Oxford International Lower Secondary

9

Computing

Student Book

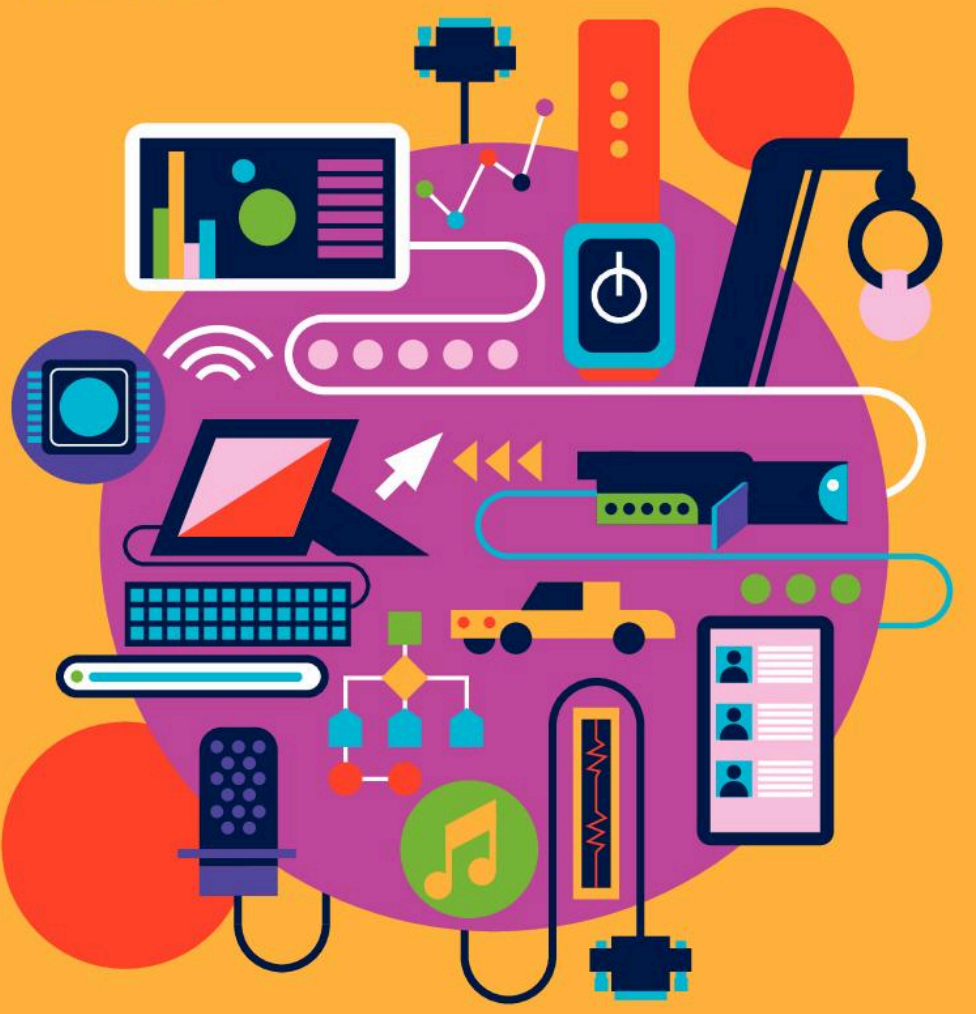
OXFORD

Oxford International Lower Secondary

9

Computing

Student Book



Alison Page
Diane Levine
Howard Lincoln
Karl Held

OXFORD

Contents

Introduction

Delivering computing to young learners

Oxford International Primary and Lower Secondary Computing is a complete syllabus for computing education for ages 5–14 (Years 1–9). By following the program of learning set out in this series, teachers can feel reassured that their students have access to the computing skills and understanding that they need for their future education.

Find out more at:
www.oxfordsecondary.com/computing.

Structure of the book

This book is divided into six units, for Year 9 (ages 13–14).

1. **The nature of technology:** What the processor is and how it works.
2. **Digital literacy:** How to participate safely in social media.
3. **Computational thinking:** The principles that underpin artificial intelligence (AI).
4. **Programming:** Using computer programs to model real-life systems and solve problems.
5. **Multimedia:** Creating a multimedia news site featuring sound and video.
6. **Numbers and data:** Using software for project management.

What you will find in each unit

- Introduction: An unplugged activity and a class discussion help students to start thinking about the topic.
- Lessons: Six lessons guide students through activity-based learning.
- Check what you know: A test and activities allow you to measure students' progress.

What you will find in the lessons

Although each lesson is unique, they have common features: learning outcomes for each lesson are set out at the start; learning content delivers skills and develops understanding.

Activity Every lesson involves one or more learning activities.

Extra challenge Activities to extend students who are able to do more.

Test A short test of four questions, of progressive difficulty, to check students' understanding of the lesson.

Additional features

You will also find these features throughout the book:

Word cloud The word cloud builds vocabulary by identifying key terms from the unit.

Be creative Suggestions for creative and artistic work.

Explore more Extra tasks that can be taken outside the classroom and into the home.

Digital citizen of the future Advice on using computers responsibly in life.

Glossary Key terms are identified in the text and defined in the glossary at the end.

Assessing student achievement

The final pages in each unit give an opportunity to assess student achievement.

- Developing: This acknowledges the achievement of students who find the content challenging but have made progress.
- Secure: Students have reached the level set out in the programme for their age group. Most should reach this level.
- Extended: This recognises the achievement of students who have developed above-average skills and understanding.

Questions and activities are colour-coded according to achievement level. Self-evaluation advice helps students to check their own progress.

Software to use

We recommend Python for writing programs at this age. For other lessons, teachers can use any suitable software, for example: Microsoft Office; Google Drive software; LibreOffice; any web browser.

Source files

You will see this symbol on some of the pages.

This means that there are extra files you can access to help with the learning activities. For example, half-completed Python programs or spreadsheet files.

To access the files, click 'Download resources' at:
www.oxfordsecondary.com/computing.

Teacher's Guides

For more on these topics, look at the Teacher's Guide that accompanies this book.

1 The nature of technology: Inside the CPU

You will learn

- about the three important parts of the central processing unit (CPU) and how they work together
- how computers can solve logic and arithmetic problems
- how robots are used in the modern world and what technology they use.

In Student Book 4 you learned that the processor (sometimes called the 'microprocessor') is at the centre of every computer system. The processor is responsible for all the work your computer does. It controls everything you see on screen. The processor is made up of millions of microscopic electronic switches.

In this unit you are going to put the processor under a microscope. You will look in more detail at the processor and its three main parts. You will learn how the three parts work together to get work done. Then you will look deeper inside to discover how the microscopic switches work.

In the last part of the unit you will learn about robots. You will learn how developments in robotics have been made possible by improvements in the way processors work.

Learning outcomes: Use or describe simple electronic logic gates (for example, AND, OR and NOT gates); Outline the structure of a processor, its components and how they work together; Describe some technical innovations that enable modern robotics

Did you know?

Colossus was the world's first programmable digital computer. It was switched on in December 1943. Colossus was invented to break enemy codes during the Second World War. The computer weighed 1 ton and filled an entire room. Modern cars might contain as many as 50 microprocessors. Each one of these is many times more powerful than Colossus.

In 2007 a replica of Colossus was built. It competed against modern computers of the day in a competition to break a complicated code. Colossus took 3.5 hours to break the code. The winner, a desktop computer, took 46 seconds.

Unplugged

Work in small groups to play a 'True' or 'False' game. Each group should split into two teams. Team A must think of an object. The object is kept secret from the other team, but Team A must say what type of object they are thinking about. For example, if the secret object is a lion, team A say that they are thinking of an animal.

Team B must work out what the animal is by making statements that can be answered with either 'True' or 'False'. In the lion example, statements could be:

Is a type of dog: False

Has a mane: True

Is a lion: True

Teams set each other challenges. The winner of each round is the team that discovers the secret object in the fewest turns.

Talk about...

The word robot comes from the Czech word *robota*. *Robota* means dull, repetitive work. Robots can do jobs that humans find boring and stressful. They can do these jobs 24 hours a day without making mistakes. Millions of jobs that humans do will be replaced by robots in the years ahead. How can we make sure that the changes robots bring will be positive?

computer system

central processing unit microprocessor

control unit arithmetic and logic unit (ALU)

RAM cache robots

vision guided robotics

embedded processor drone

1.1 Central processing unit

In this lesson

You will learn:

- what happens inside a processor
- about the parts of a computer's central processing unit (CPU).

Spiral Back

In Student Book 7 you learned that every file you store and use on a computer is made up of digital data. You learned that the brain of a computer is a microprocessor. Inside the processor are millions of tiny electronic switches. In this unit you will learn more about how the processor carries out its work.

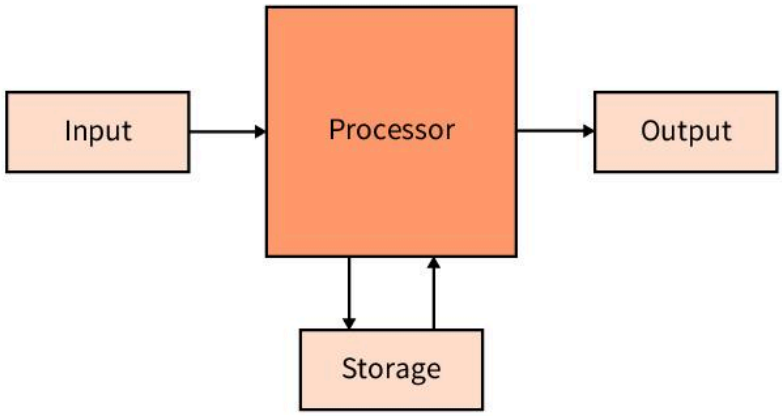
Computer systems

You have gained a lot of experience of using computers on this course and have learned many new and useful skills. Whenever you use a computer you are using a system. A **computer system** is a set of equipment that works together to help you do useful work. A computer system can be drawn as a simple diagram.

A computer system must always have input devices. Input devices allow you to put data into your computer. A keyboard is an input device.

A computer system has output devices. Output devices let you see the results of your work on the computer. A computer screen is an output device.

A computer system has storage devices. You use storage devices to save your work.



The processor

At the centre of your computer system is a processor. In Student Book 4, you learned that a processor does all the work in a computer system. A processor is small enough to fit on your fingertip. Modern processors are so small they are called **microprocessors**.

The central processing unit (CPU)

The **central processing unit** (CPU) is another name for the microprocessor at the centre of your computer system. It is the name to use when you study the computer processor in detail.

The CPU has three important parts: the control unit, the arithmetic and logic unit, and the clock.

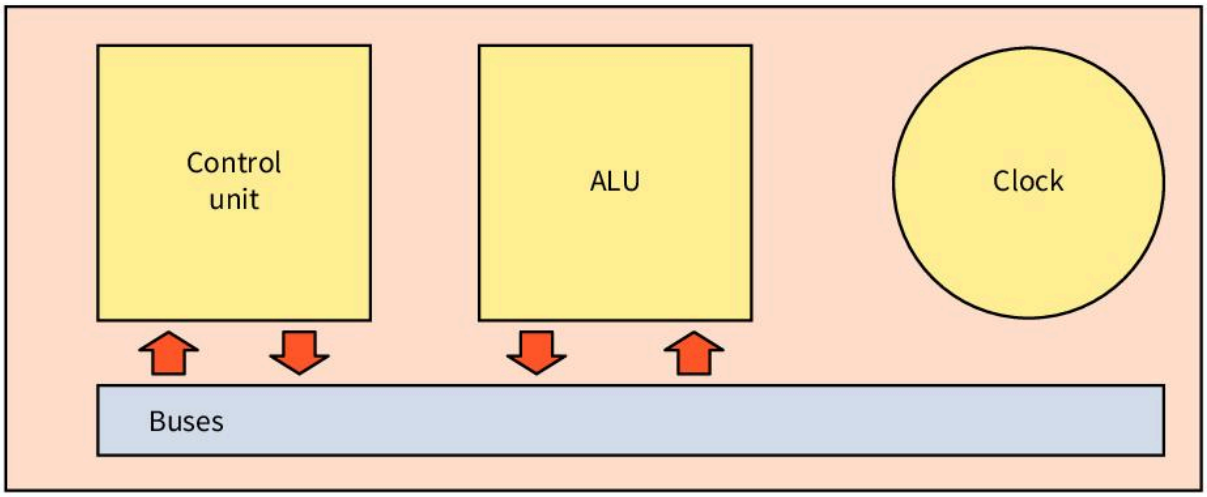
The **control unit** manages the work done by the CPU.

- When an instruction arrives at the CPU, it goes to the control unit.
- The control unit works out what the instruction means.
- The control unit makes sure that the other parts of the CPU do the work needed to carry out the instruction.

The **arithmetic and logic unit (ALU)** does all the calculations in the CPU. If you are working on a maths problem, you might use a spreadsheet to do your calculation. The control unit uses the ALU in the same way. The control unit sends instructions to the ALU. The ALU carries out the instructions.

The **clock** sends out regular electrical pulses just like the tick of a clock. A clock in your home ticks every second. The clock in the CPU of your computer ticks around 3 billion times every second. Every time the CPU clock ticks, the control unit sends an instruction to the ALU.

The CPU



Buses

The three parts of a CPU are joined together by connections called **buses**. Buses are high speed connections that carry data around inside the CPU. They are like the buses you see travelling around towns and cities. Instead of carrying passengers, the buses in a CPU carry data at very high speed.

How the CPU works

Think about the last time you played a game or watched a video on a computer. The screen is full of colour. The images you see are lifelike. Objects move just like they do in the real world.

Movement on-screen is smooth and fast. If you are playing a game, you can give instructions through a joystick or game controller. The action on-screen responds immediately to your command. High-quality audio is being played in the background while you play.

When you experience a game being played on a computer it is easy to think that the CPU must be doing very complicated things. In fact, the CPU can perform only very simple instructions.

For example, a CPU might be asked to add two numbers together with an instruction like 'ADD 2, 3'. Even this simple task has to be broken down into several smaller tasks before the CPU can complete it.

So a CPU can only do very simple tasks. What makes it seem so powerful is that it can do a task every time its clock ticks. The clock in a CPU clicks 3 billion times every second. A computer can appear to do amazing things by doing a lot of very simple tasks, very quickly.

Activity

This activity will give you an idea of how fast a computer CPU does its work. You need two team members for this game, and somebody to time them. Read the instructions and make sure you understand them. Have a practice run.

Start the timer.

1. Team member A: Say an action: 'Add', 'Multiply' or 'Subtract'.
2. Team member B: Write down the action.
3. Team member A: Say a single-digit number (1 to 9).
4. Team member B: Write down the number.
5. Team member A: Say a single-digit number (1 to 9).
6. Team member B: Write down the number.
7. Team member A: Tell team member B to work out the answer to the sum.
8. Team member B: Work out the answer.
9. Team member B: Write down the answer.
10. Team member A: Read the answer out loud.

Stop the timer and note how many seconds the task took.

A CPU can carry out the same task 300 million times every second. Multiply the number of seconds it took you to complete the task by 300. That is the number of times (in millions) that a CPU would have done the task in the time it took your team to do it once.

Extra challenge

Three students are working together on the activity. Team member A gives the instructions. Team member B carries out the calculations. Team member C operates the timer. Which part of the CPU does each team member represent?

Test

1. What are the three main parts of a CPU?
2. How does data move between the parts of a CPU?
3. Say one change you could make to a CPU to make a computer work faster.
4. Write two places that instructions for the CPU come from.

1.2 The fetch-execute cycle

In this lesson

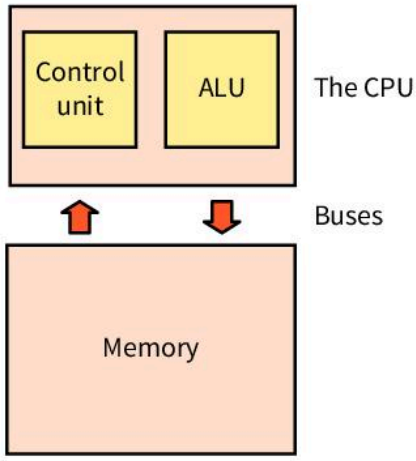
You will learn:

- what computer memory is
- what happens when a computer carries out an instruction.

