirational content on BBC radio and television will raise awareness of the BBC micro:bit, while teachers, parents and young people will be encouraged and supported to get the most out of the device through a rich range of online resources and real-world events created by the BBC and partners.

**Partnerships**

More than 25 organisations have been involved in this pioneering partnership. See live.microbit.co.uk/start-guide/partnerships for more information.
The **BBC micro:bit**: What is it designed to do?

The BBC micro:bit is a very simple computer. A computer is a machine that accepts input, processes this according to stored instructions and then produces output. All three of these elements are present on the BBC micro:bit's printed circuit board.

**Front of board**

- **LED**
  Coordinates start at (0,0) in top left hand corner. In computing, displays start at the top left hand corner so, in coding terms, this is (0,0). This is different from mathematics and graphs where (0,0) is the bottom left corner. It is important to note this is also relative, so if the screen rotates (0,0) is still the top left corner of the screen. See Challenge 3 for the use of coordinates in the Catch the egg game.

- **LED MATRIX**
  5 x 5 array of light emitting diodes (LEDs), which can each be set to on / off. The brightness of the set of LEDs as a whole can also be controlled.

- **BUTTON A**
  A form of input. The BBC micro:bit detects when this button is being pressed. This is a push-to-make switch (pressing it completes an electrical circuit).

- **PINS P0, P1, P2**
  Pins for attaching external sensors, like thermometers or moisture detectors, and actuators, like turning a motor on, so kids can build projects with them like a plant watering alarm. Can be either input or output and either digital or analogue.

- **3V AND GND**
  Enable a user to power an external device, like a motor, using the battery or USB. They also enable capacitive touch (using an object as a switch).

- **HOLE**
  Holes for sewing, mounting and hanging.

- **BUTTON B**
  See Button A
The BBC micro:bit

Back of board

**USB PLUG**
Programs can be downloaded from Windows and Macs onto the micro:bit via a USB data connection. The USB connects the micro:bit to a computer. This means the micro:bit can send data to and receive data from the computer. The USB will be used to ‘flash’ new programmes onto the micro:bit and to allow the micro:bit to communicate with a computer or an Internet connection.

**STATUS LED**
Flashes yellow when the system wants to tell the user something has happened.

**BUTTON R**
System button, which has various uses. Has to be pressed to ‘flash’ new code onto the device over BLE.

**PROCESSOR**
All the BBC micro:bit’s programs and any data are stored on the small silicon-chip micro-controller. This tiny chip designed by ARM has 128kB flash memory and 16kB RAM memory; a tiny fraction of the memory on a smartphone.

**ACCELEROMETER**
Converts analogue information about how quickly the BBC micro:bit’s speed changes to a digital form that can be used in micro:bit programs. Output from the accelerometer is in milli-g. Allows the BBC micro:bit to be used to control movement of on-screen characters such as Kodu (see page 11).

**COMPASS**
A sensor to detect magnetic fields, like the Earth’s, allowing the direction of the micro:bit to be determined and converted to a digital form that can be used in micro:bit programs. Output from the compass is degrees.

**BATTERY**
This socket connects the external battery pack (containing two AAA batteries) to the board. The battery pack is attached physically to the board with a Velcro patch.

A note about ARM

ARM designs the processors for most mobile phones and embedded systems (such as smart thermostats, car engine controllers and the processors inside digital cameras), and was founded by members of the original BBC Micro team!

BBC micro:bit is based on ARM’s mbed platform for embedded systems, but programming the BBC micro:bit is very straightforward.

A note about machine code

Machine code is the language the CPU (central processing unit) of a computer understands, but it isn’t very readable by humans as it is made up of numbers.

Machine Code is known as a low level language. High level languages, such as Blocks or TouchDevelop, are readable/understandable by humans. A program written in a high level language, like TouchDevelop, has to be compiled (translated) into machine code that the processor ‘understands’ (see page 10).

A note about ARM

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BBC micro:bit is based on ARM’s mbed platform for embedded systems, but programming the BBC micro:bit is very straightforward.
The BBC micro:bit website live.microbit.co.uk is the starting point for learning about and programming on the BBC micro:bit. There is extensive help available on the site, including scaffolded, step-by-step tutorials for programming the BBC micro:bit.

Sign in to the BBC micro:bit website to:
- save and retrieve scripts,
- compile code and ‘flash’ it to a micro:bit,
- publish scripts to the micro:bit website
- share code with other BBC micro:bit users
- set up groups, with access codes, for your students to join

To sign in:
- Enter your facilitator code provided (email BBCmicrobit@bbc.co.uk if you don’t have one).
- Authenticate your account by entering a username and password from an existing account (Facebook, Google, Microsoft, Office 365)
- Agree to the terms of use.

