Starting from Scratch

An Introduction to Computing Science
by Jeremy Scott

LEARNER NOTES v2
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Introduction

You have probably already used several computers today without realising it.

If you have sent a text, been driven in a car, or checked your watch then you have used a computer. The words you are reading now were typed on a computer.

Computers are all around us. Since they affect so many parts of our lives, it is important to understand how they work.

What is a computer?

A computer is a machine that carries out instructions given to it by a human. Without instructions, computers wouldn’t be able to do anything.

If this is the case, then what makes them special? Well, computers…

- work faster than humans;¹
- are more accurate than humans;
- can store huge amounts of information that they never “forget”.

It might seem that computers can do almost anything. However, here are some other important things to remember:

- Computers don’t have brains; they are not cleverer than humans.
- Computers don’t have feelings or “common sense”. This means that there are lots of everyday tasks that humans can perform that computers still cannot.

Activity

Write down three everyday tasks that humans perform but computers cannot (or are not very good at).

1. ____________________________________________
2. ____________________________________________
3. ____________________________________________

¹ At the time of writing, a modern personal computer could perform over 100 billion calculations every second!
Types of computer

Computers come in many shapes and sizes. Computers that most people might recognise include:

**Desktop**
A desktop PC (Personal Computer) is designed to sit on top of – or under – a desk and is used by one person at a time. It is powered by mains electricity and made up of separate devices.

**Laptop**
Laptop computers combine all the separate devices of a desktop PC into one unit. This can be carried around and powered by mains electricity or battery. Netbooks and ultrabooks are just smaller, lighter types of laptop.

**Tablet**
This has a large, touch sensitive screen which is controlled with your finger (or sometimes a special pen). It is battery-powered and very portable. Tablets have an on-screen “virtual” keyboard.

---

**Activity**
The personal computers shown above appear in order of oldest to newest types. What does this tell you about the kind of computers people want?

---

2 The word “virtual” is used a lot in Computing. It just means “not real” – it’s something that’s been recreated on a computer. Can you think of any other virtual things you get on a computer?
Other computers that may not be as well-known or recognised by most people include:

**Mainframe**

This is a large computer which can take up an entire room. Many users can use it at the same time, each with their own keyboard, mouse and monitor.

Mainframes are very expensive and need a team of people to run them. They are owned by large organisations that need to store and process huge amounts of information.

**Server**

A server is a computer that provides services for other computers on a network e.g.

- file server (stores users’ files);
- web server (serves out web pages);
- mail server (provides email services).

**Games console**

Games consoles are also computers. Most have a disc drive for loading games and a powerful processor to create realistic graphics.

Many games consoles can also connect to the Internet, letting users buy games online or compete with other gamers around the world.
Embedded

Many devices in your home have an **embedded computer** – a small silicon chip that carries out stored instructions. The modern home has over 100 of these “computers”, built into devices like a toaster, stereo, washing machine, fridge, TV, etc.

A modern car may have another 100 or more embedded computers³.

---

**Activity**

Write down **three** devices in your own home that you think might contain an embedded computer (besides those shown above).

1. ___________________________________________________________
2. ___________________________________________________________
3. ___________________________________________________________

---

Smartphone

“Smart” mobile phones like Android and Apple iPhone are really pocket computers that can also make phone calls. Most smartphones use large touch screens.

This is a good example of **convergence** where technologies that were previously separate are now combined in one device.

---

**Activity**

Write down **three** technologies that are combined in a modern smartphone.

1. ___________________________________________________________
2. ___________________________________________________________
3. ___________________________________________________________

---

³ Source: http://embedded-computing.com/guest-blogs/ota-challenges-for-automakers/
Parts of a computer

A computer is a machine that:

- takes in information
- stores this information
- processes this information
- and gives this processed information back out.

Activity

Write down inputs and outputs for the following activities on different types of computers. When you have finished, create an extra one of your own:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Input(s)</th>
<th>Output(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Playing a video game</td>
<td>Move game controller</td>
<td>Character moves</td>
</tr>
<tr>
<td></td>
<td>Click buttons</td>
<td>Menu selections made</td>
</tr>
<tr>
<td>Surfing the WWW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making a phone call</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watching TV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
There are **two** main parts to a computer: **hardware** and **software**.

### Hardware

Hardware means **computer equipment**. A single piece of hardware is called a **device**.

There are **four** main types of device in a computer:

- **Input device**: used to put data **into** the computer.
- **Central Processing Unit (CPU)**: where the computer carries out the instructions given by the programs. The faster the CPU (commonly just called the **processor**), the faster your computer will work.
- **Output device**: used for data coming **out** of the computer.
- **Storage device**: used to **store** programs and data. It is where you save your work on to.