Memory and the CPU

The CPU is the part of the computer that carries out instructions. You learned in the last lesson that it is made of a control unit, the ALU and a clock, all connected by buses.

The computer's memory is very close to the CPU. It is joined to the CPU by buses. Some people use the word 'processor' to mean the CPU and the memory.



The computer's memory is sometimes called:

- the memory unit
- IAS (Immediate Access Store)
- **RAM (Random Access Memory)**.

What is in memory?

Memory holds:

- the instructions that tell the computer what to do
- the data values that the computer needs.

In a modern computer the instructions and data are held in the same memory. But they go down two different buses to the CPU.

The memory holds one more thing: the results of the CPU's work.

When the CPU has completed an instruction, it sends the results back to memory.

How does memory work?

Memory is made of microscopic electrical circuits. The circuits can be on or off. Everything inside the memory is stored using these on/off signals.

If you completed Unit 1 of Student Book 7, you learned how data is stored inside the memory using on/off signals.

Memory and storage

Data is stored in memory as electrical signals. But if the electricity is turned off, all the data will be lost. This is why you must always save your work before you turn the computer off.

When you save your work, it is copied from memory to storage. Here are some examples of storage:

- the hard disk of your computer
- a flash memory drive
- the storage on your school network
- cloud storage on the internet.

The important thing about storage is that it stores the data even when the computer is turned off. That means that your work is not lost. Storage is also called **secondary storage**.

Advantages and disadvantages

Both RAM (electronic memory) and storage have advantages and disadvantages.

RAM is very close to the CPU. The CPU can get data and instructions from RAM easily and quickly. The disadvantage of RAM is that its contents are lost when the computer is switched off.

Secondary storage is further away from the CPU. It takes longer for the CPU to get data and instructions from secondary storage than from RAM. But secondary storage has a big advantage – it can keep data and instructions safe when they are not needed, or when the computer is turned off.

Activity

Complete this table to show the advantages and disadvantages of RAM and secondary storage. The first section is done for you.

	RAM	Secondary storage
Advantages	It is close to the CPU. The CPU can get data and instructions from RAM easily and quickly.	
Disadvantages		

The fetch-execute cycle

The CPU carries out instructions millions or even billions of times a second. Every time it carries out an instruction it follows these steps.

- **Fetch:** The control unit 'fetches' the instruction from RAM. The instruction travels down the bus from RAM to the control unit.
- **Decode:** The instruction is in the form of a binary number code. The control unit knows all the binary number codes. The control unit 'decodes' the instruction, so it knows what to do.
- **Execute:** The control unit sends a signal to the ALU to tell it what to do. The ALU carries out the instruction. 'Execute' means carry out an instruction.
- **Save:** If the instruction produces a result, then the ALU sends the result back to RAM.

These steps are called the **fetch-execute cycle**.

The computer might also need to fetch some data from RAM. Some computers fetch instructions and data in one cycle. Some computers fetch instructions and data in different cycles.

Worked example

In Student Books 7 and 8 you created programs in Python. You will create more programs in this book. Here is a single command written in Python.

```
answer = 2 + 3
```

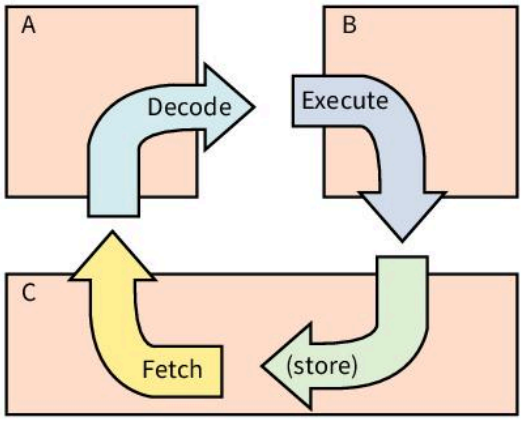
To carry out this instruction the computer must complete at least one fetch-execute cycle.

- **Fetch:** The control unit fetches the instruction (add) and the data values (2, 3) from RAM.
- **Decode:** The control unit decodes the instruction and sends a signal to the ALU, telling it to add the numbers together.
- **Execute:** The ALU carries out the instruction, and adds the two numbers together.
- **Save:** The ALU sends the result of the addition back to RAM. The result is saved in a memory location with the label 'answer'.

Some computers can do all this in one cycle. Some computers will fetch the instructions and the data in different cycles.

Fetch-execute diagram

You can draw the fetch-execute cycle using a simple diagram like this.



Activity

The parts of the fetch-execute cycle happen in different places:

- in memory
- in the control unit
- in the ALU.

Draw the diagram of the fetch-execute cycle. Instead of letters A, B and C, put the name of the place where each part of the cycle happens.

Memory and computer speed

In the last lesson you learned that the speed of the clock affects the speed of the computer. But the size of memory is also important.

RAM

If a computer has lots of RAM, then all the data and instructions can fit into the memory. The CPU can get the data and instructions very quickly. The computer will go quickly.

If a computer doesn't have very much memory, then the data and instructions won't all fit into memory. Some will have to wait in storage. The computer will go more slowly.

Cache size

The CPU has a small amount of memory which is even closer than RAM. This is called **cache**. It is very quick for the CPU to get data and instructions from cache. If a computer has a big cache then it will be able to get all the data and instructions quickly.

Word size

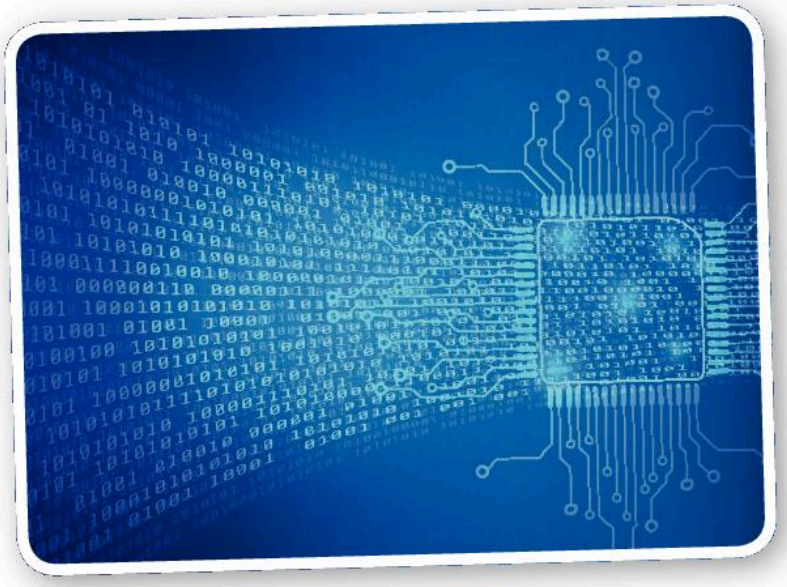
You have seen that some computers can fetch a lot of data from memory in one cycle. Other computers need several cycles. The amount of data that a computer can fetch and use in one cycle is called the 'word size'. A computer with a large word size generally works more quickly. The buses are larger so they can carry more.

Extra challenge

A friend wants to buy a fast computer. Write an email telling them what to look out for when they choose a computer. One factor is clock speed, but there are others. Tell your friend about some other factors that affect the speed of a computer. Explain why each one is important.

Test

1. What is the difference between memory and storage?
2. List the four stages of the fetch-execute cycle.
3. Describe what happens during the 'execute' stage of the fetch-execute cycle, and where it happens.
4. Explain why a computer with lots of RAM (memory) will generally go faster than a similar computer with less RAM.



1.3 The CPU and logic

In this lesson

You will learn:

- how the ALU processes logical problems
- how to write a logical argument
- how to draw a truth table.

Arithmetic and logic

You have learned that the CPU contains an arithmetic and logic unit. In the activity in Lesson 1.2 you learned how the ALU can do arithmetic.

If you are playing a game on your computer, you can see the result of the ALU performing arithmetic. For example, the strength of your character increases when you pick up energy during a game. A value is added to your existing strength total.

A game would not be interesting if it only used arithmetic. A game must also include challenges. For example:

- Does the treasure chest contain gold coins?
- Does the key open the treasure chest?

Challenges like these cannot be solved using arithmetic. They need logic. In this lesson you will learn what logic is and how it is used by the ALU.

What is logic?

Think about the statement 'the treasure chest contains gold'. There are two possible conditions. The statement can be true or false. 'The key opens the treasure chest' is a logical statement. A logical statement can be used to say if something is true or false.

Activity

'It is raining' is a logical statement. It could be true or false. Write two more logical statements about the weather.

Logic and the ALU

The computer is a digital device. A computer processor is made up of electrical switches. The electrical switches in a computer can be on or off. A computer is called a **two-state** device.

Logic also has two states. The two states are true and false. A logical statement can be true or it can be false. A computer's ALU can process logical statements. It can do so because both logic and the computer use two states.

					
OFF	ON	ON	OFF	ON	OFF
0	1	1	0	1	0

In a computer we use binary to show the state of a switch. A '1' is used to say a switch is 'on'. A '0' says a switch is 'off'. We can also use binary to show the state of a logical statement. A '1' can be used to show a statement is true. A '0' can be used to show it is 'false'.

Linking logical statements

Logic is not just about saying whether statements are true or false. Logical statements can also be used to draw conclusions from data and make decisions. To use logic to draw conclusions you must be able to combine logical statements. The word 'then' is used to combine logical statements.

Here are two logical statements about a computer game:

- Player has no lives.
- Game is over.

Each of the two statements can either be true or false. You can link the two logical statements using the word THEN:

- Player has no lives THEN Game is over.

When two statements are linked, they can be used to draw conclusions. We can say:

- 'Player has no lives' is true THEN 'Game is over' is also true.
- 'Player has no lives' is false THEN 'Game is over' is also false.

Activity

Can you think of any occasion when you have used logical statements while learning computing skills? Write down any you can think of. For each, give an example of the logical statements you have used.

Parts of a logical statement

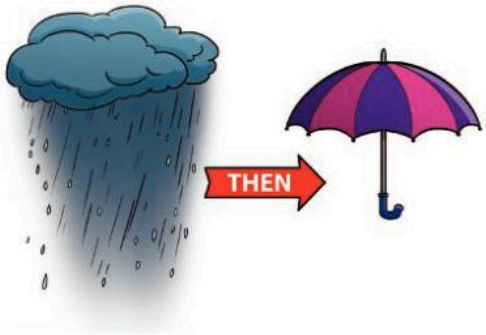
To make it easier to talk about logic, the two parts of a linked statement have names.

In a logical statement, everything to the left of THEN is called the **proposition**. Everything to the right of THEN is called the **conclusion**.

The whole statement is called a **logical argument**.

Proposition		Conclusion
Player has no lives	THEN	Game is over

Activity



The first activity used 'It is raining' as an example of a logical statement. This statement is used as a proposition in the table below. The conclusion 'Open umbrella' has been linked to the statement. Now we can say that if 'It is raining' is true then 'Open umbrella' is also true.

It is raining	THEN	Open umbrella

In the activity you wrote logical statements about the weather. Copy the table. Write a conclusion to match each of the propositions you wrote.

Truth tables

A **truth table** is a way of laying out a logical statement in table form. It is easier to understand the logic when it is laid out in a table. A written description can be confusing, especially for complex logical statements.

There are four steps in creating a truth table.

1 **Write out the argument.** Always write THEN in upper-case letters to show that it links the statements:

Player has no lives THEN Game is over

2 **Create the column headings.** Your table needs a column for each statement in your argument. There are only two statements in this example but there can be more. Always write the conclusion in the last column on the right. There is no need to use THEN in your table.

Player has no lives	Game is over

3 **Add a row for every possible response to the proposition.** In this example, the proposition is 'Player has no lives'. There can only be two responses: false or true.

Player has no lives	Game is over
FALSE	
TRUE	

4 **Complete the conclusion column.** Fill in the correct value for each possible response to the proposition.

Player has no lives	Game is over
FALSE	FALSE
TRUE	TRUE

In this simple example we have used logic to show that when a player has no lives in a game, then the game is over. Logic also shows that when the statement 'Player has no lives' is false, then 'Game is over' is also false. While you have lives, you can keep playing.

Activity

Create a logical statement that is in the same form as the example in this lesson. You might use an example based on a computer game you play. You might choose a sport or hobby you enjoy.

Write a logical statement. Draw the truth table for your statement.

Extra challenge

The logic described in this lesson is sometimes called Boolean logic. Use the internet to find out why it is called Boolean logic. Find two interesting facts about George Boole and his life.

Test

1 Put these terms in the order they appear in a logic argument:

THEN | conclusion | proposition

2 What are the two states used in logic?

3 What two types of operation can an ALU do? Give an example of each.

4 Say why a computer's ALU can process logic problems.

1.4 Complex logical statements

In this lesson

You will learn:

- how to link logical statements using AND/OR
- how to write complex logical arguments that include more than two statements.

Increasing complexity

In the last lesson you learned that computers can handle logic problems as well as arithmetic. You saw how a simple problem can be written as a logical statement like this one:

Player has no lives THEN Game is over

All the examples in the previous lesson had just two parts linked by a THEN statement.

In this lesson you will learn how to use logic to describe situations where there are more parts to the logical argument. Here is an example. Your local football club want to sign a new star player. The manager has asked the team owner to sign a player who scored 30 goals last season. The manager also wants the player to be left-footed. Here are the key points:

- Club signs player
- Player is left-footed
- Player scored 30 goals.

Using AND to link logical statements

The team manager decides to write the problem as a logical statement. He will hand the team owner a truth table to make sure the right player is found. He will use the four stages described in Lesson 1.3.

1 **Write out the argument.** The first step is to identify the conclusion. There is only ever one conclusion to a logical argument. The conclusion is a desired outcome. In this case the conclusion is 'Club signs player'.

Once you have identified the conclusion, any other statements are part of the proposition. In this case there are two statements: 'Player is left-footed', 'Player scored 30 goals'.

The two statements must be joined together. Statements in the proposition can be joined using AND or OR. In this case, the manager wants both statements to be true. If both statements must be true, join them with AND. Player is left-footed AND Player scored 30 goals THEN Club signs player.

2 **Create the column headings.** In this example the table must have three columns. The conclusion must always go in the column on the far right of the table.

Player is left-footed	Player scored 30 goals	Club signs player

3 **Add a row for every possible response to the proposition.** A two-part statement always needs the four responses in the table below. Read them carefully. Make sure you understand that no combination of true/false is missed out.

Player is left-footed	Player scored 30 goals	Club signs player
FALSE	FALSE	
FALSE	TRUE	
TRUE	FALSE	
TRUE	TRUE	

4 **Complete the conclusion column.** The two parts of the proposition are joined by AND. This means that the conclusion will be true only if both parts of the proposition are true.

Player is left-footed	Player scored 30 goals	Club signs player
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

The final table tells us that 'Club signs player' is true only when both 'Player is left-footed' AND 'Player scored 30 goals' are true. If either of the statements is false, then 'Club signs player' is also false.

Activity

Sonia wants to buy her mother a present. She wants to buy a blue vase. She has $5 saved for the present. She sees a vase in a shop window. Write a logical argument and truth table to determine if she can buy the vase.

Using OR to link logical statements

Here is a different kind of problem. An extra life is awarded in a computer game if the player reaches 10,000 points **or** collects five stars during a game. In this example, use the word OR to join the statements together. It will look like this:

10,000 points reached OR five stars collected THEN extra life awarded

A truth table will help to make sense of this statement. This time we will jump straight to step 3: Add a row for every possible response to the proposition.