For more information visit live.microbit.co.uk/help.
The BBC micro:bit website

02 Create Code

Click here to choose and select an available code editor (see below) to start creating programs for the BBC micro:bit.

All code editors come with a BBC micro:bit simulator, so you can test ideas and code on screen without having to have a BBC micro:bit plugged into the computer to run the code you write. Two key editors are currently available to program the BBC micro:bit.

**Blocks**
This is a graphical, drag and drop code editor, where coding blocks snap together. It’s quite similar to Scratch, which many students may have encountered in primary school. There’s support for the main input and output functions of the BBC micro:bit, as well as standard programming constructs such as sequence, selection, repetition and variables.

It’s easy to start a project in Blocks and then convert it to a TouchDevelop script.

**TouchDevelop**
The TouchDevelop editor sits between visual, block-based languages, such as Blockly, and traditional, text-based programming languages, such as Python. The editor is based on the TouchDevelop programming language and comes with a BBC micro:bit library of commands installed.

Like other text-based programming languages, TouchDevelop provides a great deal of flexibility: as well as supporting input, output, sequence, selection, repetition and variables, there’s also support for user-defined functions, making this a good choice for developing the ideas of decomposition and abstraction.

**Other code editors**
A number of other code editors will be available from the Autumn term 2015. See live.microbit.co.uk/create-code for up-to-date information on which code editors are available.

03 Tutorials

The BBC micro:bit site offers different types of coding tutorials. Some tutorials are interactive and lead you through the creation of a program step-by-step with on-screen tips. Others present guided challenges with fewer instructions. Here we provide support by signposting key instructions and routes through projects.

04 Projects

This is a bank of BBC micro:bit projects created by other coders for you to explore, use and adapt.

Some of these projects have been created by the BBC and BBC micro:bit partners, but most will be written by young people themselves and other BBC micro:bit users. These are a great starting point for seeing just what the BBC micro:bit can do, as well as learning how to program it. It’s much easier to take someone else’s program and edit it to make it work a little (or a lot) differently, than having to start programming from a blank screen.

05 Getting Started

These are video and step-by-step guides for getting started with the BBC micro:bit. These videos and guides walk you through the process of starting to write some code, including switching between the different code editors available, saving projects, installing the loader software on your computer, connecting the BBC micro:bit and uploading code to it via the loader. This content will be continually updated.

06 Teachers and Parents

This introduces the BBC micro:bit in the context of its use in the classroom and at home. It contains useful information for anyone supporting children on their BBC micro:bit journey.

07 Help

Here you will find frequently asked questions and where to go for additional support.
Getting started with the TouchDevelop editor

Once you’ve signed in to the BBC micro:bit website (see details on page 6), you can get started with coding!

01
Type live.microbit.co.uk into your web browser.

02
Click Create Code.

03
In the TouchDevelop section, click the second link down.

04
Have a go at clicking some of the buttons on screen to see what they do.

CODING AREA
This is where all your coding takes place.

RUN
Click to run a program. The simulator on the right-hand side of the screen will show the code in action.

UNDO
Click to undo any changes to your code.

MY SCRIPTS
Click to return to any previous scripts you’ve written in the TouchDevelop editor.

SCRIPT
Click to display all the functions you’re working with, any libraries you’re using as part of your code (these are sets of functions developed by other people that you can use in your script) and any global data.

FUNCTION MAIN
while true do
  micro:bit - plot(2, 2)
  micro:bit - pause(200)
  micro:bit - clear screen
  micro:bit - pause(200)
end while
end function
Click on the micro:bit->plot(2,2) instruction that’s already in the script. A code keyboard will appear at the bottom of the screen.

**Where next?**

To try out some simple programs to use with the BBC micro:bit, see *Coding building blocks* on page 11. To start working through step-by-step BBC micro:bit programming challenges, see pages 12-26. Once you’ve completed all three challenges, visit [live.microbit.co.uk/start-guide/certificate](http://live.microbit.co.uk/start-guide/certificate) to pick up your certificate!

**Learning more about TouchDevelop**

There’s much more to TouchDevelop than the BBC micro:bit. Because of its touch-based interface, it’s a great coding platform to use on tablets or even smartphones. Typically, it’s used to produce web-based apps that can run online on any platform, so it’s also a good tool to use when teaching students to develop apps for smartphones or tablets, without having to worry about platform-specific details.

The main TouchDevelop website, [touchdevelop.com](http://touchdevelop.com), has all the details, the online editor itself, plenty of shared examples and a number of interactive, step-by-step tutorials.
How does my program get onto the BBC micro:bit?

For your program to work on the BBC micro:bit, first it has to be compiled. Compiling means to translate a program into a more efficient computer language.