Put simply: if you can touch it, it’s hardware!

### Activity

Decide if the following devices are **input**, **output** or **storage** devices then put each one into the correct column. The first three have been done for you.

keyboard; hard disc drive; monitor; speaker; scanner; printer; mouse; DVD drive; microphone; flash drive (memory stick); game controller; touch screen; memory card

<table>
<thead>
<tr>
<th>Input Device</th>
<th>Storage Device</th>
<th>Output Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>keyboard</td>
<td>hard disc drive</td>
<td>monitor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Software

A computer can perform different tasks, depending on the instructions it is given.

A list of instructions is called a program. Without a program to tell it what to do, a computer would just be a (useless) collection of hardware devices.

Software is the name given to programs and the information they use.

Activity

Complete the table below of ten different jobs you can do on a computer and the name of a software package that lets you do it.

<table>
<thead>
<tr>
<th>Task</th>
<th>Software package</th>
</tr>
</thead>
<tbody>
<tr>
<td>Browse the World Wide Web</td>
<td>Google Chrome</td>
</tr>
<tr>
<td>Play a game</td>
<td>Angry Birds</td>
</tr>
<tr>
<td>Edit a movie</td>
<td>iMovie</td>
</tr>
</tbody>
</table>
Programming languages

Computers follow instructions given to them by humans. They can solve only the problems that people tell them to solve. To tell a computer what to do, you must know what problem you want to solve and have a plan for solving it.

Unfortunately, these instructions can’t just be given to the computer in normal English. A computer can perform tasks very quickly, but it is not intelligent like we are.

A computer will do:

- only what it is told
- exactly what it is told.

This means that computer programs have to be written in a very precise way, according to strict rules. There must be no confusion over what instructions mean.

A set of instructions and rules that a program can be written in is called a programming language.
Programming in Scratch

The rest of this course will focus on how to write computer programs.

You will be using Scratch, created by MIT (Massachusetts Institute of Technology), one of the USA’s leading universities.

Scratch is a powerful software development package. It lets you create programs (called projects) that combine sound, graphics and animation.

You can upload your projects to the Scratch website and share with other Scratchers around the world. It really is the cat’s whiskers!

You will learn how to use Scratch through a series of lessons. At the end of each one, there will be some questions which will help to check if you have understood what you have learned.
1: Scratching the Surface

This lesson will cover

- The Scratch environment, including
  - Sprites & stage
  - Properties
    - Scripts
    - Costumes/backdrops
    - Sounds
- Creating a program with animation & sound

Introduction

Watch the video introduction to Scratch. This will introduce you to Scratch and its screen layout.

https://vimeo.com/80961102

All the world’s a stage

A Scratch program contains sprites (characters) that “perform” on a stage. Sprites and the stage have three kinds of properties (or settings):

1. Scripts

   These are the instructions that control a sprite. Scripts are made from blocks.

   There are eight different kinds of blocks – to do with motion, control, looks, etc. – and over 100 blocks in total. Note that sprites need scripts to perform a task.

2. Costumes/Backdrops

   Costumes are “outfits” for a sprite. The same sprite can have several costumes and so be made to look completely different.

   The stage can have different backdrops which can be changed. Backdrops are just like costumes for the stage.

3. Sounds

   These are sounds that sprites or the stage can use. Again, each sprite (or the stage) can have many different sounds. Scratch lets you import (bring in) recorded sounds or even record your own using a microphone.
Task 1: Up on the Catwalk

Watch screencast Catwalk.

This will go over the main elements within Scratch and take you through the task of creating your first computer program. If you get stuck, go back in the screencast or ask your partner.

Task 2: Frère Jacques

Watch screencast FrereJacques.

This will show you how to create a simple tune in Scratch. If you get stuck, go back in the screencast or ask your partner.

Did you know...? Frère Jacques is one of the best-known songs in the world. It is a French song about a religious monk (“Brother John” in English) who has the job of ringing the morning bell before the days of alarm clocks. Unfortunately, poor Jacques has overslept!

Task 3: My Tunes

Once you have completed Task 2, try creating a program that plays another simple song. Choose one where lines of the music repeat, so you can use the repeat command.

Congratulations – you have just started your journey to become a computer programmer!

---

The score shown above is in a different key from the version created in the Task 2 screencast.
**Putting things in order**

Blocks in the same script get executed (carried out) in sequence, one after the other. Blocks in separate scripts can sometimes be executed at the same time. This is called parallel processing – having the computer do more than one thing at a time.

For example, if you have several scripts, they will all get executed together when the flag is clicked.