10,000 points	Five stars	Extra life
FALSE	FALSE	
FALSE	TRUE	
TRUE	FALSE	
TRUE	TRUE	

Notice that the true and false entries are the same as in the previous example. If you replace false with a 0 and true with a 1 you will have the binary numbers 00, 01, 10, 11. In decimal that is 0, 1, 2 and 3. That may help you remember how to write the true and false entries into the table.

Step 4 is to complete the conclusion column. Extra life is true if either 10,000 points reached OR five stars collected is true.

The completed table looks like this:

10,000 points	Five stars	Extra life
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

The table can be used to draw conclusions. The table tells you that if a player reaches 10,000 points or gathers five stars, they get an extra life in the game. Also, the player gets an extra life if both 10,000 points are reached **and** five stars are collected.

Activity

A building is equipped with smoke sensors and heat sensors. If either sensor is triggered, an alarm must sound so that the building can be cleared. Write a logical argument and truth table to describe this system.

Extra challenge

A bank is equipped with a high security safe. To open the safe:

- a key must be turned in a lock
- a personal pin number must be entered
- the alarm must be turned off.

Draw a truth table for this system. Your table will need eight rows.

Test

Complete the missing word in questions 1 and 2.

1. Mark 40% or greater _____ work handed in on time THEN Student gains pass.
2. Sun is shining _____ it is raining THEN Wear a hat.
3. How many combinations of true/false are there for a logical argument with three parts to the proposition? (For example, a AND b AND c THEN d.)
4. What is the maximum number of conclusions in a logical argument?

1.5 Logic gates

In this lesson

You will learn:

- how to describe the AND, OR and NOT logic gates used in a computer
- how to draw truth tables for AND, OR and NOT gates
- how computer logic gates compare to logic in the real world.

A computer can carry out complicated tasks such as creating realistic game worlds. It can navigate spacecraft through space. How is this possible when a computer is only made up of switches that can be turned on or off?

Those switches can be combined together into larger units. The larger units can perform more complicated tasks. Those units are called gates. In this lesson you will learn about three types of gate that are used in a computer:

- the AND gate
- the OR gate
- the NOT gate.

You have learned that logical statements using AND and OR can be used to describe situations we come across in everyday life and in computer games. Now you will learn how the computer's ALU uses logic gates to control programs such as games.

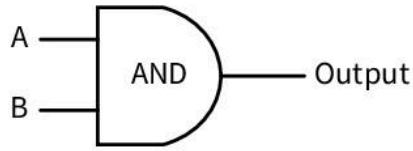
The AND gate

You have learned how using AND in logical statements can describe problems. For example, you drew a truth table for the logical argument:

Player is left-footed AND Player scored 30 goals THEN Club signs player

Imagine you are writing a football manager game. How will the computer running the game make sure the manager signs the right player?

The CPU is made up of millions of on-off switches. Those switches are organised into larger units called **gates**. One of those gates is the **AND gate**. Each type of gate that a computer uses has its own symbol. The symbol for the AND gate is shown in the image.



The AND gate has two inputs. They are called A and B. The gate is inside the CPU so it can only understand binary. The value of each input can be either 0 or 1. The output of an AND gate is 1 if **both** input A and input B are 1. Otherwise it is 0.

You can draw a truth table for the AND gate in the same way that you drew truth tables for logical statements in Lessons 1.3 and 1.4.

1 Label the table: The AND gate.

2 Insert column headings for all inputs and outputs.

The AND gate

A	B	Output

3 Enter the possible values for the inputs.

The AND gate

A	B	Output
0	0	
0	1	
1	0	
1	1	

4 Complete the output column.

The AND gate

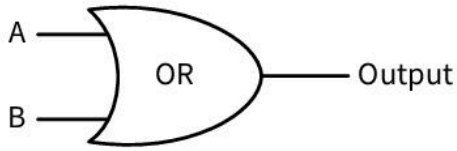
A	B	Output
0	0	**0**
0	1	**0**
1	0	**0**
1	1	**1**

Check that you understand why the pattern of zeros and ones is as it appears in the table. This is an AND gate. The output is only 1 when both input A AND input B are 1.

The pattern of zeros and ones in the AND gate truth table is exactly the same as the pattern of true/false in the truth table for the AND logical statement. That is how the CPU is able to carry out logical operations.

The OR gate

Another type of gate the computer uses is an **OR gate**. The OR gate has its own symbol too.



The OR gate has two inputs. They are labelled input A and input B. It has one output. The value of each input can be either 0 or 1. The output of an OR gate is 1 if **either** input A **or** Input B **or** both is 1.

The truth table for the OR gate looks like this. It is exactly the same as the OR truth table you saw in the last lesson. Because of this the CPU is able to use the OR gate to perform logic.

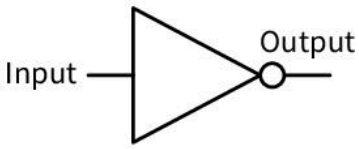
The OR gate

A	B	Output
0	0	**0**
0	1	**1**
1	0	**1**
1	1	**1**

Check that you understand why the pattern of zeros and ones in the output column is as it appears in the table.

The NOT gate

Other gates are used in a computer. They help us get the answers we need. A NOT gate has only one input and one output. A **NOT gate** reverses the input. If the input is 1 the output is 0. If the input is 0 the output is 1.



The truth table for a NOT gate looks like this:

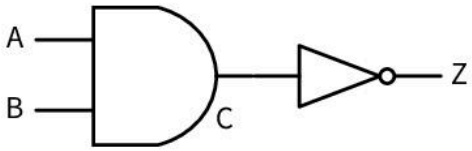
The NOT gate

Input	Output
0	**1**
1	**0**

Gates always have only one output. All gates except the NOT gate have two inputs.

Circuits

In this lesson you have learned about the AND and OR gate. You have seen that they can be used by the ALU to solve logic problems. That is because they act in the same way as logic statements in the real world.



Gates become more powerful and more useful when they are joined together. When gates are joined together, they form a **circuit**. The image shows a simple example of a circuit.

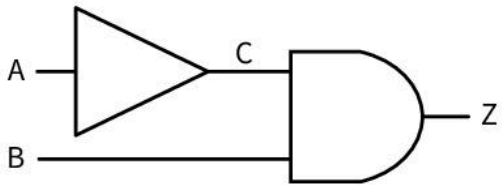
To create a truth table for a circuit, you must create a column for every input and output. You must include any connections that link two gates. In this example there are two inputs to the left of the circuit (A and B) and an output on the right (Z). You also need a column for the input to the NOT gate (C).

Enter all the possible values for the inputs, A and B, first. Then enter the values for column C. This is the output of the AND gate. Finally, enter the values for column Z, using the values in column C as the input.

A	B	C	Z
0	0	0	**1**
0	1	0	**1**
1	0	0	**1**
1	1	1	**0**

Activity

Draw the truth table for this simple circuit.



Extra challenge

Other logic gates used in computers include the NOR gate and the NAND gate. Research the web to find out about these two gates. Draw the symbol and a truth table for each of them.

Test

1. How many outputs do gates have?
2. Describe what a NOT gate does.
3. When does an OR gate give an output of 1? Explain your answer using a truth table.
4. The shapes of the AND, OR and NOT gate symbols have something in common. What is it? Why do you think they share that shape?

1.6 Robots and robotics

In this lesson

You will learn:

- what robots are used for and what they might be used for in the future
- about the technology used in robots.

What is a robot?

A **robot** is a machine that is designed and programmed to carry out tasks at speed and with great accuracy. A robot is autonomous. This means it can work independently without constant human intervention. A robot senses and responds to its environment.

The advantages of robots

- Robots carry out repetitive work reliably. They don't get bored or make mistakes.
- Robots work quickly. They can work for 24 hours a day if needed.
- Robots can work in dangerous environments that would be risky for humans.
- Robots can work in restricted spaces where humans cannot reach.
- Robots work with hazardous materials like chemicals and radioactive material.

Digital citizen of the future

Robotics is the science and technology of robots. It is a growing area of work for computer scientists and engineers. Do you think you will work with robots in the future? Research the internet to find information on careers in robotics.

How are robots used?

Robots have become vital tools in many industries. The car and electronics industries already depend on robots. The range of jobs that robots are used for is growing as robot design improves.

Robots in manufacturing

In manufacturing industries, robots do repetitive jobs such as soldering electrical components or making microchips. Accuracy is very important in the production of microprocessors. A tiny mistake can mean the processor does not work properly. Robots work quickly and do not make mistakes.

In car factories, robots are used to paint cars. This is a hazardous job for humans.

Robots in agriculture

Agriculture is one of the fastest growing areas for robots. Robots can be used both in glasshouses and out in the fields. Crop spraying by plane is one of the most dangerous jobs humans do. **Drones** are now used to spray crops. Robots are being developed to harvest crops including soft fruits like berries.

Some farmers use tractors and other farm equipment that uses satellite guidance to plough fields and do other jobs. Fully autonomous tractors will soon be a feature on farms. Fully autonomous equipment has been developed for jobs like removing weeds.

Robots in medicine

Robots have many applications in medicine. Surgeons work with robotic surgical instruments to perform surgery they could not do with their own hands. This means that surgery can take less time and patients recover faster.

Robotic equipment is used to scan patients. It can create a detailed 3D image of internal organs. This helps doctors to make an early and accurate diagnosis of illness. Robots are also being used to help patients recover. A robot has been developed that lifts patients in and out of bed. It is more comfortable for the patient and saves nurses from injury.

Robots in distribution

Distribution centres store goods that are sent out to shops or to customers who have purchased them online. Robots are used to pick goods that are to be sent to shops and customers. Distribution centres might use drones and autonomous robot vehicles in the future to deliver goods. Drones can deliver vital goods to remote areas quickly.

Disaster recovery

Natural and man-made disasters create dangerous environments for humans to work in. Buildings might be damaged and unstable. Areas might be polluted with chemicals or radioactive material. Fires might break out. Robots are ideal for this situation. They have sensors to help assess dangers. Infrared sensors can help detect people that need to be rescued. Robots can be equipped with mechanical tools to solve problems or take samples from a disaster site.

The technology of robots

The growth of robots has depended on the advances in technology. Some key developments are listed here.

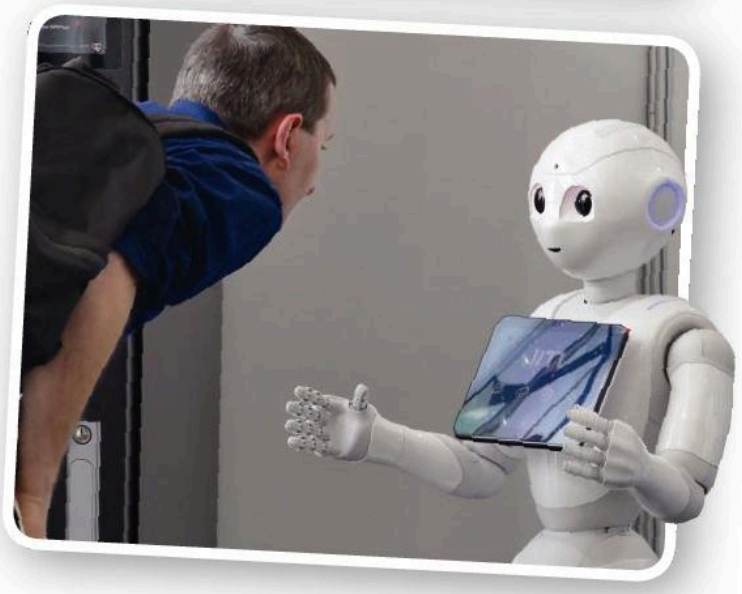
Sensors

To be autonomous and act independently, robots must be able to sense the world around them.

- **Proximity sensors** use infrared light beams to detect the position of nearby objects.
- **Bumper switches** tell a robot that it has hit something.
- **Pressure pads** are used to control robot hands as they pick objects up. They stop the robot hand crushing objects.

There have been important new developments in recent years.

Vision guided robotics (VGR) allows robots to use video cameras to see in 2D and 3D. Sophisticated software allows a robot to identify objects and interact with them. In older robot systems, items had to be in the right position for the robot to pick up and use.



Voice recognition and **natural language processing (NLP)** are giving robots a sense of hearing. In time we might be able to speak and give instructions to a robot as if we were talking to a human assistant.

Microprocessor development

Microprocessors have become smaller and more powerful. This has allowed powerful processors to be embedded into robots. **Embedded processors** are important. They allow the robot freedom of movement. Robots carry the processing power they need with them.

Parallel processing uses several CPUs working together to create faster, more powerful processors. Two, four or even eight CPUs work together. This provides the processing power needed by sophisticated robots.

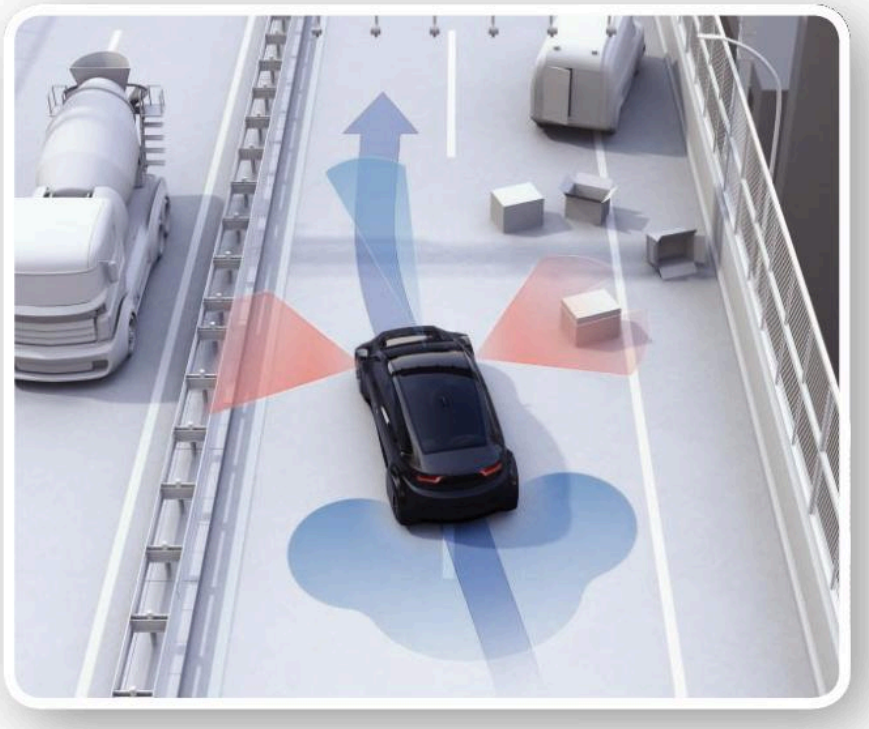
Artificial intelligence

Artificial intelligence (AI) is the use of computers to simulate intelligent behaviour. Robotics is a major area of research in AI. In the future, AI might allow robots to learn and improve the way they do jobs without human input. Robots might use the cloud to pass what they have learned onto other robots. You will learn more about artificial intelligence in Unit 3.

Real time operating systems

Robots operate in the real world. They must respond to events as they happen. This is called real time. **Real time operating systems (RTOS)** have been developed to allow robots to work in the real world.

An RTOS runs several jobs at the same time. Each job is given an importance rating. If an important job starts, it is given all the processing power it needs. Safety processes have a high importance rating. If the RTOS detects a possible collision, the process that avoids collision is given all the processing it needs. Other jobs stop until the important job has finished.



Activity

Choose one of the industries described in this lesson where robots are used. Do research on the web to find out more about the use of robots in this industry.

Extra challenge

Find out what technologies are used in the industry you looked at in the activity.

Explore more

An autonomous car is a kind of robot. An autonomous car drives itself with no human control. Talk to your family about autonomous cars. Would they feel comfortable driving around town in an autonomous car? Write down the arguments people give for and against.

Test

1. Describe how robots can help doctors.
2. What are the advantages of using robots in manufacturing industries?
3. Say two ways that sensors allow computers to sense the world around them.
4. Say how artificial intelligence can improve the way robots operate.