When you hit the compile button on the TouchDevelop editor interface, your program is actually compiled twice.

First, your program is translated into a C++ program. C++ is a very popular language for programming software systems, both large (like Microsoft Windows) and small (like the BBC micro:bit).

Second, the C++ program is translated into a binary file that contains the machine code in the instruction set used by the ARM processor that is on your BBC micro:bit. Compiling to C++ actually happens in the web browser itself, and then the C++ code is sent over the internet to a server (at developer.mbed.org) which compiles the C++ code to the ARM machine code (the hex file), which then gets sent back to your browser. When you drag the hex file over to the drive for your BBC micro:bit, your ARM binary program is installed and begins to run.

The BBC micro:bit hardware is built using ARM’s open source mbed platform. This means that as well as using TouchDevelop and the other editors on the BBC micro:bit site, it is possible for more confident coders to program the BBC micro:bit using industry-standard development tools, including ARM’s online C++ compiler at developer.mbed.org.

Getting your programs onto the BBC micro:bit

The last stage – getting your program onto the micro:bit itself – is quite easy.

- Hit the compile button in the code editor. A .hex file will be created.
- Assuming there aren’t any error messages at this stage, download the ‘.hex’ file.
- Plug the BBC micro:bit in to your computer’s USB port using a standard micro USB cable (supplied). The BBC micro:bit should show up as a USB storage device.
- Drag the .hex file onto the drive that corresponds to the BBC micro:bit. Once the system LED has stopped flashing, press the reset button on the back of the BBC micro:bit to start the program.

Once a program is uploaded to the BBC micro:bit, the device can be unplugged and will run independently, as long as the user has attached a battery pack.
Coding building blocks

It's easy to get started with coding on the BBC micro:bit. The images below show the code you need (both in the Blocks and TouchDevelop editors) to make your BBC micro:bit do simple things. These could be used to kick off your first BBC micro:bit coding sessions with your students and can also be used in more complex projects.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Code in Blocks</th>
<th>Code in TouchDevelop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Press a button to turn on a light</td>
<td><img src="image1" alt="Code in Blocks" /></td>
<td><img src="image2" alt="Code in TouchDevelop" /></td>
</tr>
<tr>
<td>Scrolling text</td>
<td><img src="image3" alt="Code in Blocks" /></td>
<td><img src="image4" alt="Code in TouchDevelop" /></td>
</tr>
<tr>
<td>Flashing heart image</td>
<td><img src="image5" alt="Code in Blocks" /></td>
<td><img src="image6" alt="Code in TouchDevelop" /></td>
</tr>
</tbody>
</table>

Online tutorial: [live.microbit.co.uk/td/tutorials/button-light](live.microbit.co.uk/td/tutorials/button-light)

Online tutorial: [live.microbit.co.uk/td/tutorials/scroll-text](live.microbit.co.uk/td/tutorials/scroll-text)

Online tutorial: [live.microbit.co.uk/td/tutorials/flashing-heart](live.microbit.co.uk/td/tutorials/flashing-heart)
Outcome
Display of a Creeper face (similar to the character seen in Minecraft) on the BBC micro:bit LED display:
- By default, all of the lights are off.
- There will be a single state (Minecraft Creeper face).
- The image will turn off after 3 seconds.

Decomposing the problem
This challenge can be decomposed into four parts:
1. Design how our single state will look (which LEDs will be switched on to display our Creeper face).
2. Use the image editor to turn on the required LEDs.
3. Create a timer to pause the image for 3 seconds.
4. Reset the display to its original state: OFF.

Tutorials
For a video tutorial go to live.microbit.co.uk/start-guide/video-tutorials/digital-key-chain
For a guided coding tutorial go to live.microbit.co.uk/td/tutorials/digital-key-chain

Design how each state will look
Before we start to code, we need to plan what our single state will look like.

01
Draw a 5 × 5 grid and colour in the boxes to show what the Minecraft Creeper face will look like.

You don’t have to program a Creeper face. The image could be anything you like.

02
Start by opening a new browser window and typing live.microbit.co.uk in the address bar.

Click on Create Code. In Blocks, click New project. Type in a name for your script, such as Creeper. Click on create.
Programming a Minecraft Creeper face using the image editor within TouchDevelop

The Images section includes blocks that control the creation and display of an image on the BBC micro:bit through LEDs.

Select the show image block. You will notice that an offset value of 0 is displayed. Changing this allows you to display your image in different positions on the BBC micro:bit display.

We now want to select which LEDs will be ON for our Creeper face.

Select the Images button then the create image block. Tick the boxes in the block to make the shape of the Creeper face, as shown in the image.

Drag the create image block into the empty position on the show image block. This will make sure that the Creeper face appears when you press the run button.