**Extension 1: Dance away**

Try to make a sprite dance in time to your music, starting the program when the flag is clicked. There are two ways you could do this:

- create a single script that includes the sprite movement blocks amongst the play note blocks
- have separate scripts for the same sprite – one script plays the tune whilst the other makes the sprite dance.

You can find another screencast (Dance Party) to give you some inspiration at https://scratch.mit.edu/projects/10128067.

Make sure you create a tune, rather than just use a music loop, though!

**Extension 2**

Experiment by adding some other blocks to your program, such as the looks blocks e.g.

These let you create some really fun effects!
Did you understand?

1.1 Look at the section of code opposite that controls a sprite. Write down what you think the user will see when the flag is clicked.

_____________________________________________________________________________

_____________________________________________________________________________

Why?  _______________________________________________________________________

_____________________________________________________________________________

Now try out the code yourself and see if you were right.

1.2 Now add a **wait 1 secs** block between the two move blocks. Describe what happens now.

_____________________________________________________________________________

Explain why this happened  _______________________________________________________________________

_____________________________________________________________________________

1.3 Look at the section of code below that controls a sprite.

Write down what you think the user will see when the flag is clicked.

_____________________________________________________________________________

_____________________________________________________________________________

Why?  _______________________________________________________________________

_____________________________________________________________________________

Now try out the code yourself and see if you were right.
1.4 In the stack of blocks below, how many times does the sprite move 10 steps?

![Blocks Diagram]

1.5 A programmer wants the cat to dance to some music. However, the cat doesn’t start dancing until after the music has finished!

![Blocks Diagram]

Why is this?
1.6 In the example below, a programmer has chosen a piece of music (sound “Xylo1”) to play during a game. However, when the flag is clicked, the computer just plays the first note of the music – over and over again!

What mistake has the programmer made?

1.7 In Extension 1: Dance Away, you made a sprite dance to a tune you created. There were two ways you could do this:

- have a single script with the movement blocks amongst the play note blocks
- have separate scripts for the same sprite – one script plays the tune whilst the other makes the sprite dance.

Why do you think experienced programmers would use separate scripts?

1.8 Make up a question like those from 1.1–1.6 and pass it to your neighbour.

Lazy or smart?

Computer programmers always look for shortcuts to make their lives easier. A good example is how we used a repeat block in Frère Jacques to repeat the same line of music instead of having two identical sets of blocks. As well as looking neater, it also means that you won’t make a mistake when creating a second set of blocks.

Do you think this makes programmers lazy or smart? (Hint: the answer is smart!)
2: Story Time

This lesson will cover

- creating stories and plays
- sequencing instructions
- events

Task 1: A bad joke

Watch screencast BadJoke. This shows how to use Scratch to create a joke or play between two characters.

Once you have done this, try creating a joke of your own – for example, a “Knock, Knock” joke – that uses two characters like the one in the example.

Pay attention to when each character (sprite) “speaks” by planning out the code, including speaking and waiting, like the one below:

<table>
<thead>
<tr>
<th>Girl</th>
<th>Boy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Say “Hey, I've got a joke!” for 3 secs</td>
<td>Wait 3 secs</td>
</tr>
<tr>
<td>Wait 3 secs</td>
<td>Say “Okay – let's hear it!” for 3 secs</td>
</tr>
<tr>
<td>Say “My dog's got no nose” for 3 secs</td>
<td>Wait 3 secs</td>
</tr>
<tr>
<td>Wait 3 secs</td>
<td>Switch to costume of boy shrugging</td>
</tr>
<tr>
<td></td>
<td>Say “How does it smell?” for 3 secs</td>
</tr>
<tr>
<td>Say “Terrible” for 2 secs</td>
<td>Wait 2 secs</td>
</tr>
<tr>
<td></td>
<td>Switch to costume of boy laughing</td>
</tr>
<tr>
<td></td>
<td>Say “&lt;Groan&gt;” for 3 secs</td>
</tr>
</tbody>
</table>

Write down any problems you had and what you did to overcome them.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
Task 2: A short play

Write a short story or play. There should be **two or three scenes** (backdrops) where the actors (sprites) change costumes.

Keep it simple with only two or three actors (sprites). Write a script on lined paper, with each actor’s lines side-by-side, as shown in the previous example.

**Hint:** You can use the `broadcast` block to let a sprite trigger an event, such as a scene change e.g.

<table>
<thead>
<tr>
<th>In the sprite script</th>
<th>In the stage script</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="broadcast" /></td>
<td><img src="image" alt="when I receive" /></td>
</tr>
<tr>
<td></td>
<td><img src="image" alt="switch backdrop to" /></td>
</tr>
</tbody>
</table>

You can find another screencast (walking_places) to give you some inspiration at [https://scratch.mit.edu/projects/8157/](https://scratch.mit.edu/projects/8157/)

Extension 1: A walk-on part

Make your characters walk on to the screen and stop at a certain point during the play.