Check what you know

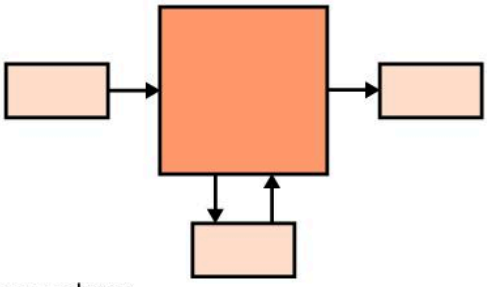
You have learned

- about the three important parts of the CPU and how they work together
- how computers can solve logic and arithmetic problems
- how robots are used in the modern world and what technology they use.

Try the test and activities. They will help you to see how much you understand.

Test

1 This is a diagram of a computer system. Draw this diagram and add the following labels in the right place.

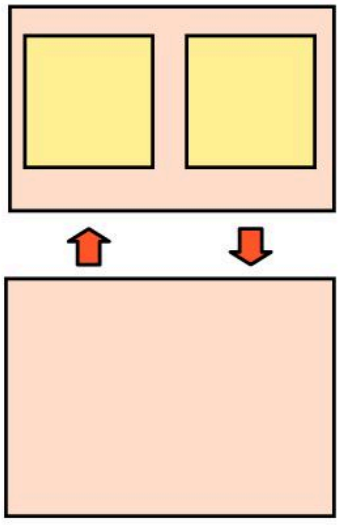


- Processor
- Input
- Output
- Storage

2 Draw a diagram of an OR gate.

3 Draw a truth table to match the gate you drew.

4 This diagram shows the parts of a processor, plus the memory. Copy the diagram and add the following labels.



- CPU
- Memory
- ALU
- Control unit
- Buses

5 Draw a diagram of the fetch-execute cycle, labelling each stage.

6 Describe one way you can improve the performance (speed) of a computer. Explain why it makes the computer go faster.

7 Draw a circuit made of an AND gate followed by a NOT gate.

8 Draw the truth table to match the circuit you drew.

Activities

Write a report about the use of robots in an industry or profession. For example, car manufacturing, agriculture or medicine. Work on the industry you chose in the activity in Lesson 1.6, or choose a different industry.

1 Describe some of the ways that robots are used in the industry you have chosen.

2 Say what developments in technology have led to greater use of robots in the industry.

3 Choose one of the technologies you described in activity 2. Give examples of how that technology has made robots more useful.

Self-evaluation

- I answered test questions 1 and 2.
- I completed activity 1.
- I answered test questions 1–4.
- I completed activities 1 and 2.
- I answered all the test questions.
- I completed all the activities.

Re-read any parts of the unit you feel unsure about. Try the test and activities again – can you do more this time?

2 Digital literacy: Dilemmas

You will learn

- what social media is
- how to care for yourself and others online
- how to manage your digital footprint and privacy
- how to keep a healthy balance between screen time and offline time.

Everyday life is full of dilemmas. A dilemma is a situation where you have to make a difficult choice between two or more things. Sometimes all of your choices are great options. Sometimes all of your choices are very challenging.

When you use digital technologies you are faced with choices and dilemmas. Because you already understand many aspects of digital technologies and how they work, you will be able to make good decisions when you are faced with a dilemma. But everyone makes mistakes – it is an important part of growing up. Some technologies mean that your mistakes can be shared with many other people. They might be online for people to see for a very long time.

Social media are **interactive** technologies. You can use them to make and share things online. You can share ideas and thoughts, images, videos and writing. The things you make yourself are called user-generated **content**. In this unit you will learn about the dilemmas you might face when you use social media. In each lesson, you will be given a different dilemma to think about. You will learn how to use social media safely and responsibly.

Learning outcome: Understand how to use social media safely, responsibly and with regard to others

Unplugged

What social media sites can you think of? Make a class list of names. Can you remember the logos of these sites? Working in groups or on your own, draw the logos of as many sites as you can. Next time you go online, check whether you got the logos right.

Did you know?

In 2018, 500 hours of video content was added to one popular video-sharing social media website every second.

Talk about...

Companies like to show their adverts to the people that will be most interested. This is called targeted advertising.

What kinds of information might companies want to know about their users? How can they use that information to target their adverts?

social media content
privacy cookie digital footprint
addictive design ethics of care
post curate humane design
interactive

2.1 Who am I?

In this lesson

You will learn:

- why people might make fake social media accounts.

Spiral Back

In Student Books 7 and 8, you learned how to use content from online sources. You learned how to explain risks you take when you use the internet. You carried out an online research project, and thought about how computers can help with learning and discovery.

What does it mean to 'be yourself'?

Humans are very complicated living things. We change as we grow. We work together and alone. We understand the world around us in different ways. We start friendships, argue, and make friends again. We want to make a difference in the world. We want to be treated with respect.

Activity

Work with someone in your class. Talk to each other about these topics. Make notes about each other's answers:

- I am good at…
- I would like to get better at…
- I am happy when…
- I worry about…
- At home I enjoy…
- At school I enjoy…

The way you see yourself is called your self-concept. Your self-concept is linked to how you feel about yourself. Talk together about what your answers might tell you about your self-concept.

How do you present yourself online?

What do you think could be inside each of these boxes? Perhaps it is something nice. Perhaps it is something unpleasant. Perhaps it is nothing. The outside of the box does not tell us very much about what is inside.

Our digital lives are a bit like these boxes.

What does the outside of your box look like? What faces do you choose to show online?

What is inside your box? How do you choose to communicate online? How do you choose to behave online?

Fake social media profiles

Some people choose to set up more than one social media profile. They have more than one box they choose to show others online. There are many reasons why you might set up a fake social media profile:

- To protect yourself.
- To allow you to express your individuality without being criticised by others.
- To try out different types of personality or sides of your own personality.
- To share, or **post**, content that only certain people will be interested in, for example hobbies. These are called affinity groups. Affinity means that you like something. For example, you might really like a book. You could find other people who like the book on social media. You could communicate about the book with other fans using a website or app.

  But you might be embarrassed about liking the book. You might not want anyone else to know. So you might set up a fake profile. Then you could post without other people knowing who you are.

  Some people set up fake profiles in affinity groups for more serious reasons. They might want to gather information about the things people like so that they can target adverts at them. They might want to influence people to change their minds about the things they like. They might want to meet people who they should be kept away from.
- To post content that is personal for friends or family. For example, you might have had a bad grade at school. You might need to talk to someone about it, or ask for help to improve the grade.
- To post private thoughts, rude or worrying content. Then nobody in everyday life will be able to link the profile with the person who posted the content.

Risks of fake social media profiles

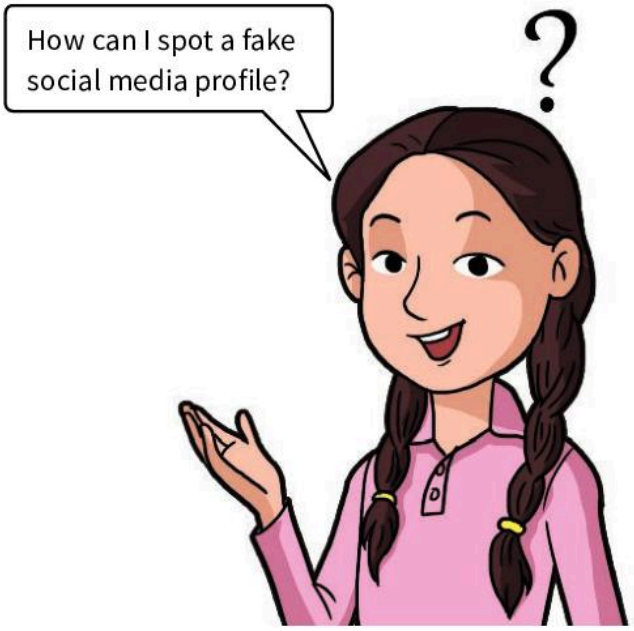
Some reasons for setting up a fake social media profile are positive. But a fake social media profile could harm you or other people.

When you use a fake social media profile, nobody knows who you are. You might see content that is not appropriate. It can be hard to keep track of which profile you are using. You might accidentally upset people if you post a comment from the wrong profile.

Many fake social media profiles are trying to get personal or private information from you or people close to you, or take money from you. Some fake social media profiles might try to influence your views on important issues.

Many people and organisations use fake social media profiles. This makes it very difficult to know who to trust online.

How to spot a fake social media profile



1. **The content does not make sense.** For example, the person might share very different views over a short period of time. They might use language that does not make sense.
2. **The profile has very little activity.** If the only content on the profile is a picture, then it is likely that the profile is fake.
3. **They follow a surprisingly large number of people.** If someone has only a few followers, but is following thousands of people, be on your guard.
4. **The profile picture looks fake.** Some browsers have a reverse image search function. Use this to see if the photo came from a real person.

Activity

Create this table using a word processor or spreadsheet program:

Fake accounts can be harmful	Fake accounts can be useful

Complete the table. Why can fake accounts be both harmful and useful?

Extra challenge

Discuss the following question in a group. When you 'go online', are you really going to different places?

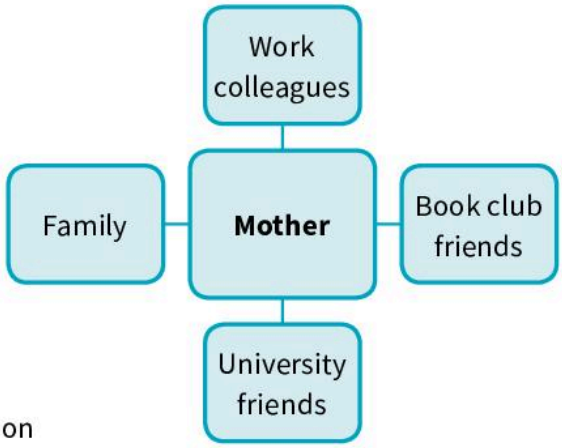
Explore more

More than two billion people around the world use the internet. Find an adult outside school who uses social media. Draw a network of the different types of people the adult connects with on social media.

The map could look something like the one on this page.

You can add as many new lines and boxes as you like.

Does the diagram include any people the adult does not see very often? Does the adult worry about the ways they use social media?



Test

1 Name three different types of content that could be posted on social media.

2 What sort of person would you like to be seen as online?

Amanda has set up three different social media profiles.

3 Give a possible reason for each of the three social media profiles Amanda has set up.

4 Explain the risks Amanda faces by setting up so many different social media profiles.

2.2 Types of social media

In this lesson

You will learn:

- about different types of social media
- about what information is safe to share with people online
- how to recognise warning feelings and how to act on them.

Types of social media

There are lots of different types of social media.

Social networking sites

Social networking sites help you to connect with family, friends, new people, and people trying to sell you things. They try to make you feel like you are connecting with real human beings. In a social networking site you can share your thoughts, images and videos. You can join groups to connect with people with similar interests. You can share your achievements, education and work history. You can look for new jobs.

Social review sites

On a social review site, people post comments about experiences they have had and things they have bought. You can read their thoughts about these things. You can share your own experiences with others.

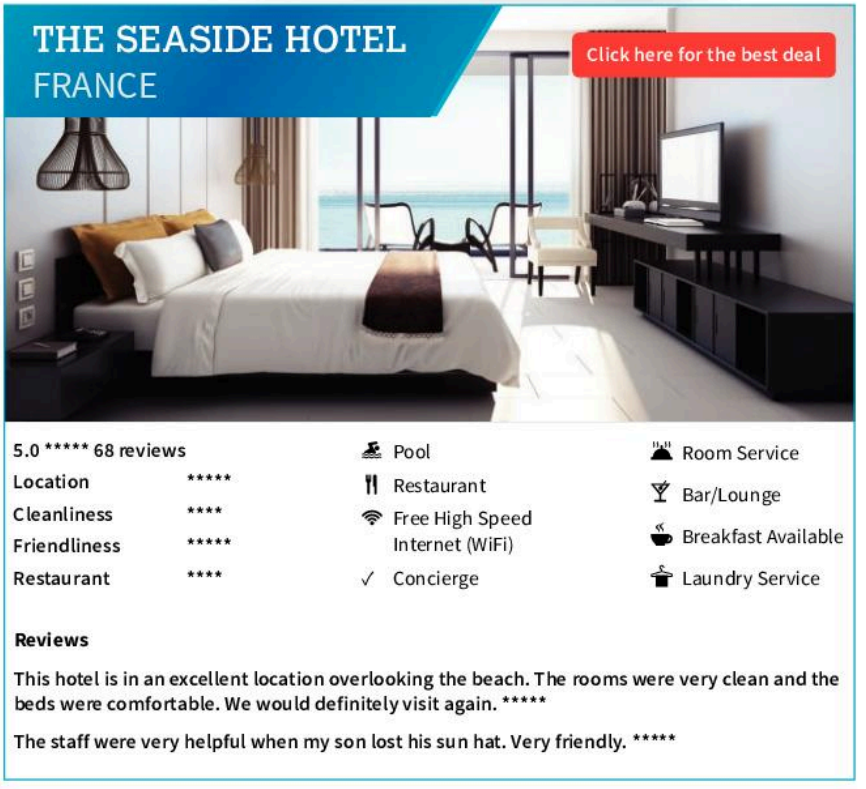


Image sharing and video hosting sites

People use image and video sharing sites to create and share images and videos. The companies that run the sites can **curate** the content. This means they select what to show first and how to group the content. The users of the site can also do this.

Microblogging

Microblogging means making short messages that can be shared with many people at once. On many microblogging sites you can use the hashtag symbol # to help other people find your content.

Activity

If you plan to use social media, you will need to decide which type of social media you would most like to use.

- Use the internet to find one example of each type of social media you can access in your country.
- Find the part of the website that tells you how old you have to be before you are allowed to use the site.

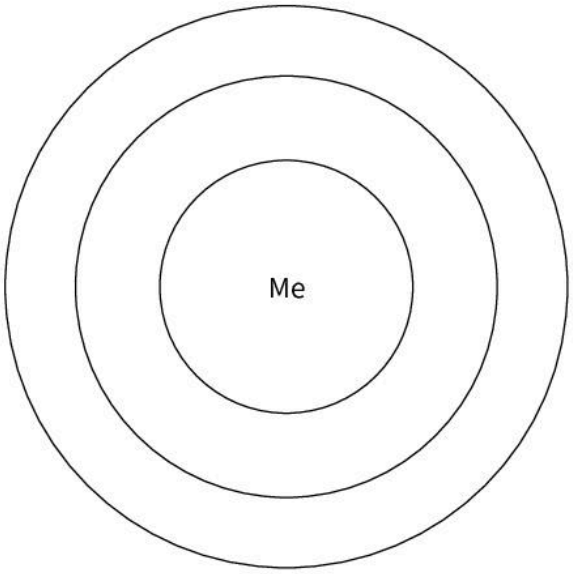
Your social media communities

When you use social media you communicate with many people. It is important to think about how well you know someone online, so that you can be safe and responsible. To work out how well you know someone, ask yourself:

- How often do I see the person?
- How often do I communicate with the person?
- How do we communicate?
- How long have I known the person?
- How did I get to know the person?
- Do I know the person in everyday life or just online?
- Have I seen the person communicate with other people I trust?
- Has the person ever said anything that makes me feel uncomfortable?

Activity

On a large piece of paper, draw a set of rings like this.



Put your name in the centre of the circle.

Think about the people you interact with most days. How well do you know them? If you know them extremely well, write their names in the middle circle with you. If you know them less well, put them in the next circle. If you do not know them well, put them in the last circle.

Make a similar diagram for people you interact with using social media, text messaging, or online gaming. What is the difference between your two diagrams?

What should you share?

You can share different types of information on social media. What you choose to share depends on which group you are sharing with.