It’s important that we test our programs regularly. This allows us to debug the program and fix any errors.
Press the run button to test your program. What does it look like on the simulator? If it doesn’t work as expected, go back and try to find and correct the problem.

Create a timer to pause for 3 seconds

To display the Creeper face for a short period of time, we need to add a timer.

From the Basic menu, select the pause block. The BBC micro:bit uses milliseconds as input, so 1000 is equivalent to 1 second.

We want to pause for 3 seconds, so change the number to 3000.

Drag the block upwards so it snaps into place below the show image block.

Reset the display to its original state: OFF

To finish our program, we’re going to turn all of the LEDs off. This will help to prolong the battery life of the BBC micro:bit.

Click on the LED menu. Select the clear screen block and snap it under the pause block. This will make sure that all of the LEDs are turned off after the Creeper face has displayed for 3 seconds.

You should now have a finished program which will display a Creeper face.

Do your own thing!

- Change the pattern in the create image block to show your own design.
- Instead of clearing the display, add another show image and pause block to create a simple two-state animation. Can you experiment with the brightness of the Creeper image between face changes?

A solution for the complete digital keyring code can be found on page 27. The working code can be found at live.microbit.co.uk/start-guide/solutions/digital-key-chain.
Challenge 2: Digital pet

Programming an animated pet using variables and functions

Outcome
A digital pet (similar to Tamagotchis from the 90s) with different states that can be controlled by pressing buttons A and B (our input). The idea is that our digital pet has demands for attention. In this example our different states will represent some of these demands:

- The default state of the pet is AWAKE.
- Button A will stroke the pet, causing it to fall ASLEEP.
- Button B will feed the pet, so it is EATING.

Decomposing the problem
This challenge can be decomposed into four parts:

1. Design how each state will look (which LEDs will be switched on).
2. Create a function which tells our BBC micro:bit which LEDs to turn on for each state.
3. Create a while loop to continue showing a state until a different button is pressed.
4. Create conditional statements to specify which function to run if a particular button is pressed, e.g. if input A pressed then go to ASLEEP state.

Tutorials
For a video tutorial go to live.microbit.co.uk/start-guide/video-tutorials/digital-pet
For a guided coding tutorial go to live.microbit.co.uk/tutorials/digital-pet

Design how each state will look
Before we start to code, we need to plan out what our pet will look like for each state.

01
Draw a 5 × 5 grid and colour in the lights to show what your pet will look like at different times, for example: AWAKE, ASLEEP, EATING (as shown right).

02
Start by opening a new browser window and typing live.microbit.co.uk in the address bar. Click on Create Code. In TouchDevelop, click New project. Type in a name for your script, such as Digital pet. Click on create.

Create a function for each state
We’re going to start by programming a function for the different states of our digital pet (e.g. which LEDs are ON and which are OFF for each state). We’re going to do this first because we will want to call on these functions later, without having to leave the main process.
To create the first function (for our AWAKE face), select the `script` button from the top of the screen. Click on the + button to bring up your resources menu.

Select `function` from the menu. This will bring you to a coding area (as shown right). Notice that it will say `do stuff` at the top. This is the current name of the function. Click on `do stuff` and rename your function `set awake`. Click `OK`.

Now that we have named our function, we need to specify which LEDs should be turned on within the function. We can do this using the image editor. Click `do nothing` in the coding area. A keyboard will pop up at the bottom of the screen. Select `micro:bit`. Notice how the keyboard changes. Select `create image`.

Select the button on the code keyboard that looks like a grid. This will bring up your image editor. Each box represents one of the LEDs on the BBC micro:bit display. Select the appropriate boxes (to match your grid from step 1) to create your AWAKE face. Click off the editor to return to your code. Click `store in var` (to store this data in a variable). Press the + button to add a new line of code. In the code keyboard click `img` (this is the variable you have just created). Click `show image`.

You have now completed your first function. It should look something like this.

Use what you’ve learnt so far to create the other two functions for the ASLEEP and EATING states of your digital pet.

Name your A function `set sleep` and your EATING function `set eat`.
Challenge 2: Digital pet

Creating a **while loop**

We want each state of your digital pet to continue playing until a button is pressed. We therefore need to add a **while loop**. A while loop will continue running a piece of code until a certain condition is met.

08

Before you continue, click on **script**. Underneath **code** you will see your **main** program. Main is like your ‘home’ code; all the other functions you create will run from this. You should see all the functions you have created underneath **main**. Click **main** to select it.

09

Select **do nothing** within the main function to start writing your code. Select **while** from the keyboard.

10

Your while loop will appear as shown right. This will make our program loop indefinitely.