**Hint:** you will have to start your sprite actors at the edges of the screen and use the `show` and `hide` blocks to make them appear at the correct place every time.
Bugs

A bug is an error which stops your code working as expected. There are two main types of bug which can occur in a program:

- Syntax error
  This happens when the rules of the language have been broken e.g. by mis-spelling a command. Syntax errors usually stop the code from running. Languages like Scratch provide code in ready-written blocks, so you won’t make many syntax errors.

- Logic error
  This means your code runs, but doesn’t do what you expect. Unfortunately, it’s still possible to make logic errors in Scratch!

A third kind of error is also possible:

- Execution (or run-time) error
  This means your program crashes (stops running) when it is run (executed). This may be the result of performing an operation such as division by zero, for example.

Finding and fixing these errors in a program is known as debugging.
Did you understand?

2.1 The program below shows the scripts for two sprites to tell a joke to each other. Why would this program not work?

<table>
<thead>
<tr>
<th>Girl</th>
<th>Boy</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Girl script" /></td>
<td><img src="image2.png" alt="Boy script" /></td>
</tr>
</tbody>
</table>

2.2 The program below shows the scripts for two sprites to tell a joke to each other. Besides being a terrible joke, what is wrong with this program?

| ![Girl script](image3.png)       | ![Boy script](image4.png)       |

Page 20
2.3 The program below shows the scripts for two sprites to tell a joke to each other. Why would this program not work properly?

<table>
<thead>
<tr>
<th>Girl</th>
<th>Boy</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Scripts for Girl]</td>
<td>![Scripts for Boy]</td>
</tr>
</tbody>
</table>

2.4 Now make up a “buggy” question of your own and pass it to your neighbour.

![Image of a question]

---
Event-driven programming

Some computer programs just run and continue on their own with no input from the user e.g. your program to play a tune.

However, many programs react to **events** (things that happen), such as:

- the click of a mouse or press of a key;
- the tilt of a game controller;
- a swipe of a smartphone screen;
- a body movement detected by a motion-sensing controller such as a Kinect.

In Scratch, event blocks have a curved top (sometimes called a “hat”):

- **when flag clicked**
  Reacts when the flag is clicked; often used to start a program.

- **when space key pressed**
  Reacts when a key is pressed. Click the small black triangle to select the key you want to detect. Useful for controlling a sprite, or triggering an action.

- **when this sprite clicked**
  Reacts when a sprite is clicked. Useful for controlling characters in a program.

It is also possible to create your own events in Scratch using the **broadcast** command.

2.5 Look at the Scratch environment and write down some other **events** or **conditions** that Scratch programs can react to.

**Hint:** the **Control** and **Sensing** blocks are a good place to start.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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3: A Mazing Game

This lesson will cover

- Game creation
- Collision detection

Introduction

You are going to create a simple game where the player guides an “explorer” character around a maze using the arrow keys.

The game will end when the explorer rescues its friend in the middle.

Introduction

Watch screencast Maze to learn how to create the Maze game.

Task 1: Setting the scene

Set up the game by importing the stage costume (Maze) and two sprites – an explorer and a friend for the explorer to rescue. Don’t do any more at this point.

The Importance of Design

Before we make anything – a house, a dress or a computer program – we should start with a design. Because there are two important parts to most programs – the interface (how it looks) and the code – we design these separately.

- The easiest way to design the interface is by sketching it out on paper.
- To design the code, write out a list of steps it will have to perform in English. This is known as an algorithm and is just like the steps in a food recipe.

Solving problems like this is what programming is really about, rather than entering commands on the computer.

All good programmers design algorithms before starting to code!
Task 2: Designing the solution

Let’s look again at the two main things we need to code in our game:

1. moving the explorer;
2. reaching centre of the maze (and rescuing the explorer’s friend).

The table below shows an algorithm for moving the explorer and Scratch code that does the same thing.