- You might share personal information with the people in the middle circle. For example, you could tell them about a happy experience you had.
- You might share information about local events with people you do not know that well. For example, you might advertise a charity event in your area.
- You might choose to only share other people's content with people you do not know well at all.

No matter which type of information you are sharing with which group, remember that social media content lasts a long time. Think about whether you would want other people to see that information in many years.

Warning feelings

Sometimes people do not behave well on social media. Bad behaviour can make social media risky or unsafe. When you see bad behaviour you might get a warning feeling. You should always listen to your warning feelings.

Can you think of any examples of behaviour that could cause a warning feeling?

When you have a warning feeling:

- **slow down** – how are you feeling?
- **think about the situation** – what caused you to have the feeling?
- **think** – what are your choices?
- **act** – make a good choice, or ask an adult for advice.

Extra challenge

Imagine you posted an image like this on your social media site.

Look at the comments.

What might each of the posters be thinking?

What impact do these comments have on your feelings?

John: That looks amazing.

Seth: How can you drink that stuff?

Arjun: Whaaaaat? I thought you said you were going to the library to study!

34 likes

Add a comment... Post

Test

1. Give an example of a type of social media.
2. What steps should you take if you have a warning feeling when using social media?
3. Choose a type of social media you have used, or would like to use. Write why this would be a good choice of social media for you.
4. What risks do you face when you use social media?

2.3 Your digital footprint

In this lesson

You will learn:

- what a digital footprint is
- how to analyse a digital footprint to work out information about someone
- how to manage your own digital footprint.

Invisible audiences

Maryam and Naomi are doing the same activity. Maryam and Naomi are both showing other people a photograph. Maryam is showing her friend the photograph. Naomi is posting a photograph on a social media site.

What Naomi is doing is different to what Maryam is doing. The people who see Naomi's photograph are invisible to her. Anyone who can see information about you online is part of your invisible audience. Anyone who can see content that you have posted is part of your invisible audience.

What other people find out about you online influences who they think you are. It can change their views about you. It can even change how they feel about you.

What is a digital footprint?

Look at these footprints.

Can you see the footprint with no shoes? Can you see the sneaker or trainer footprint? You can tell a lot about someone from their footprint.

Your **digital footprint** is the mark you leave when you are online. It is all the information about you that you have posted about yourself, or other people. Your digital footprint includes information that you intend to share. It also includes information that you share without realising.

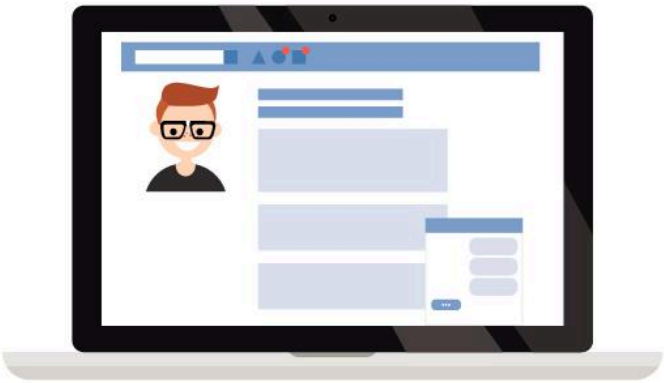
Your digital footprint can:

- show a lot about you
- be shared widely
- last a long time.

Activity

Draw around your foot. Choose one type of social media you use or know about. What could be found out about someone using their digital footprint? Write as many types of information as you can think of on your foot artwork. You might include:

- what someone looks like



- where they live

- what they like to do or buy

- their views about important things.

What does persistent mean?

We all make mistakes. It is a normal part of growing up. But our online mistakes are persistent. This means they do not disappear over time. It is important that we all look after our own and other people's digital footprints.

Almost everything you post on the internet will remain 'forever' in some way. The content can be easy or difficult to find. Social media companies store everything. Companies store the visible activities we do, such as commenting, posting or liking. They also store data about the things we delete or decide not to post. You might think that you are making a temporary post. But the information lasts a long time.

It is a little like being a time traveller. You can travel back in digital time to see what was important to you one year ago, ten years ago, or even longer. When you make friends face-to-face, you share information about yourself slowly. You get to know each other as you develop trust. Now, a new friend can look at your social media and learn a lot about you very quickly.

Some social media sites claim that content is destroyed after someone has seen it. Users want to have conversations that are not recorded forever. Users want to be able to forget. Even sites that say they will delete content usually store the content on their servers for a period of time. And it is easy to take a screenshot of something that is meant to be deleted. Then it can be stored and shared in other social media.

Looking after your digital footprint

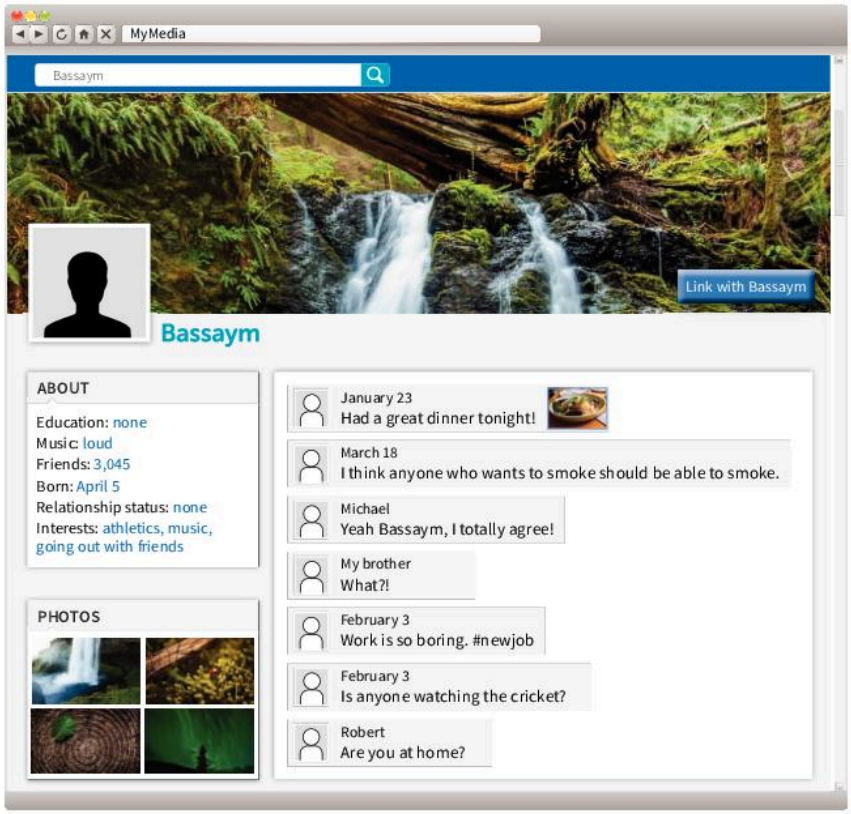
You can manage your digital footprint by:

- thinking before you post
- searching for yourself sometimes so that you can see what your digital footprint might look like to other people
- making sure your privacy settings are secure.

You will learn more about privacy settings in the next lesson.

Activity

Bassaym has applied for a job. The company has searched for his digital footprint to see whether he is someone they would like to employ. This is what they see on one of his social media sites.



- Would you employ Bassaym? Give reasons for your answer, using evidence from his social media page.
- What assumptions about Bassaym did you make from his digital footprint?
- Is there a way you could check whether your assumptions are correct?
- Are your assumptions based on fact? Or are they based on your feelings about something you have seen on Bassaym's digital footprint? How can you check?

Extra challenge

What would you like your digital footprint to look like in ten years' time? Write yourself a postcard or email that you could look at in ten years. Include your ideas about how you would like your digital footprint to look.

Test

1. Your digital footprint is persistent. What does this mean?
2. Which of these kinds of information can be in your digital footprint?
   - Photos of you as a young child
   - Text messages
   - Comments you have made on other people's content
   - A handwritten letter you sent to an elderly grandparent
   - A wish list on a shopping website
   - Videos you upload to a video sharing site
3. Aarav uses a social media account to send short videos and photos to his friends. The content disappears from the account after it has been seen by his friends. Should Aarav worry about what he sends? Give a reason for your answer.
4. Name three ways that you can manage your digital footprint.

2.4 Digital privacy

In this lesson

You will learn:

- what privacy is
- how advertisers and others collect information about you, and what they do with that information
- ways to protect your privacy.

What is privacy?

Have you ever had thoughts you would prefer to keep to yourself? Thoughts that you would prefer not to share with other people? These are private thoughts. **Privacy** means being protected from being watched or listened to by other people. The protection can be from individual people, or groups like the government, or companies.

This is Amirah. Amirah is comfortable sharing a lot of information with other people online.

This is Raya. Raya does not like to share a lot of information with other people online, even her family.

Everyone has different boundaries for how much information they do or do not like to share online.

Activity

Discuss these examples of things you may or may not want to share. Explain your thinking.

- Your cousin has posted a photograph of their new clothes on a social media site. You do not think the clothes look very good. Would you share your views?
- You really enjoy a book that is aimed at younger readers. There is an online group for people interested in that book. Other people might see that you have joined the group. Do you join or stay away?
- Your mother has a photograph of you as a baby on her social media site. Would you ask her to remove it?

Digital privacy

Privacy is complicated when you are online. Different apps and websites collect information about what you type, what you are interested in, your personal information, and how you move across the internet.

When you use social media, you are often asked to create an account. The company that owns and runs the software asks for information about you. Companies use the information you give them to advertise to you, and to make money. You can connect with other people on social media who have also given their information to the company.

Raya gets an email from her cousin. Her cousin has just had a new baby. The cousin's email looks like this:

Sender:	Cousin Ratri
Date:	15 May 2019
Subject:	New baby

Hey Raya

I've attached a photo of baby Abdul. He has the cutest little cheeks and is really funny. I just wish he would sleep!

Love

Ratri

Raya spends some time browsing websites for a toy for baby Abdul. Raya sees an advert pop up while she is browsing a website.

Companies put adverts online in places where they know you will see them. They build computer algorithms to choose adverts based on the information they can find out about you. They get this information from websites you have visited or signed up to. The information includes:

- how you use apps
- what you search for
- when you use apps and websites
- how long you spend on different apps and websites.

Activity

Below is a sign-up form for a social media website.

- What information is being shared?
- Who could the information be shared with?
- What is the site really asking you to do when you click 'Accept & Sign Up'?
- Find the privacy policy and privacy settings for a social media site you use. Make sure you have chosen to opt out of sharing your information if possible.

Sign up

First name

Last name

User name

Password

Phone number

Date of birth

Month | Day | Year

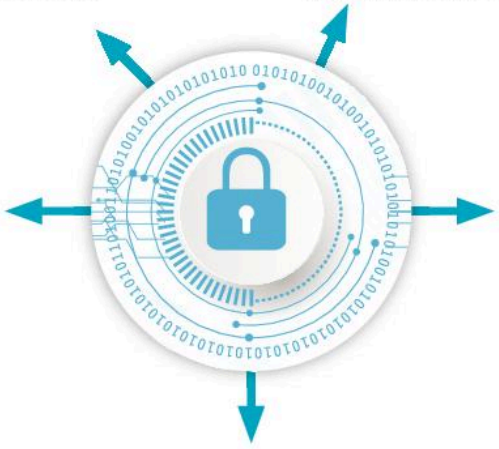
Tap 'Accept & Sign Up' to acknowledge that you have read our Privacy Policy and agree to the Terms of Service. We will send you a message to verify this number. Other users may capture or save your messages, such as by taking a screenshot or using a camera. Be careful about what you post!

Accept & Sign Up

Ways to protect your privacy

Change your passwords often. Choose a password that is at least eight characters long. Your password should contain a mixture of letters, numbers and symbols.

Switch off your current location. Social media apps are able to see where you are on a map. Some apps share this location. You might want to keep your location private.



Switch off the automatic login function. Having to type in a password or give a fingerprint to use an app makes it more difficult for somebody else to access it.

Manage your audience. Some social media sites let you choose which groups to share a message with. Use this feature to control who sees the content you post.

Hide your activity status. Most social media sites show when you are online or when you were last online. Some show what you are doing at that moment. You can often hide your activity status using the Profile or Account menu.

Extra challenge

One way companies get information about you online is by using **cookies**.

Research online to find out more about cookies.

- What is a cookie?
- What type of information is collected by cookies?
- Why do companies collect this information?

Test

1 Fill in the gaps.

Privacy is being _____ from being watched or listened to by other people. The _____ can be from _____, or groups like the _____, or _____.

2 Write two ways to manage your digital privacy.

3 Michael wants to join a social media site where you can play games with other users. He cannot find a privacy policy for the site. He cannot find any privacy settings. You have to give personal information to join the site. Should Michael join the site? Explain your thinking.

4 Your family have moved into a new house. You have a photograph of your family outside the new house. Would you share the photograph on social media? Explain your thinking.

2.5 Ethics of care

In this lesson

You will learn:

- about the responsibilities that come with using social media
- how to care for yourself and others online.

Ethics of care

Social media can be a place where people are kind, creative and connect to each other. It can also be a place where people say or do hurtful things. We all need to be responsible when we use social media.

When you are using social media, remember these three ideas.

1 We depend on each other.

As human beings we often learn and grow together. We sometimes help each other out when times are difficult. We make friends and argue with each other. Our societies need us to make things and give things to each other. Some societies need us to sell things to each other.

We also need each other on social media. We want other people to hear what we want to say to the world. We want to communicate with our friends and family. Companies need us to use social media.

2 Not everyone feels strong all of the time.

When you respond to something on social media, try to remember that the other person might be feeling vulnerable, scared, worried or sad. Only write something you would say to their face. Try to remember that what you post will probably make a difference to the person reading the post. Think about how you would like the person seeing your post to feel.

3 What we say, type, share and do every day on social media should aim to protect and promote better lives for everyone.

These ideas together mean you can develop a digital **ethics of care** that will make your experiences on social media helpful and positive.

Activity

Do you have any experiences with social media? If so, have your experiences been good, bad, or a bit of both?

Work in a group to make a list of the useful and problematic things about social media. Think about the many types of social media you can use. What are the useful and problematic things about each? Write down your thoughts in two columns like this:

Useful	Problematic

Share your lists with the rest of the class. Does everyone agree?