11

Running this program at this stage would burn the battery. To fix this, add a pause instruction at the end of the loop. Click **do nothing** in the code, then on the code keyboard click **micro:bit**, **more**, then **pause**. Any pause duration will work; in this case, we can even pick 0.

Test your **program** and **debug**

It’s important that we test our programs regularly. This allows us to debug the program and fix any errors. Emphasise this point with students.
Select the do nothing block within the while loop. Click the code button on the keyboard.

Select the set awake function that you created previously. Now press the run button. You should see your digital pet come to life in the simulator!

Create **conditional (if) statements** to specify which functions to run

When coding, we can use a conditional (if) statement to control the outcome of a program. In this program, we want to create conditional statements to specify which function to run if a particular button is pressed, e.g., if input A (Button A) is pressed, then go to ASLEEP state; if input B (Button) is pressed then go to EATING state.

Remove the set awake function you used to test your program in the previous step. Now select the if button from the keyboard. This will insert a piece of IF code.

You now need to specify the condition for your IF code (e.g., if button A is pressed, then...). Select micro:bit from the keyboard. Now click on button is pressed on the keyboard. This code allows the BBC micro:bit to detect when button A or B is pressed.

Try testing your code at this point. If you press button A, you might notice that your digital pet only sleeps for one millisecond. This is because you haven’t specified how long you want your pet to sleep for when you press button A. We will need to pause the state.
16

Button A is always selected by default. Button A is what we want to press to activate the ASLEEP state so you don’t need to change anything in the code here.

function main ()
while true do
  if @microbit ➔ button is pressed("A") then
    do nothing
  else do nothing end if
  @microbit ➔ pause(0)
end while
end function

17

We now need to add our set sleep function inside the IF statement. Select do nothing within the IF code. On the keyboard press code and then select your function for sleep.

18

We now need to tell our pet what to do when we’re not pressing button A. Select the else do nothing code. On the keyboard, click code and then your set awake function.

function main ()
while true do
  if @microbit ➔ button is pressed("A") then
    set sleep
  else
    set awake
  end if
  @microbit ➔ pause(0)
end while
end function

19

For the purpose of testing, let’s include a pause for 5000 milliseconds (5 seconds). In your code, click on your set sleep function. Click on the ➔ button below it. Now click on micro:bit on the keyboard and select the pause button. Replace 100 with 5000.

function main ()
while true do
  if @microbit ➔ button is pressed("A") then
    set sleep
  else
    set awake
  end if
  @microbit ➔ pause(5000)
end while
end function

Do your own thing!

- Can you add in another IF condition which will feed your pet?
- Try using the image editor to create key frames which make your digital pet’s mouth move when it is EATING.
- Can you make use of the scrolling text so that you know when your digital pet is going to wake up? Try micro:bit ➔ show string.
- Can you program your pet to say that he is hungry after 60 seconds?
- Can you use a variable to count how many times you’ve fed your pet? Use the buttons to check your total.

A solution for the complete digital keyring code can be found on page 27. The working code can be found at live.microbit.co.uk/start-guide/solutions/digital-pet.
Outcome
A ‘catch the egg’ game in which an egg (represented by a single LED) ‘falls’ from the top of the BBC micro:bit display and can be caught in a moveable basket at the bottom of the display. The script includes code for the accelerometer, which allows a user to control the position of the basket when the device is tilted:
- By default, the first ‘egg’ LED starts to drop from the centre of the top line of the display
- The subsequent ‘eggs’ will then fall from random positions at the top of the display.
- The ‘basket’ will be moved by tilting the BBC micro:bit.

Decomposing the problem
This challenge can be decomposed into six parts:
1. Create the global variables for the game.
2. Assign initial values to each of the global variables.
3. Plot the starting positions of the LEDs.
4. Create a forever loop to update the display regularly.
5. Get the ‘egg’ to drop down the LED display.
6. Change the position of the basket using the accelerometer functionality.
7. Use IF conditions to check the final position of the egg.

Tutorials
For a video tutorial go to live.microbit.co.uk/start-guide/video-tutorials/catch-the-egg
For a guided coding tutorial go to live.microbit.co.uk/tutorials/catch-the-egg

Create the global variables for the game
Global variables are different to local variables (which only work inside a single loop). Global variables are accessible from any part of our program.

01
Start by opening a new browser window and typing live.microbit.co.uk in the address bar. Click on Create Code. In TouchDevelop, click New project. Type in a name for your script, such as Catch the egg. Click on create.

02
We’re going to start by creating a number of global variables that will be accessible from any part of our program. To begin, click on the script button in the top-right corner.
A menu will pop up, which allows you to add other features to your program. In this case, we’re going to add in a global variable by clicking on the + button.

Select the data button from the menu that appears.