<table>
<thead>
<tr>
<th>Algorithm for moving explorer</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>when the flag is clicked</td>
<td></td>
</tr>
<tr>
<td>repeat forever</td>
<td></td>
</tr>
<tr>
<td>if right arrow key is pressed</td>
<td></td>
</tr>
<tr>
<td>point right</td>
<td></td>
</tr>
<tr>
<td>move 5 steps</td>
<td></td>
</tr>
<tr>
<td>if left arrow key is pressed</td>
<td></td>
</tr>
<tr>
<td>point left</td>
<td></td>
</tr>
<tr>
<td>move 5 steps</td>
<td></td>
</tr>
<tr>
<td>if up arrow key is pressed</td>
<td></td>
</tr>
<tr>
<td>point up</td>
<td></td>
</tr>
<tr>
<td>move 5 steps</td>
<td></td>
</tr>
<tr>
<td>if down arrow key is pressed</td>
<td></td>
</tr>
<tr>
<td>point down</td>
<td></td>
</tr>
<tr>
<td>move 5 steps</td>
<td></td>
</tr>
<tr>
<td>if explorer touches the same colour as the maze wall</td>
<td></td>
</tr>
<tr>
<td>go back to starting position</td>
<td></td>
</tr>
</tbody>
</table>

Algorithms let programmers concentrate on what the program has to do instead of how to do it on the computer. Once the algorithm is worked out, writing the code is easy!

Notice how an algorithm is indented to show which parts belong inside other parts e.g.

repeat forever
   → if right arrow key is pressed ........ goes inside repeat forever
      → point right................................... goes inside if right arrow key is pressed
      → move 5 steps .................................. goes inside if right arrow key is pressed
Task 2: Designing the solution (continued)

The table below shows an algorithm for the explorer’s friend sprite.

From this algorithm, see if you can create the code yourself. Remember to put it in the friend sprite!

<table>
<thead>
<tr>
<th>Algorithm for reaching centre of maze</th>
<th>Code for friend sprite</th>
</tr>
</thead>
<tbody>
<tr>
<td>when the flag is clicked</td>
<td></td>
</tr>
<tr>
<td>show sprite</td>
<td></td>
</tr>
<tr>
<td>repeat forever</td>
<td></td>
</tr>
<tr>
<td>if touching explorer sprite</td>
<td></td>
</tr>
<tr>
<td>say “Thank you!”</td>
<td></td>
</tr>
<tr>
<td>hide sprite</td>
<td></td>
</tr>
<tr>
<td>stop all scripts</td>
<td>Code this one yourself!</td>
</tr>
</tbody>
</table>

Now test your game to see if it works.

Extension 1: Getting in tune

Add a background tune to your game (sound “xylo1” seems to suit, but choose what you think sounds best).

Think about the following:

- Where would be the best place to store this, since it applies to the whole game?
- How will you get the music to keep playing?
- Should you play sound or play sound until done block to play the music?

Extension 2: Add an enemy

Add a sprite that constantly moves back and forth across the stage. If your explorer touches the enemy, the explorer should go back to the start.

Hint: set your enemy sprite to move only left & right.

The if on edge, bounce block is useful to bounce back and forth off the edge of the stage.
Did you understand?

3.1 A programmer creates a maze game like the one you’ve just created. Unfortunately, her character doesn’t move as expected.

What mistake has she made?
3.2 Look at the examples of code below.

Do they perform the same task? ____________________________

Explain your answer ____________________________________________

_____________________________________________________________
3.3 The code below controls a sprite going round a maze. If the sprite touches the side of the maze (the colour blue), it returns to its starting position of -150, 150.

Unfortunately, the sprite sometimes touches the walls of the maze and returns to the start when the player doesn’t expect.

What mistake has the programmer made?

```
when [green flag] clicked
forever
  if [key right arrow] pressed? then
    move 5 steps
    point in direction 90°
  if [key left arrow] pressed? then
    move 5 steps
    point in direction -90°
  if [key up arrow] pressed? then
    move 5 steps
    point in direction 0°
  if [key down arrow] pressed? then
    move 5 steps
    point in direction 180°
  if [touching color] ? then
    go to x: -150 y: 150
```

3.4 In this example, the sprite is supposed to return to the centre of the maze when it touches the sides (coloured blue); however, it only does this sometimes.

What mistake has the programmer made?
3.5 In this example, the sprite never returns to starting position, even if it touches the walls of the maze (coloured blue).

What mistake has the programmer made?

3.6 Now make up a buggy question of your own and pass it to your neighbour.
This lesson will cover

- The Scratch environment
  - Sprites
  - Code blocks
- Fixed loops
- Programming computer graphics

Introduction

In this lesson, you will write programs to create simple computer graphics using Scratch’s Pen blocks.

Task 1: Shaping up

Watch screencast Graphics. This demonstrates how to use Scratch to create some simple computer graphics (pictures).

Complete the table by writing the code to create a heptagon (7 sides) and triangle:

<table>
<thead>
<tr>
<th>Square</th>
<th>Pentagon</th>
<th>Hexagon</th>
<th>Heptagon</th>
<th>Triangle</th>
</tr>
</thead>
<tbody>
<tr>
<td>repeat 4 move 100 steps turn 90 degrees</td>
<td>repeat 5 move 100 steps turn 72 degrees</td>
<td>repeat 6 move 100 steps turn 60 degrees</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Now try out your programs. Either double-click on the stacks of blocks or – even better – make your own block for each shape.