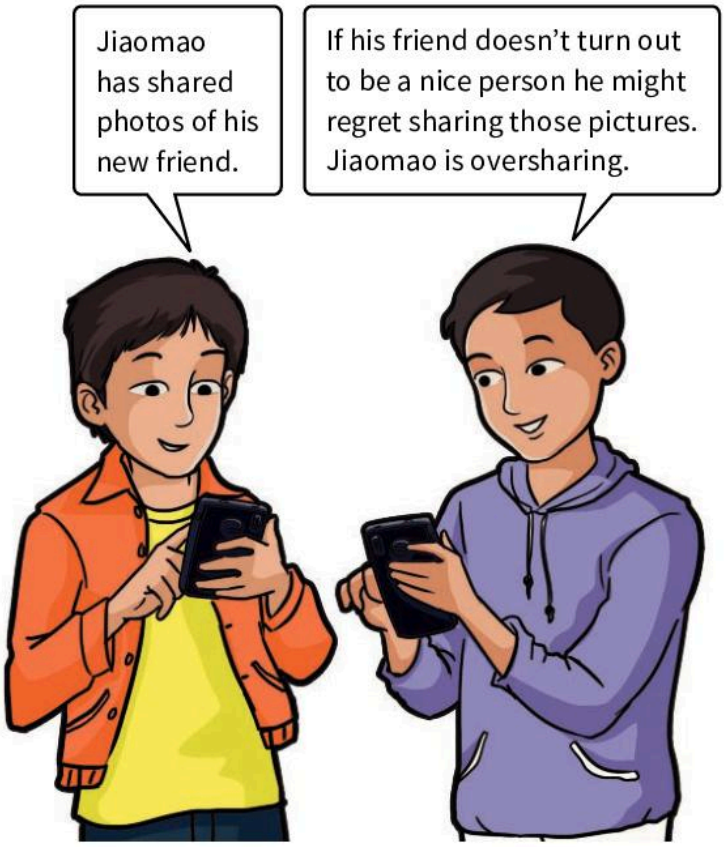
Obligations

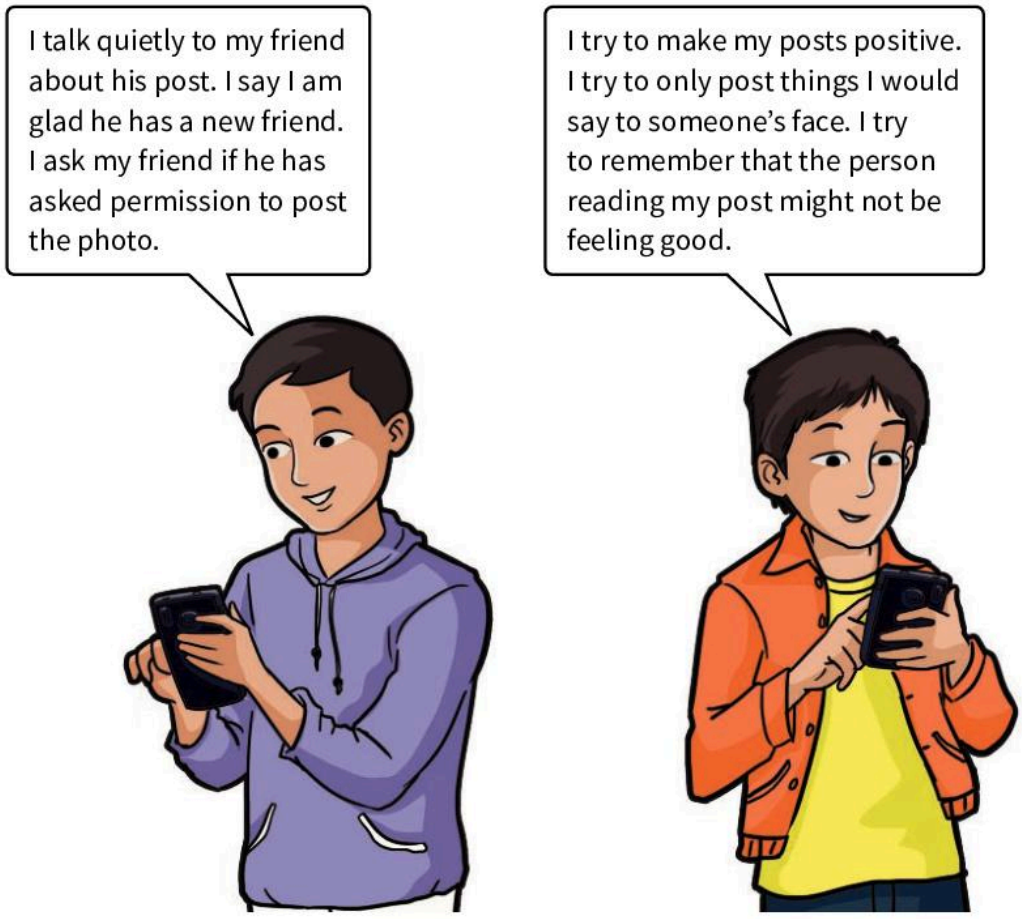
An obligation is something you do because it is a tradition in your society. You do it because you feel it is the right thing to do. Obligations are like responsibilities or duties. Our obligations bind us together. Understanding your digital obligations can help you be part of making digital society a good place to be.

What would you do if your friend shared too much on social media?

- Not post anything?
- Send a private message suggesting your friend removes the image?
- Comment on the photo and laugh at your friend for posting the image?

What is your obligation to your friend? What is your obligation to your own digital footprint?





Activity

Draw a picture of yourself in the middle of a piece of paper. Write down up to three obligations you have for looking after your own digital footprint.

Now draw a group that is important to you somewhere else on your page. It could be your family, your friends, or your community. Write down up to three obligations you have for looking after their digital lives.

Be creative

Create a poster for your school that helps other people know how to look after their own and others' digital footprints.

Extra challenge

You have thought about your obligations to yourself and people you know.

Think about your obligations to people online that you have never met, and may never meet. What are your obligations to these people?

Test

1 What are the three main ideas you should remember to show digital ethics of care to yourself and others?

2 Which of the three ethics of care ideas means most to you? Explain your thinking.

3 Sarah wants to post some pictures of a family celebration on social media. Some of the pictures include her young cousins. They are aged 1 and 4. What should Sarah do?

4 a Name one obligation you have to yourself to look after your digital footprint.

b Name one obligation you have to others you know, or do not know, to look after their digital footprints and wellbeing.

2.6 Healthy balance

In this lesson

You will learn:

- how to keep a healthy balance between screen time and offline time.

Knowing when to stop

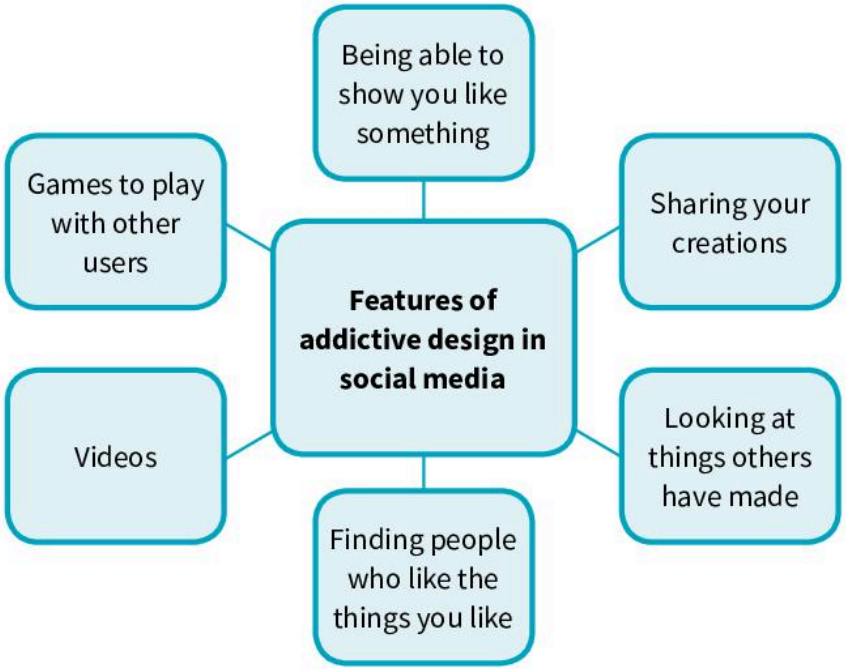
Using social media can be fun. The software is designed to draw you in. It links you with lots of people and keeps you interested. Sometimes people enjoy using technology so much they find it difficult to stop. Some people even believe they are addicted to their phones or other computing devices. Addiction means that they do not think they could stop using their technologies.

Sometimes we do not use technology because we need to connect with someone, make something, or find something out. Sometimes we use technology because it is a habit.

Your brain is built for you to have some habits. These could be simple habits like getting dressed or greeting a family member.

Many types of social media are designed to make using the software a habit. This is called **addictive design**. Addictive design aims to use the pleasure your brain gets from succeeding at something or carrying out a habit to get you to feel good. The good feeling means you will probably use that social media again.

Look at the mind map. These are some of the ways designers try to get you to have good feelings about using their social media. Can you think of any other ways?



Designers use lots of different functionalities to make social media addictive.

Some apps make it easy for you to use filters to make simple photos look amazing very quickly.

Some apps use push notifications to tell you that something new has happened in the app. Seeing the notification might make you want to visit the app.

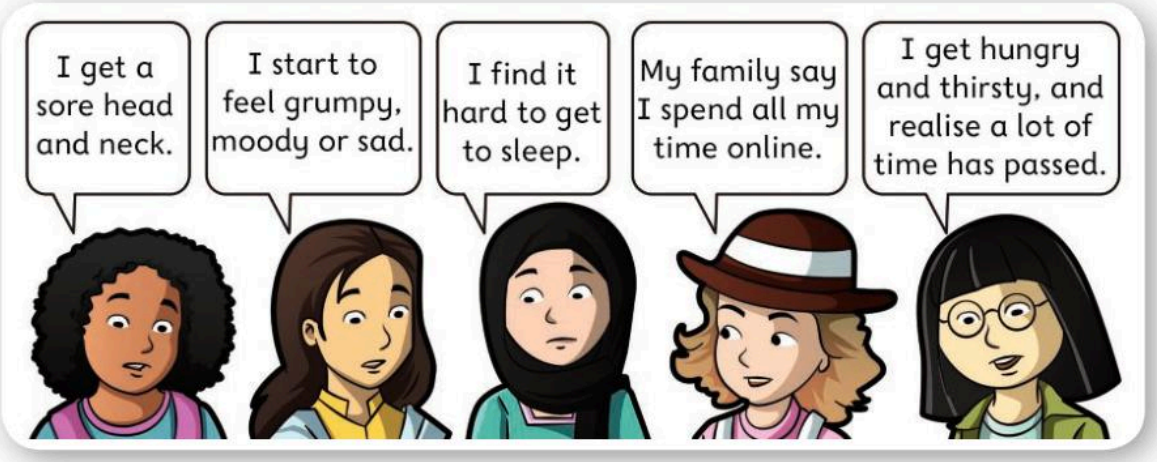
Some apps use loading screens and adverts to make you wait for new content. They might even reward you in some way for waiting. Most apps will not reward you every time you use the app. They will reward you to keep you interested.

Activity

If you use social media, make a list of all of the addictive design features you have used over the past week. Which features do you like best? Which are you not interested in?

Finding a healthy balance

There are lots of ways to recognise that you need to take a break from using social media.



Your digital ethics of care means you need to look after yourself. If you notice any of these signs, do something else for a while. Maybe you could plant something, take some exercise, do some craft, do a chore, talk with someone, or play an instrument.

Humane design

Some technology design companies are trying to help you to keep a healthy balance between your social media use and other activities. Making software that tries to make lives better for people is called **humane design**. Humane design works well when designers think about the meanings people get from using social media, rather than just the product they are buying. Some apps and software have both addictive and humane design features.

In humane design, the software should show that the designer:

- understands the real problems of everyday lives
- is able to suit the history, culture and environment of a place. The people using the software are more important than the software itself
- understands that people do not use social media alone. Social media is used together with face-to-face conversations and people's complicated lives
- knows how to iterate the design to make it better.

There are many examples of humane design. Humane design means being able to:

- turn off any reminders that come from the software, rather than from people

- make your screen change to black and white after a certain amount of time using social media. Your brain likes to see the colourful images on your device. Making the screen black and white (or greyscale) reminds you to take a break
- put addictive design apps in a separate place on your device
- charge your device in a different place from where you sleep
- avoid difficult feelings like envy and promote positive feelings like dignity.

Activity

- Use the internet to find out the goals of humane design. Reflect on each thing you find out. Do you agree with the goal? Why, or why not?
- Think of two design features that you would think of as humane design. For example, your phone might alert you if you have been using an app for too long.
- Share your humane design features with your class. Make a class list of humane design features.
- Which types of social media that you know about have humane design features?

Extra challenge

Get your brain into a new habit. Set one rule for yourself for a month to help you keep a healthy balance between your social media use and other activities.

Test

1. Write two things that would help you notice if you are using too much social media.
2. Why is it important to keep a healthy balance between how much social media you use and other activities you do?
3. Write an example of a type of social media that uses addictive design. Write one addictive design feature it uses.
4. Draw a table like this:

Addictive design	Humane design

Put each of these design features into the correct column.

- Keeps track of how long you have been using the social media.
- Makes it possible to hide or remove your social media profile.
- Makes it very difficult to leave the social media.
- Gives you rewards for spending more time or money using the social media.
- Automatically plays content such as videos.

Check what you know

You have learned

- what social media is
- how to care for yourself and others online
- how to manage your digital footprint and privacy
- how to keep a healthy balance between screen time and offline time.

Try the test and activities. They will help you to see how much you understand.

Test

1 Why is it important to care for yourself and others online?

2 Why would someone set up a fake social media account?

3 Write a definition of 'digital footprint'.

4 Name three ways you can protect and manage your digital footprint.

Elena has joined a new social media site. She notices that her brother is also using the site. Elena sees that her brother has posted some hateful messages to other people about what they look like.

5 What do you think Elena should do? Explain your thinking.

Activities

1 Design an online advert that could go on a social media site. You could draw your design on a piece of paper, or on a computer. Think about:
   - What would you like to sell to other people?
   - Who would you like to sell to?
   - What information should go on an online advert?

2 You want to make sure that the right users see your advert. What kinds of information would you need to collect about social media users to do this?

3 Name three ways you can protect yourself from giving away your information.

Self-evaluation

- I answered test questions 1 and 2.
- I completed activity 1.
- I answered test questions 1–4.
- I completed activities 1 and 2.
- I answered all the test questions.
- I completed all the activities.

Re-read any parts of the unit you feel unsure about. Try the test and activities again – can you do more this time?

3 Computational thinking: Artificial intelligence

You will learn

- what artificial intelligence (AI) means
- how AI is used in real life
- some methods used to develop AI
- the benefits and limitations of AI.

In this unit you will learn about artificial intelligence (AI). You will explore some programming methods used to develop artificial intelligence. You will learn the advantages and disadvantages of different AI techniques.

This unit uses a case study. You will look at the work of a radio operator on an Antarctic base. He receives signals which are displayed as text messages. He must check the signals to see if they are real human messages or bad signals caused by interference. He uses a range of different programming techniques to help spot bad signals.

You will make some programs to help with this task. We have provided example programs with 'good' and 'bad' signals for you to check.

Talk about...

Do you think a computer will ever be made that is as intelligent as a person? Would this be a good thing or a bad thing?

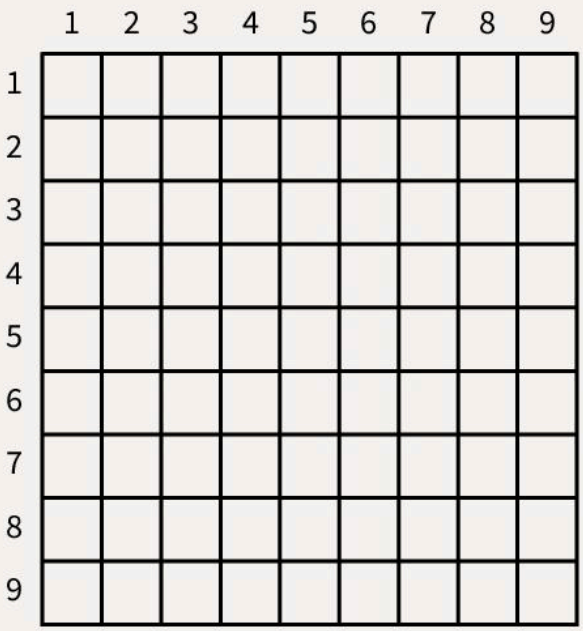
Learning outcome: Describe some computational techniques that enable artificial intelligence (AI)

Unplugged

In this activity you will look at an example of image recognition.

Here is a grid shape. The rows and columns are numbered.

Make a small copy on an ordinary-sized piece of paper and a larger copy on a poster-sized sheet. This example has 9 rows and 9 columns. You can vary the size. You can draw the grid by hand or make it using a word processor.



Create a secret design

One student is the designer. They create a face (or other design) by shading in some of the cells on the small sheet. The designer keeps the design secret.

Guess the design

Pin the large grid up where everyone can see it. Students pick cells at random. Students can either point to a cell on the big sheet, or call out its position ("Row 3 column 7").

If the chosen cell is part of the design, the designer must say so. The students can colour in that cell in the big grid.

See how quickly you can recognise the design, or complete the design.

Did you know?