Now it’s time to select your data type. For this program we’re going to use Number for our variables. This is because we’re going to be using x and y coordinates (to designate the position of our falling eggs and the basket to catch them in), which are usually stored as numbers.

We’re going to start by creating a score variable which will track how many times we catch our egg in the basket. Type in score, then click the ok button. You should see your score variable in vars.

Naming variables

Explain, or remind students, to be as descriptive as possible when naming variables (e.g. score, timer, etc.) rather than using generic names (e.g. variable 1, variable 2, etc.). It’s much easier to find and fix problems with variables when you can easily work out which one isn’t working.
Repeat steps 2–6 to create all the variables for your game. You will need to create four variables in total: score, \( x \) (to control the position of the basket), \( \text{obstacle} \ x \) (to control the horizontal position of the egg) and \( \text{obstacle} \ y \) (to control the vertical position of the egg.)

Once you have finished setting up each of the variables, you should have something which looks like the following.

**Assign initial values to each of the global variables**

As with any programming language, when you declare your variables, you need to set them to a value. This value can be manipulated and changed later on.

Return to your main script. Click do nothing below the main function, then select the data button from the keyboard.

Select the variable \( x \) to begin with. Remember: \( x \) controls the position of the basket.

To assign a value to the \( x \) variable, select the assignment button \( (=) \) from the keyboard. We want the basket to sit in the centre of the bottom row of the display, so type in 2. Click on the + button below the \( x \) variable to add lines for the other three variables.

Assign values to the remaining three variables by following the steps above. We want the egg to start falling from the top centre of the display at the beginning of our program, so set \( \text{obstacle} \ x \) to 2 (middle) and \( \text{obstacle} \ y \) to 0 (top). Set the score to 0 (because we haven’t scored anything yet).
Plot the starting positions of the LEDs

All LEDs on the BBC micro:bit display are OFF by default. We’re going to set the BBC micro:bit to plot our first lights.

12. Click the + button to add another line of code below your assigned variables. Select the micro:bit library from the keyboard and then select the plot button (on screen 2 of the keyboard). You should now have something which looks like the image shown on the right.

13. The code shown above will only turn on a LED at position 0,0. We need to remove each of these values and replace them with our obstacle x and obstacle y value. Delete the first 0 and then select obstacle x. Repeat this process to enter obstacle y.

14. We now need to plot the starting position of the basket (x). Click the + button to add a new line of code. Then select the micro:bit library from the keyboard and then plot. Change the first 0 to the x variable and the second 0 to 4.

Test your code

It’s important to test that our code is working correctly so we can debug any errors. Regularly remind students of the importance of testing.

15. At this point in the program we’re going to run it by selecting the run button. You should see something similar when you run your program.
Before we can light up the LED beneath the first LED, we need to unplot the original LED. This will ensure a smooth change from one lit LED to another, as if the egg is falling downwards. Select micro:bit from the keyboard and unplot. Unplot both your basket position \( (x) \) and your egg position \( (obstacle\ x,\ \text{obstacle} \ y) \), as shown in the picture.

To get the egg to move down the display, we need to change the vertical position of the egg \( (obstacle\ y) \). We can do this by adding 1 to the value of \( \text{obstacle} \ y \), each second. Select \( \text{obstacle} \ y \). Select the assignment \( (:=) \) button, \( \text{data} \) and \( \text{obstacle} \ y + 1 \).

You now need to plot the new obstacle, using plot as previously. We will need to make sure that we slow down the board. Select micro:bit and pause for 300 milliseconds. This will allow you to see the lights fall down the screen at a slower pace.

Preview your program, you should notice the ‘egg’ fall down the board.
We’re going to add the next line of code above the pause. Select micro:bit from the keyboard. To use the accelerometer you will need to select the acceleration button. Now select store in var. The program sets the acceleration to left and right. This is the default position (x); you can also control up and down (y). You should have something like this:

```
obsstacle y := obstacle y + 1
micro:bit -> plot(obsstacle x, obstacle y)
var millig := micro:bit -> acceleration("x")
micro:bit -> pause(300)
```

We now need to work out the position of the accelerometer and then turn the LED on. Select the x variable from the data menu in the keyboard. Select the assignment (=) button.

```
micro:bit -> plot(obsstacle x, obstacle y)
millig := micro:bit -> acceleration("x")
x :=
```

We need the math library in TouchDevelop so that we can do our rounding and work out the position of the accelerometer.

```
+ micro:bit -> plot(obsstacle x, obstacle y)
millig := micro:bit -> acceleration("x")
x := 2 + math
```

Select the min button. Replace the first number with 2 and then math and then max. This code is finding the highest and lowest values that the board could move to the left and right. You should have something like the picture, right.

```
x := 2 + math -> min(2, math -> max(0, 0))
micro:bit -> pause(300)
```