Did your programs work?

If not, why not?
The Rule of Turn

Did you spot the pattern here?

In every shape, we turned a **full circle** (360°). To work out how many degrees we need to make at each turn, simply...

**Divide the total number of degrees turned in the shape by the number of turns taken**

So... in a square, we go round 360° in 4 turns, so 360/4 = 90° per turn;

in a pentagon, we go round 360° in 5 turns, so 360/5 = 72° per turn.

Task 2: You're a star!

Now use the Rule of Turn above to draw a five-pointed star (opposite).  
**Hint:** Pay careful attention to what the rule says!

Task 3: Circle

Create a circle. This is easier than you might think: simply

repeat 36 times
- move 5 steps
- turn 10 degrees

Task 4: Circular pattern

Make a pattern out of 36 squares arranged in a circle of their own.

repeat 36 times
- **draw a square** ........ put the code to draw a square here
- turn 10 degrees

Try changing the shape to squares, triangles or hexagons.

Nesting

In Task 4, we saw one **repeat** loop inside another – this is called a **nested** loop.

In this case, the program starts the outer **repeat**, then enters the inner repeat, which carries on until it’s finished. The outer repeat then carries on and so on.

Add a **wait 0.1 secs** command in your code to see this happening more slowly.
**Extension 1: The main event**

Create your own procedures to draw each of the shapes you have already created (square, triangle, pentagon, etc.).

Once you have done this, adapt your program for **Task 4: Circular pattern** that calls up a square procedure for the repeating shape.

**Extension 2: Our house**

Draw a house like the one shown opposite.

**Write an algorithm** – that is, plan the steps out on paper – before you try to code this!

**You will need to use** penup and pendown **blocks.**

**Hint:** Think about how you could use procedures to reduce the amount of code you create.

**Extension 3: Mmm... doughnuts**

Adapt the pattern above to create a multi-coloured doughnut shape.

**Write an algorithm before you try to code this!**

**Hint:** There are 36 circles, but the pen moves slightly – with the pen up – before putting the pen down and drawing the next one. The program also uses the change pen color by block to make it colourful.
Extension 4: The Olympic Rings

This is hard! Try to write a program to draw the five Olympic rings. Write an algorithm before you try to code this!

Hint: make each circle using a procedure and think about the spacing between the centre points.

Did you know...?  The Olympic flag was flown for the first time at the 1920 Summer Olympics in Antwerp, Belgium and has been flown at every Olympic Games ever since.

The five rings represent the five continents of America, Africa, Asia, Australasia, Europe. The colours – blue, yellow, black, green and red on a white background – were chosen because every nation had at least one of them on its national flag.

---

5 The Olympic rings symbol is reproduced by kind permission of the International Olympic Committee. The Olympic rings are the exclusive property of the International Olympic Committee (IOC). The Olympic rings are protected around the world in the name of the IOC by trademarks or national legislations and cannot be used without the IOC’s prior written consent.
Did you understand?

4.1 The program from the screencast is shown below. Suggest any way(s) in which it could be made more efficient.

```plaintext
- When clicked:
  - Go to x: -200 y: 0
  - Clear
  - Show
  - Pen down
  - Square
  - Square
  - Square

- Define square:
  - Repeat 4
    - Move 100 steps
    - Turn 90 degrees
  - Pen up
  - Move 150 steps
  - Pen down
```
4.2  Look at the program below.

Write down the order in which the scripts are carried out after the flag is clicked (number them in order 1, 2 and 3).

<table>
<thead>
<tr>
<th>Number</th>
<th>Script</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><img src="image1.png" alt="Diagram 1" /></td>
</tr>
<tr>
<td></td>
<td><img src="image2.png" alt="Diagram 2" /></td>
</tr>
<tr>
<td></td>
<td><img src="image3.png" alt="Diagram 3" /></td>
</tr>
</tbody>
</table>

Now describe what the code will do.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
4.3 Look at the code examples below.

a) How many times will the sprite move 10 steps? ____

Why? _____________________________________________

b) How many times will the sprite move 10 steps? ____

Why? _____________________________________________

4.4 Discuss the following “procedures” from real life. Write an “algorithm” for each one!

a) Getting ready for school

b) Making breakfast

Think: In each example, are there steps that could go in separate scripts and get carried out at the same time?
4.5 In the **Storytime** activity you used the **broadcast** event to send a message between a sprite and the stage.