Deep Dream Generator (deepdreamgenerator.com) is a website that uses visual images to explore AI. It provides a set of tools to help you explore different AI algorithms. The website lets you upload photos and use AI techniques to change them into different colours and styles. In this example, AI has merged photos of a wall and a cat to create an artwork that has elements of both.

heuristics
reinforcement machine learning
expert systems
artificial intelligence
decision tree

3.1 Antarctic base

In this lesson

You will learn:

- what artificial intelligence is.

Spiral Back

In Student Book 8, you made Python programs to work with lists. In this lesson you will build a program to traverse a list. If you have forgotten any of the skills, look back at Student Book 8 for more help.

CASE STUDY

Antarctica is a large continent at the far south of the globe. It is very cold. Scientists live there. They receive messages by radio. In this unit you will write programs to process the signals received at an Antarctic base. The signals are text strings. This is a simplified version of the real-life task.

Taz is a radio operator. He must check each signal. He must only pass on good signals. He must delete bad signals. You will write a program to help Taz.

Start the program

We have provided the first part of a program. Download this program from our web page. The program provides you with a series of short example signals.

```
signals = [".",
           "Weather warning: there is a storm approaching",
           "~",
           "Helicopter arriving McMurdo station 10:00 Tuesday",
           "**",
           "First aid kit needed at far camp",
           "*&_)*&^%^&*%^$~@:~",
           "Food delivery drop will be delayed by 48 hours",
           "Repairs needed at the observation platform",
           "Urgent - update all anti-virus systems",
           "Please re-send meteorological data",
           "234724u2u23u888",
           ".."
           "asjdha## djhaidj# ddjiadj#",
           "Medical officer requested at main base",
           " %",
```

The text strings are stored in a list called `signals`. It has 20 items. In real life there would be more than 20 signals. Some of the signals are good and some are bad.

Now you will add code to this program to let Taz check the signals one by one.

Traverse the list of signals

Taz needs to look at each signal, one after the other. Looking at each element in a list is called **traversing** the list. Now you will make a program that traverses the `signals` list.

You will use a loop. What kind of loop should you use to count through all the items in a list? The answer is a `for` loop. That is a counter-controlled loop.

The loop will count until it reaches the end of the list. Here is the code you learned in Student Book 8:

```
stop = len(signals)
for i in range(stop):
        print(signals[i])
```

But there is an even quicker way.

Python shortcut

Python offers a useful shortcut. This shortcut will count through every element in the list.

```
for item in signals:
        print(item)
```

Python will count through each item in the list, printing each one out in turn.

If you put this code at the end of the program and run the program, you will see this output.

```
.
Weather warning: there is a storm approaching
~
Helicopter arriving McMurdo station 10:00 Tuesday
**
First aid kit needed at far camp
*&_)*&^%^&*%^$~@:~
Food delivery drop will be delayed by 48 hours
Repairs needed at the observation platform
Urgent - update all anti-virus systems
Please re-send meteorological data
234724u2u23u888
..asjdha## djhaidj# ddjiadj#
Medical officer requested at main base
 %
43umcu3rg0ucthgm@:;<
Penguin migration has begun 2 weeks early
Solar flare may affect radio communication
-
```

Activity

Add code to the `signals` program to traverse the list. Run the program and make sure it works.

Check each signal

The program shows the signals one after the other. Now you will extend the program so that Taz can say if the signal is good or bad.

To do this you need an input command.

```
good = input("is this a good signal (Y/N) ")
```

The answer typed by the user will be stored as a variable called `good`.

Copy the good signals

Finally, you will copy every good signal into a new list.

At the start of the program, make an empty list. You can call it `good_signals`.

```
good_signals = []
```

Inside the loop, after `print(item)`, use an `if` statement to copy signals to this list. You will only copy the signal if the user says it is good.

```
good = input("is this a good signal (Y/N) ")
if good == "Y":
    good_signals.append(item)
```

At the end of the program you can print out the list of good signals. You can use this command to print out the whole list.

```
print(good_signals)
```

Or you can use a `for` loop to traverse the list, printing each item on a different line.

Here are the commands you have added:

```
good_signals = []

for item in signals:
    print(item)
    good = input("is this a good signal (Y/N) ")
    if good == "Y":
        good_signals.append(item)

print(good_signals)
```

Activity

Extend the program so that the good signals are copied to a new list. Run the program and make sure it works.

Extra challenge

Create a second list called `bad_signals`. Add extra lines of code to the program so that every bad signal is copied to this list.

Traverse the lists of good and bad signals, printing one element at a time. Add messages to explain which list is which.

Problems that are hard for computers

In real life there would be a lot of signals. There could be hundreds per hour. Checking them is a lot of work for Taz. Can a computer help to do this work?

Computers can help with many tasks. They can follow clear logical and mathematical instructions. They can do calculations and comparisons very quickly and accurately.

But computers are not so good at other tasks. Checking messages in human language is an example of a problem that is hard for a computer to do. That is because this problem does not have clear steps to a solution. The messages are varied and unpredictable.

Artificial intelligence

Artificial intelligence or AI means building computers that can solve problems using human-like judgement.

This includes tasks such as:

- recognising faces
- diagnosing illness
- driving cars
- speaking in a realistic human way
- solving complex problems.

In this unit you will learn about some of the methods used to make computers solve more problems and work in more intelligent ways.

Methods

This unit will introduce the following methods:

- heuristics
- expert systems
- decision trees
- machine learning.

You will not create real examples of AI. But you will learn about some of the ideas that are used in AI. If you want to find out more, work hard at computer science and maths. You could be involved in developing the next generation of AI.

Test

1. What does AI stand for?
2. Give one example of how AI might be used in everyday life.
3. In the example in this lesson, the human user made a decision that would be hard for a computer to make. What was the decision?
4. What happened as a result of the decision made by the user?

3.2 Heuristics

In this lesson

You will learn:

- what heuristics are
- how heuristics can be used in programming.

Heuristics

Sometimes a problem is very difficult to solve. Getting it right will need a lot of steps and take a long time. Programmers might use heuristics to speed up problem solving.

A **heuristic** is a rule that helps you make a quick decision. A heuristic is like a guess, or a rough estimate. But it is a guess based on careful thinking about the problem.

Heuristics are not always completely accurate. But they provide a quick way to simplify difficult problems.

Examples of heuristics

Here are some examples of heuristics we might use in everyday life:

- If you see or smell smoke, there might be a fire.
- Food that is not a normal colour is probably bad to eat.
- A broken ladder might not be safe to use.

These are rules that help us to make sensible decisions. These guidelines are not always accurate but they are helpful. We can use these heuristics if we don't have more information.

The heuristic you will use

In this lesson you will use this heuristic:

Signals with fewer than three characters are bad.

Some of the bad signals are just one or two random characters. None of the good signals are this short. So this heuristic will get rid of many bad signals.

This heuristic is not perfect. It will not find all bad signals. But it will simplify the task.

Start the heuristic program

Open the program you made last lesson. This program:

- traverses the list
- displays each element
- gets input from the user
- appends the signal to the `good_signals` list if the user enters "Y".

Activity

Are you a confident programmer? Try to change the program from the last lesson by working independently. Use the heuristic to make a list of good signals.

Make the heuristic program

This section will explain how to write the heuristic program. If you have not done it yet, follow these instructions. If you have done it, check your work.

Open the program you made last lesson. You will change the program to use the heuristic. That means it can check the signals, without input from the user.

Delete commands

The old program has these commands. They are inside the loop.

```
print(item)
good = input("is this a good signal (Y/N) ")
```

These commands print out the items and ask for a user decision in each case. You do not need these commands in the heuristic program. The computer will make its own decision. Delete these commands.

Change commands

The `if` statement in the old program looks like this:

```
if good == "Y":
```

The command tests if the user has input the answer "Y". The new program will not use this test. There is no input from the user. Instead the program will check if the string is longer than 2 characters.

```
if len(item) > 2:
```

Make this change.

Here is the completed program.

```
good_signals = []

for item in signals:

    if len(item) > 2:
        good_signals.append(item)

print(good_signals)
```

Activity

Create the program shown here. Run the program to make sure it works.

Using the heuristic

The heuristic has made a list of good signals. It has run quickly, and without any input from the user. This program could check hundreds of signals in the time that Taz would take to check one or two.

Has it worked?

Here is part of the output of the heuristic program. You will see a full screen like this.

```
['Weather warning: there is a storm approaching', 'Helicopter arriving
McMurdo station 10:00 Tuesday', 'First aid kit needed at far camp', '*
&_)*&^%^&*%^$~@:~', 'Food delivery drop will be delayed by 48 hours',
'Repairs needed at the observation platform', 'Urgent - update all ant
i-virus systems', 'Please re-send meteorological data', '234724u2u23u8
88', '..asjdha## djhaidj# ddjiadj#', 'Medical officer requested at mai
n base', '43umcu3rg0ucthgm@:;<', 'Penguin migration has begun 2 weeks
early', 'Solar flare may affect radio communication']
```

Look at the new list of good signals. Has the heuristic worked?

- Many of the bad signals have been removed from the list.
- All the good signals are still in the list.

But:

- Some bad signals are still in the list. They were not found by the heuristic.

The heuristic has helped a lot. But it has not completely solved the problem.

This is a common feature of heuristics. Heuristics are a shortcut method. Heuristic results are not perfect. But you can see the heuristic has simplified the task. Taz has fewer signals to check.

Extra challenge

Taz noticed that good signals were always broken up into separate words. They include spaces. He made a second heuristic:

If a signal has no spaces in it then it is a bad signal.

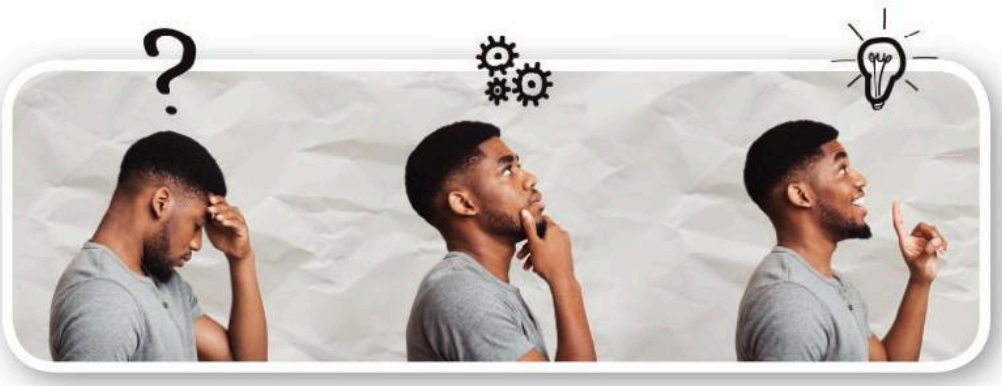
Add this heuristic to the program. Has this heuristic improved the accuracy of your program? HINT: Use the 'in' operator.

Heuristics and AI

Artificial intelligence aims to make computers that can solve human-type problems. This often requires complex decision-making. To make accurate decisions can be very difficult.

Heuristics offer a shortcut to simplify a difficult decision. Humans use heuristics in real life. By putting heuristics into programs we can help computers to make human-like decisions.

Your work in this lesson is a very simple example.



Advantages and disadvantages of heuristics

Using a heuristic in a program has several advantages:

- A heuristic can solve a problem quite quickly.
- A heuristic can mean less work for the user.
- A heuristic gives a good-enough result.

A heuristic has some disadvantages:

- The heuristic is not always accurate. It can produce some incorrect results.
- The heuristic may provide a solution, but it might not be the best solution.

Usually we would combine heuristics with other types of problem solving.

Heuristics in use

Heuristics are used by virus-checking software. Computer viruses have some typical features. We can make a heuristic that will catch viruses by doing a quick check for typical features. This is similar to how Taz found bad signals by checking for string length.

Test

1. What does heuristic mean?
2. State one advantage to Taz of using a heuristic to spot bad signals instead of checking them himself.
3. State one disadvantage of using a heuristic.
4. Taz spotted that some bad signals contain the symbol #. Write code to:
   - traverse the signals list
   - identify signals that contain "#"
   - copy these signals to a list called bad_signals.

Digital citizen of the future

Some people think that computers are always right. But computer systems often use heuristics and other shortcut methods. Heuristics are estimates, and they are not always correct. For example, a spellcheck in a word processor won't always spot that you have used the wrong word.

Remember that information and advice from a computer is only as good as the program that controls it.

3.3 Expert systems

In this lesson

You will learn:

- what an expert system is
- how algorithms and expert systems are used in AI.

CASE STUDY

Taz has developed a program that uses heuristics to spot bad signals. He has other heuristics he can use. Taz wants to put all the heuristics he knows into a structured program. He hopes that by combining all the heuristics he knows he will produce an effective program to screen out bad signals.

The name for this is an expert system.

Algorithms

An **algorithm** sets out the steps to solve a problem. An algorithm can be used as the plan for a program. An algorithm will state:

- **inputs:** data used by the algorithm
- **processes:** changes made to the data
- **structures:** such as loops and `if` structures
- **outputs:** the values produced by the algorithm.

An algorithm must state exactly what the computer will do at each stage of the process.

The goal of artificial intelligence is to create a computer system that will make human-type decisions and judgements. One way to do this is to make a big complicated algorithm. The algorithm will take all the factors that a human would consider. It will output a decision that matches what the human would decide.

What are expert systems?

An **expert system** is an algorithm that represents the knowledge of an expert.

For example:

- a doctor
- a judge
- an engineer.

The person who makes the program will talk to the expert. They will find out what decisions the expert would make. They will make one big algorithm that copies the decisions that the expert would make.

An expert system might decide:

- what illness someone has, based on their symptoms
- what jail sentence someone should have, based on their crime
- what part of a car is broken, based on the signs.

Medical expert system

For example, a medical expert system might:

- input information such as temperature, heart rate, aches and pains
- process the data using `if` structures with logical tests
- output a diagnosis such as chicken pox.

Advantages and disadvantages

An expert system can reach a decision without needing to ask a person. This has some advantages:

- You can use an expert system when a person is not available.
- An expert system will always make the same decision without bias or favour.
- The rules are set out in program code so you can check they are fair.

An expert system has disadvantages too:

- It can be hard for an expert to put their skills into words.
- Not everything can be reduced to logical tests.
- Experts can be wrong, and then the algorithm will be wrong too.

Activity

Here are the actions you must take to create an expert system. Put these actions in the right order.

Create a program from the algorithm.	Decide how to represent each expert decision as a logical test.	Find an expert.
Make an algorithm that contains all the logical tests you need.	Ask the expert to describe their decision making and the result of each decision.	

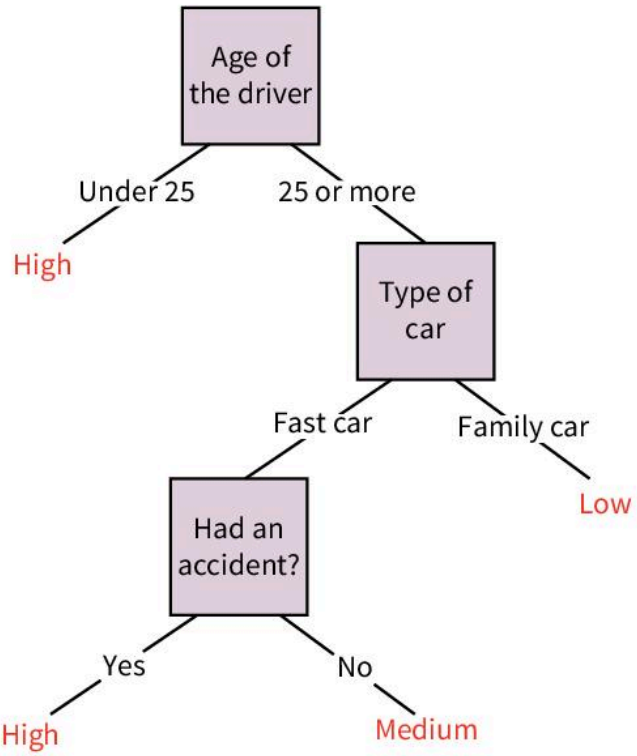
Decision tree

An expert system is made of logical tests. A good way to set out the tests is to draw a **decision tree** that shows all the decisions. By following the branches of the tree, you can get to the right decision.