To finish, we need to replace the maximum values with −2 and then the variable we created. In this case it’s called millig. Divide it by 200.

```
x := 2 + math -> min(2, math -> max(-2, millig / 200))
end while
do nothing
end function
```
26

Select IF from the menu and select the condition. Select obstacle y from the variables and say if it's greater than 4 (4 is the bottom of the board).

```javascript
var millig := micro:bit.acceleration("x")
if (millig.x := 2 + math.min(2, math.max(-2, millig / 200)))
if (obstacle y := 4) then
    do nothing
else do nothing end if
micro:bit := pause(300)
```

27

Inside this IF condition, we're going to tell the 'egg' to find a new position at the top of the screen. We're going to set the value to $-1$ so that the 'egg' is hidden just above the board before it appears at zero. We're then going to set the position of obstacle x using the math library to find a random value. Can you repeat the code shown? If you test your program now, you will notice that the 'egg' keeps falling down the screen in random positions.

```javascript
if (obstacle y := 4) then
    obstacle y := -1
    obstacle x := math.random(5)
else do nothing end if
micro:bit := pause(300)
end function
```

Do your own thing!

- Now that the 'egg' falls down the display, use an IF statement to detect if the egg and the basket are lined up (i.e. did you catch the egg in the basket).

- You will need to detect the position of the basket first (you could store this position in a variable). Once you've detected the position of the basket, you will need to detect the position of the egg (IF it's reached the bottom of the screen). Store this information as a variable, too. You can use an IF statement to compare the two positions.

- Try to work out what you need to do to finish the game. If you get stuck, take a look at the online video tutorial, guided coding tutorial, or the solution on page 27.
Challenges and solutions

Challenge 1

Challenge 2

function main ()
while true do
if micro:bit → button is pressed("A") then
  -> set sleep
  micro:bit → pause(5000)
else
  -> set awake
end if
if micro:bit → button is pressed("B") then
  -> set eat
  micro:bit → pause(5000)
else
  -> set awake
end if
micro:bit → pause(0)
end while
do nothing
end function

Challenge 3

function main ()
  x := 2
  obstacle x := 2
  obstacle y := 0
  score := 0
  micro:bit → plot(obstacle x, obstacle y)
  micro:bit → plot(x, 4)
while true do
  micro:bit → pause(0)
  micro:bit → unplot(x, 4)
  micro:bit → unplot(obstacle x, obstacle y)
  obstacle y := obstacle y + 1
  micro:bit → plot(obstacle x, obstacle y)
var millig := micro:bit → acceleration("x")
x := 2 + math → min(2, math → max(-2, millig / 200))
micro:bit → plot(x, 4)
if obstacle y > 4 then
  obstacle y := 1
  obstacle x := math → random(5)
else do nothing end if
  micro:bit → pause(300)
end while
end function
Creating your own tutorials

Using TouchDevelop to create an interactive tutorial for your students

Once you’ve tried out some of the BBC micro:bit challenges with your students, you’ll probably be looking for ways to challenge them further. One way of doing this is to create guided coding tutorials using the tutorial editor.

Once they’ve worked through a tutorial, why not challenge them to adapt their programs to make them work differently, or to add new code to make them more complex?

Outcome

A tutorial that guides the user to create a script that scrolls text across the screen if button A is pressed.

- By default, all of the lights are off.
- There will be a single state.
- The text will scroll to the left.

Decomposing the problem

This challenge can be decomposed into three parts:

1. Create code for the function you wish the BBC micro:bit to perform.
2. Publish the script and convert it into a tutorial.
3. Check that the tutorial works.

Create code for the function you wish the BBC micro:bit to perform

You will need to create the code you wish your students to reproduce before you can create your tutorial.

Start by opening a new browser window and typing live.microbit.co.uk in the address bar. Click on Create Code. In TouchDevelop, click New project. Type in a name for your script, such as Scrolling text. Click on create. You will notice an empty function named main. Click on the do nothing statement to position the edit cursor inside the function.
Creating your own tutorials

We’re going to start by adding code that will check for the input of the buttons. Click on the **while** button in the on-screen keyboard, which will create a **while true** loop.

Click on the **do nothing** statement inside the **while** loop. Then click on the **if** button in the code keyboard to create an **if-then-else** statement. Select the **condition** (this is displayed in red).

Click **micro:bit** in the on-screen keyboard and select **button is pressed**. This will automatically default to button A. If you test your program at this point, nothing will happen.

Click the **do nothing** statement under **if-then**. Select **micro:bit** in the on-screen keyboard and then find the **show string** button. Click after the speech marks in the code, and then click **edit** in the code keyboard. Type in the scrolling text you wish to appear and click the tick button.