In this example, a programmer is using a **broadcast** event instead of a **procedure** to create a circular pattern of squares like the one labelled “Correct” below. Unfortunately, it always goes wrong, displaying the pattern labelled “Wrong”.

<table>
<thead>
<tr>
<th>Correct</th>
<th>Wrong</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Correct Pattern" /></td>
<td><img src="image" alt="Wrong Pattern" /></td>
</tr>
</tbody>
</table>

Look at the programmer’s code opposite. What mistake has he made?

**Hint:** it’s something to do with how fast the computer works.

Now enter the code above and run it to see the mistake for yourself. Once you have done this, create a **procedure** to draw the square and use it in the first script instead of the **broadcast square** block.

What does this tell you about the way that the **broadcast** command works compared to a **procedure**?
4.6 Now make up a “buggy” question of your own and pass it to your neighbour.


Did you understand? (Extension 3 only)

4.7 A programmer tries to draw a doughnut like the one in Extension 3. Unfortunately, it just draws lots of circles on top of each other.

What mistake has she made?

Don’t worry if you can’t see it straight away – this is tricky! If necessary, enter the script into Scratch and run it to help you understand what’s going on.
This lesson will cover

- Decision statements
- Conditional loops
- Variables
- Random numbers
- Animation
- Sound

**Introduction**

Watch screencast **ForestArchery** to see how to create this game.

**Task 1: Designing the solution**

Let’s look again at the two main things we need to code in our game:

1. moving the target;
2. shooting the target.

Try to code your program from the algorithms given overleaf, rather than looking at the screencast again.

**Algorithm to move target (in Target sprite)**

when flag is clicked

repeat forever

glide in 1 second to a random position*

* $x$ is a random number from -240 to 240

$y$ is a random number from -180 to 180

**Algorithm to move sight and shoot (in Sight sprite)** /*...*/
Algorithm to move sight and shoot (in Sight sprite)
when flag is clicked
repeat forever
  go to mouse location (the mouse x and mouse y positions)
  if the mouse button is down (the user has clicked the mouse)
    if the sprite is touching the target sprite
      add 1 to score variable
      play Pop! sound
      Say “Hit!” for 0.5 seconds

Task 2: Hit and miss
Change your code to make the program count misses as well as hits (taking off 1 point from the score):

If touching target
  change score by 1
  play Pop! sound
  Say “Hit!” for 0.5 seconds
else
  change score by -1
  play sound
  say “Miss!” for 0.5 seconds

Task 3: Against the clock
Add a timer variable to your program which makes the game last 30 seconds. Make the variable appear on the screen as it counts down from 30 to 0.

when flag is clicked
repeat 30 times
  wait 1 second
  change time by -1
stop all scripts
Task 4: Bullseye!

Using `if` and `touching colour` blocks, change the program so that when the target is hit, it adds the following to the score:

- White – 1 point
- Black – 2 points
- Blue – 3 points
- Red – 4 points
- Gold – 5 points (and says “Bullseye!”)

Task 5: Stay positive!

Adapt the program so that the user will never get a negative score.

Hint: take off a point only if the score is above zero.

---

Did you know...?

Humans are known to have practised archery for at least 10,000 years. It was first used for hunting (see cave painting opposite⁶), then in warfare.

In medieval England, it was compulsory for all men to practise archery regularly, so they would be skilled if required to go to war.

Nowadays, archery is a popular leisure activity enjoyed by people all around the world.

---

⁶© Instituto de Turismo de España (TURESPAÑA). Image of cave painting from Cova dels Cavalls remains the exclusive property of Turespaña and cannot be used or reproduced without Turespaña’s prior written consent.
Variables

In this game, we introduced the idea of keeping a score using a variable block.

A variable is a space in a computer’s memory where we can hold information used by our program – just like storing things in a box.

We should always give a variable a sensible name that tells us what kind of information is stored in it – just like putting a label on the box to tell us what’s inside.

To create a variable in Scratch, we make a variable block.

Once a variable is created, the information stored inside it can be set or changed (that is, varied – hence the word “variable”).

Extension 1: A Mazing cool feature

We’re now going to add a new feature to your Maze game from lesson 3 – a timer that gives the user 30 seconds to finish the game.

To do this, add a variable called time and create a new script that does the following:

when flag is clicked
set variable (time) to 30
repeat until time = 0
  wait 1 second
  subtract 1 from variable (time)
say “You Lose”
stop all scripts

Before you write this script, think about where might be the best place to put it.
Hint: is it something that applies to a single sprite or the whole game?

Extension 2: A harder maze

Now create a maze of your own which has more than one route to the middle.

Hint: Just create a new stage backdrop for this.
Extension 3: Do I get a prize?

Create new sprites in your Mazing game to act as bonuses along the way.