Your code should now scroll the text when you push button A. Test your program to see if it works.
Publish the script and convert it to a tutorial

Now that you’ve created a script, you need to convert this into a tutorial.

07

Click my scripts to return to the script overview page. Publish your script by clicking on the publish button. Next press on the details tab then convert to tutorial button. This button will generate a tutorial that produces your script.

08

At this point, you will be editing a new script. Notice the TODO sections of your code. The TODOS allow you to describe each step in your program. Navigate to the function main (see right).

09

The example in the picture, right, shows how you might change the first line of text to act as an introduction to the tutorial for your students.

10

To edit the text which will support, or explain, individual steps of the tutorial, click on the script button at the top of the screen.
Select #0 main () from the list. Notice the TODOs for you to describe. It is important to explain the steps in this picture to your students.

You should aim to explain each of the TODO steps in as much detail as you can. It will help the students to understand the theory behind the step.

Check the tutorial works

Click the my scripts button (left arrow) to return to the script overview page. Press the follow tutorial in editor button to check if your tutorial runs in the correct order.

The following image shows an example of what you might see on the screen.

Once you’re happy with your tutorial, click my scripts and publish your tutorial.

If you are interested in becoming more advanced in tutorial creation, visit touchdevelop.com/docs/creatinginteractivetutorials. This detailed guidance includes instructions for the addition of avatars, which can explain the step-by-step process to your students.
The **BBC micro:bit and the curriculum**

Although the BBC micro:bit has been designed with young people's own independent use in mind, for schools in England following the new computing curriculum, BBC micro:bit has the potential to be a really interesting platform for exploring lots of the required content.

### KS3 Computing PoS Subject content

- **design, use and evaluate computational abstractions that model the state and behaviour of real-world problems and physical systems**

- **understand several key algorithms that reflect computational thinking** [for example, ones for sorting and searching]; use logical reasoning to compare the utility of alternative algorithms for the same problem

- **use two or more programming languages, at least one of which is textual, to solve a variety of computational problems; make appropriate use of data structures** [for example, lists, tables or arrays]; design and develop modular programs that use procedures or functions

- **understand simple Boolean logic** [for example, AND, OR and NOT] and some of its uses in circuits and programming; understand how numbers can be represented in binary, and be able to carry out simple operations on binary numbers [for example, binary addition, and conversion between binary and decimal]

- **understand the hardware and software components that make up computer systems, and how they communicate with one another and with other systems**

- **understand how instructions are stored and executed within a computer system; understand how data of various types (including text, sounds and pictures) can be represented and manipulated digitally, in the form of binary digits**

- **undertake creative projects that involve selecting, using, and combining multiple applications, preferably across a range of devices, to achieve challenging goals, including collecting and analysing data and meeting the needs of known users**

- **create, re-use, revise and re-purpose digital artefacts for a given audience, with attention to trustworthiness, design and usability**

- **understand a range of ways to use technology safely, respectfully, responsibly and securely, including protecting their online identity and privacy; recognise inappropriate content, contact and conduct and know how to report concerns**

### BBC micro:bit contexts

- **Students can learn much about the idea of abstraction by thinking about the different layers of systems that have to operate together to make the BBC micro:bit work, as illustrated by the relationship of TouchDevelop or Blockly to C++ and to the ARM mbed machine code that runs on the chip itself.**

- **There’s scope here to get students thinking algorithmically, carefully planning their programs before they write any code. Some key algorithms could be implemented on the BBC micro:bit too, from finite state machines (Challenge 2: Digital pet) to ‘guess my number’ games using binary search.**

- **Students could compare programming the same algorithm in both the Blocks and TouchDevelop code editors. They can also learn to design and develop modular programs using user-defined functions in TouchDevelop.**

- **There’s chance to explore Boolean logic using the AND, OR and NOT operators built in to the language and the A and B input buttons on the BBC micro:bit.**

- **The 25-pixel display lends itself to investigating binary representation, both for images, creating simple bitmap sprites, and for numbers, using it to display numbers up to \(2^{25}\) using binary place value! Why not create a binary counter or even a clock using the BBC micro:bit?**

- **As it’s a simple system, the BBC micro:bit provides a more accessible way for students to grasp complex ideas of how hardware and software systems behave and communicate.**

- **The use of compiled machine code here might be part of a unit of work exploring how instructions are stored and executed in computers.**

- **There’s ample scope for creative projects here, achieving challenging goals and meeting the needs of known users. The limitations of the BBC micro:bit interface make it a great way to think creatively about design and usability.**

- **Remixing code via the BBC micro:bit site provides some great opportunities for working with ‘digital artefacts’ produced by others.**

- **Participating in the BBC micro:bit online community provides an opportunity to emphasise the need for respect and responsibility when working online.**