These should disappear (hide) when the explorer touches them and add to a score variable. Be sure to place some of them away from the quickest route around the maze to make it more challenging!

Extension 4: Now you see it...

Add some code to your Mazing game that shows and hides your bonus sprites after random times e.g. between 1 and 5 seconds (but experiment to see what works best).
Did you understand?

5.1 Look at the script below to make a timer variable count down from 30 to 0.

```scratch
when clicked
set [time v] to 30
repeat until [time v] = 0
    wait [1] secs
    change [time v] by -1
end
stop all
```

Will it work? ____________________________
Explain your answer _______________________ 
______________________________________
______________________________________

5.2 Now make up a buggy question of your own and pass it to your neighbour.

______________________________________
______________________________________
______________________________________

Summary

Computing Science concepts
In this course, you have learned about some important ideas within Computing Science:

- What a computer is
- Types of computer
- Hardware
- Software
- Program design, including algorithms
- Bugs

Programming structures/commands
You have also used the following programming features:

- Reacting to events
- Decision-making
  - if...then
  - if...then...else
- Variables – for example
  - scores
  - timers
- Loops
  - fixed (repeat, forever)
  - conditional (forever if)
- Collision detection
  - touching sprite
  - touching colour

Scratch has many more commands, but you have now learned enough to go on to the next stage.

Scratch features/...
Scratch features

You have also learned about the following features of Scratch:

- Sprites & stage
- Properties
  - Scripts
  - Costumes/backdrops
  - Sounds
- Animation
- Graphics tools

You now have all the skills you need to create some really amazing Scratch projects!
Scratch Project

Working in a pair or group, you are now going to create a Scratch project of your own!

You may have some ideas already, but programs are normally created in a series of stages:

1. Analyse
2. Design
3. Implement
4. Test
5. Document
6. Evaluate
7. Maintain

Or... A Dance In The Dark Every Midnight!
Analyse

Working in pairs or small groups, **brainstorm three ideas for your project**.

Think of the areas you’ve covered so far...
Is it going to be music or graphics-based? A story? A game?
Think of how it might link in with other subject areas you’re studying.

The Scratch gallery at [https://scratch.mit.edu/explore/](https://scratch.mit.edu/explore/) might give you some ideas.

1. ____________________________________________________________
   ____________________________________________________________

2. ____________________________________________________________
   ____________________________________________________________

3. ____________________________________________________________
   ____________________________________________________________

**Now discuss your ideas with your teacher.**

Once you have agreed on your project, describe what it will do below.

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
Design (Screen)

Make a storyboard of your project.
Your sketch should be labelled to show what is happening and what each sprite does.
Design (Code)

Design the steps for your code (algorithm):

- Think about the steps each sprite or the stage will have to perform. Write them in English.
- Think about variables your project will use.

<table>
<thead>
<tr>
<th>Sprite/Stage</th>
<th>Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Sprite/Stage</td>
<td>Algorithm</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Think about variables your project will use.

<table>
<thead>
<tr>
<th>Variable name</th>
<th>What it will store</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
Implement

Now create your project!

- Gather the sprites, costumes, sounds and backdrops
  *Remember to give them sensible names.*
- Then create the scripts
  *Make sure you have your algorithms in front of you!*

Test

Test your project to make sure it works.

Let your classmates test it too and note their comments below:

Good points: ___________________________________________
........................................................................
........................................................................

Bad points: ___________________________________________
........................................................................
........................................................................

Describe bugs that were found (by you or by testers) and how you fixed them:

Bug: _______________________________________________
Solution: ___________________________________________
........................................................................
........................................................................

Bug: _______________________________________________
Solution: ___________________________________________
........................................................................
........................................................................
Document

You’re now going to post your project on the Scratch website.

Write down below a brief description (50 words max.) of:

- your project’s **main features** and
- how to use them.

Remember – you want to get people to try out your project!

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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________________________________________________________________________

Once you have written the description, enter it into your project’s **Notes and Credits** on your project’s page on the Scratch website (you will need to be logged into the Scratch website and click to do so).
Evaluate

How did the project turn out compared to how you originally planned it?

________________________________
________________________________
________________________________

What mistakes did you make on the way?

________________________________
________________________________
________________________________

If you were to start again from the beginning, what would you do differently?

________________________________
________________________________
________________________________

Look at your code again.
Is there anywhere you could have taken a shortcut to make it “slicker”?

________________________________
________________________________
________________________________
Maintain

What additional features would make your project better?

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

Congratulations

You have now completed this introduction to Computing Science in Scratch!

Remember that you can use Scratch at home, so there’s no need for this to be the end of your time as a programmer.

http://scratch.mit.edu