Here is a simple decision tree that shows the decisions of an insurance expert. The expert has to decide how much car insurance a person should pay – high, medium or low.

The decisions are shown in square boxes. After each decision you must branch either left or right. The branches are labelled. Each branch stands for a different choice.

This is a simplified decision tree. In real life, insurance decisions use many more factors than this.



Using the decision tree

You can use the decision tree to find an answer to a question. For example, think of a person with these attributes:

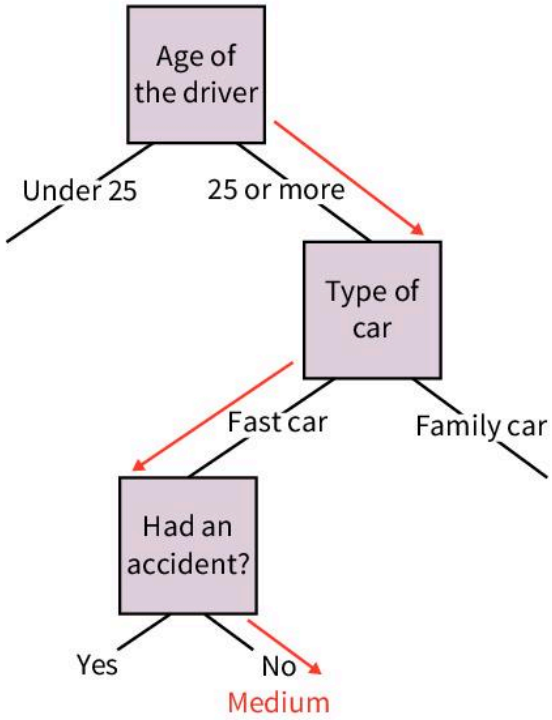
- driver is aged 30
- fast car
- has never had an accident.

How much would this person pay for insurance?

To answer this question, you start at the top of the decision tree. The first question is the age of the driver: 30 is greater than 25 so we take the right branch of the tree. Repeat this process for every decision in the tree.

The red lines show the route through the decision tree.

The answer is: Medium insurance payment.



Automating the decision tree

If something is **automated** it can work on its own without a human user.

To automate a decision tree, you turn it into a program. Each branch of the tree represents an `if... else` structure. The `if` structures are nested inside each other. You will learn more about this in the next lesson.

Activity

Here are the rules that Taz will use to decide if a signal is good or bad.

- If the signal has fewer than 3 characters, it is a bad signal.
- (For signals of 3 or more characters) if the signal contains a # it is a bad signal.
- (For signals of 3 or more characters that do not contain a #) if the signal contains no spaces it is a bad signal.

Turn these rules into a decision tree.

Extra challenge

Look at the examples of bad signals in your last program. Add one more rule to the decision tree based on your judgement.

Test

1. Give an example of an expert who might help to create an expert system.
2. State one advantage of using expert systems to make decisions.
3. State one disadvantage of using an expert system to make decisions.
4. What is automation? How can you automate an expert system?

Explore more

Talk to someone in your family about the decisions they make.
Here are some examples:

- how to make the dinner
- what tasks to do to look after a pet
- where to go on holiday this year.

How do they make their decision? Can you turn their decision process into a decision tree? You will learn a lot about expert systems, whether you manage to make a tree or not.

3.4 Automate a decision tree

In this lesson

You will learn:

- how to automate an algorithm by turning it into a program.

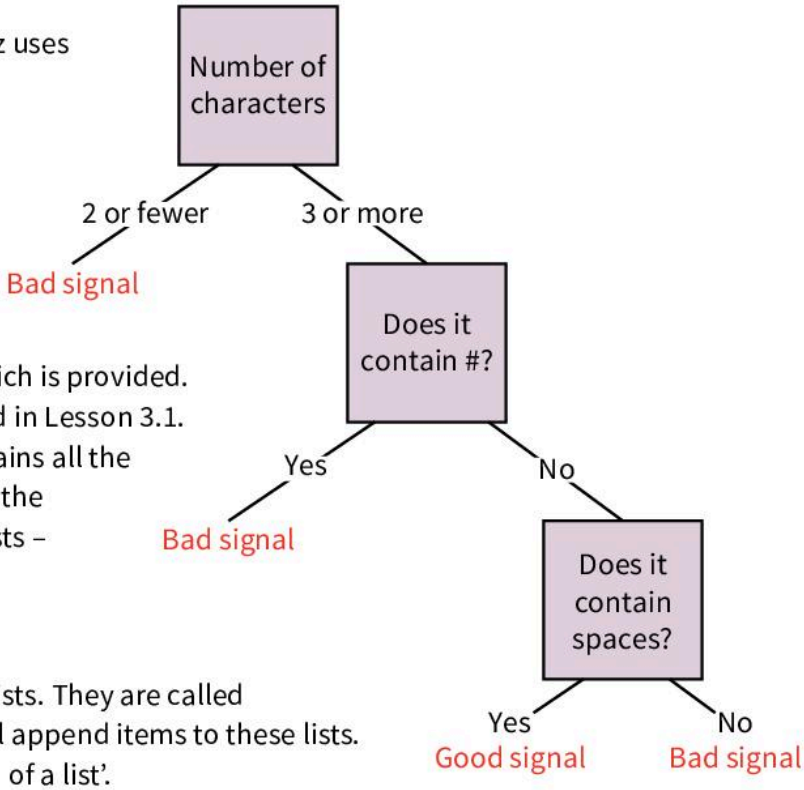
CASE STUDY

Taz has developed a decision tree. It combines all the heuristics he uses to check signals. Taz wants to automate the decision tree. He will make a program that will carry out all the decisions.

The decision tree

This decision tree shows the heuristics that Taz uses to check signals.

Now you will make a program to match this decision tree. This means every branch of the tree will be turned into an `if... else` structure.



Start the program

Load the empty signal processing program which is provided. This is the same program that you downloaded in Lesson 3.1. This gives you the list called `signals`. It contains all the signals, good and bad. Now you will automate the decision tree. It will sort the signals into two lists – the good signals and the bad signals.

Make good and bad lists

At the start of the program, create two empty lists. They are called `good_signals` and `bad_signals`. You will append items to these lists. Remember that append means 'add to the end of a list'.

```
good_signals = []
bad_signals = []
```

Traverse the list

Next you will use a `for` loop to traverse the list and print out each signal. You already used these commands in Lesson 3.1.

Here is the program so far. The new commands come below the big list of signals.

```
good_signals = []
bad_signals = []

for item in signals:
    print(item)
```

Add the first branch

Now you will put `if... else` structures inside the loop. Remember that one structure inside another is called a **nested structure**. A nested structure has double indentation. This decision tree will use lots of nested indentation.

The first decision is based on the length of the signal.

- If the signal has fewer than three characters it is appended to the list of bad strings.
- Else the program prints out `"more tests required"`. You will add more tests later.

You have done a similar task before.

```
good_signals = []
bad_signals = []

for item in signals:
    if len(item) < 3:
        bad_signals.append(item)
    else:
        print("more tests required")

print(bad_signals)
```

The `if` structure is nested inside the loop. That means the test will be carried out every time the loop repeats.

At the end of the program, the computer prints out the list of bad strings.

Make a program that automates the first branch of the decision tree, and prints out the list of bad strings.

Continue the decision tree

Delete the command to print `"more tests required"`. Now you will add the extra tests.

The next branch of the decision tree checks if the character # is in the signal.

```
if "#" in item:
    bad_signals.append(item)
```

Here is the program so far. You can see the nested structures.

If you have made this program, run it now to check that it works.

```
good_signals = []
bad_signals = []

for item in signals:
    if len(item) < 3:
        bad_signals.append(item)
    else:
        if "#" in item:
            bad_signals.append(item)


print(bad_signals)
```

Final branch of the decision tree

Finally, you will add the third branch of the decision tree.

```
if "#" in item:
    bad_signals.append(item)
else:
```

Now type the final test. This test checks if the signal includes a space.

```
    if " " in item:
```

Good strings contain a space. Bad strings do not.

Here is the completed program. This program includes every test from the decision tree.

```
good_signals = []
bad_signals = []

for item in signals:
    if len(item) < 3:
        bad_signals.append(item)
    else:
        if "#" in item:
            bad_signals.append(item)
        else:
            if " " in item:
                good_signals.append(item)
            else:
                bad_signals.append(item)


print(bad_signals)
print(good_signals)
```

Activity

Write a program to automate the decision tree, as shown in this lesson. Run the program. You should see that the program has managed to divide the list into good and bad signals. Here is a sample of the output you will see.

```
['.', '~', '**', '*&_)*&^%^&*%^$~@:~', '234724u2u23u888', '..
asjdha## djhaidj# ddjiadj#', ' %', '43umcu3rg0ucthgm@:;<', '-
']
['Weather warning: there is a storm approaching', 'Helicopter
 arriving McMurdo station 10:00 Tuesday', 'First aid kit need
ed at far camp', 'Food delivery drop will be delayed by 48 ho
urs', 'Repairs needed at the observation platform', 'Urgent -
 update all anti-virus systems', 'Please re-send meteorologic
al data', 'Medical officer requested at main base', 'Penguin
migration has begun 2 weeks early', 'Solar flare may affect r
adio communication']
```

Conclusion: expert systems and AI

You have seen that a program to automate a decision tree is quite complex, even if the decision tree is simple. The program has many nested structures.

Automating a decision tree makes a program that will make human-like decisions. For this reason many people think that expert systems are an example of AI.

But some human decisions cannot be turned into a simple algorithm of yes/no choices. This type of decision cannot be replaced by an expert system using a decision tree.

In the next lesson you will learn about an alternative to using an algorithm to make decisions.

Extra challenge

In the last lesson you saw a decision tree used by an insurance expert. If you have time, automate this decision tree by making it into a program.

You will need to ask for input from the user at each decision point.

Test

1. A decision tree includes decisions where the tree splits into two branches. What program structure matches this part of a decision tree?
2. Supposing a scientist sent a signal with the symbol # in it. Would the decision tree classify this as a good or bad signal?
3. Explain in your own words why this program includes a loop.
4. Explain in your own words how the append command is used in this program.

Be creative

Use a decision tree to set out the plot of an adventure story. For example, the hero could have a choice of two doors to go through – each door would lead to different decisions and further adventures.

If you have time, there are other creative activities that you can develop from this work.

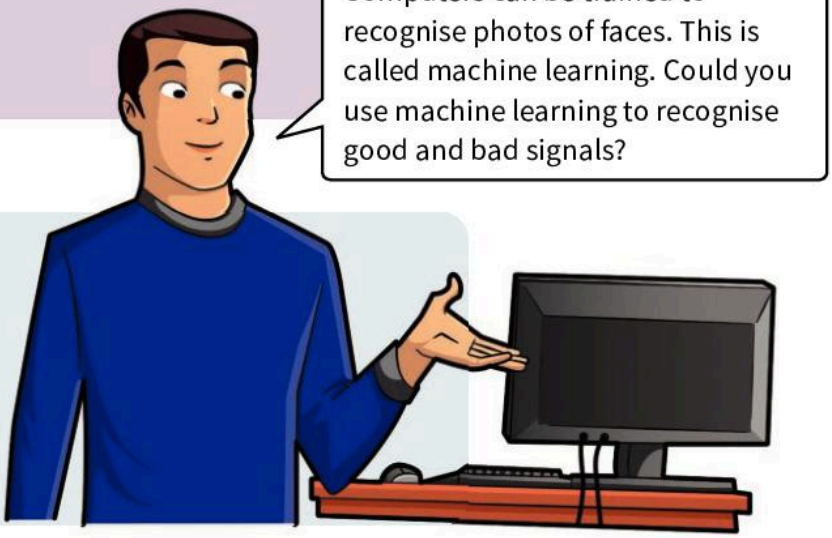
- Make a colourful poster of the decision tree. You can include drawings to represent the different choices.
- Write the adventure out in full, as a story. The reader can follow different branches of the story according to their choices at each stage.
- Turn the decision tree into a Python or Scratch program. It will be like a text-based adventure game. Friends can run the program and answer the questions to experience the game.

3.5 Machine learning

In this lesson

You will learn:

- what machine learning is
- how machine learning is used in AI.



CASE STUDY

Taz works with many scientists at the Antarctic base. One scientist tells Taz about machine learning.

In this lesson you will find out if machine learning methods could be used to help Taz.

What is machine learning?

The normal way to make a program is to write an algorithm. An algorithm sets out the steps to solve the problem. You turn the algorithm into a program. The computer will carry out the commands in the program.

In the last lesson you made a program to match an expert system algorithm.

Machine learning works differently. You do not make an algorithm. The computer has to learn how to solve a problem for itself. This is called **training** the computer.

There are several types of training. For example:

- supervised training
- unsupervised training
- reinforcement learning
- deep learning.

Training the computer

In this section you will look at how machine learning is used to train computers to recognise pictures of faces.

The computer can recognise people and other objects in a street scene.

A driverless car uses AI to spot people in the road.

Supervised training

In supervised training the computer is given a lot of data that has already been organised and labelled. For example, the computer might be given millions of images. The images have been labelled to say if they show faces or not. The computer will learn to tell the difference between faces and other images.

Unsupervised training

In unsupervised training the computer is given a lot of data. It is not sorted or organised. The computer has to find the patterns for itself.

For example, the computer might be given millions of images of many types. The computer will put the pictures into groups that are similar. One of those groups will be pictures of faces.

Groups are called **clusters**. All the images in a cluster will have a lot in common.

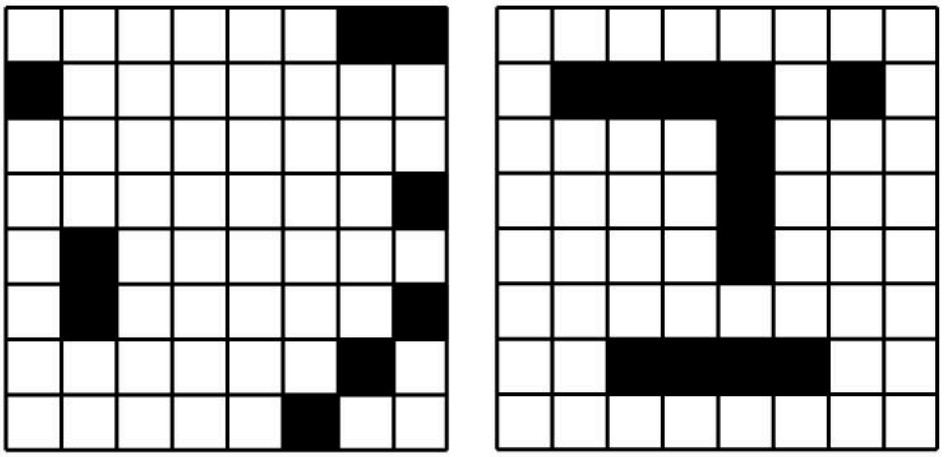
This means the computer can use data that has not been labelled. There is lots of this type of data on the internet.

Reinforcement learning

In reinforcement learning, the computer starts by producing random or undirected signals or actions. **Reinforcement** is feedback that lets it know if it has moved towards the right goal. This is like when your school work is marked by a teacher.

Gradually the computer learns to produce output that is closer and closer to the right result.

For example, this computer made random patterns of dots.



A human user told the computer which one looked more like a face. Gradually, by getting lots of feedback like this, the computer learned to make patterns that look a lot like a face.

Deep learning

Deep learning combines the other methods into a highly complex learning process. Deep learning typically uses a different type of computer structure called a neural network.

Deep learning can produce very powerful results. Computers have learned to make images that look exactly like photos of real people.

Advantages and disadvantages

Machine learning has big advantages:

- You don't need to tell the computer how to solve the problem.
- You give the computer a goal and it will work out its own solution.

But machine learning has limitations:

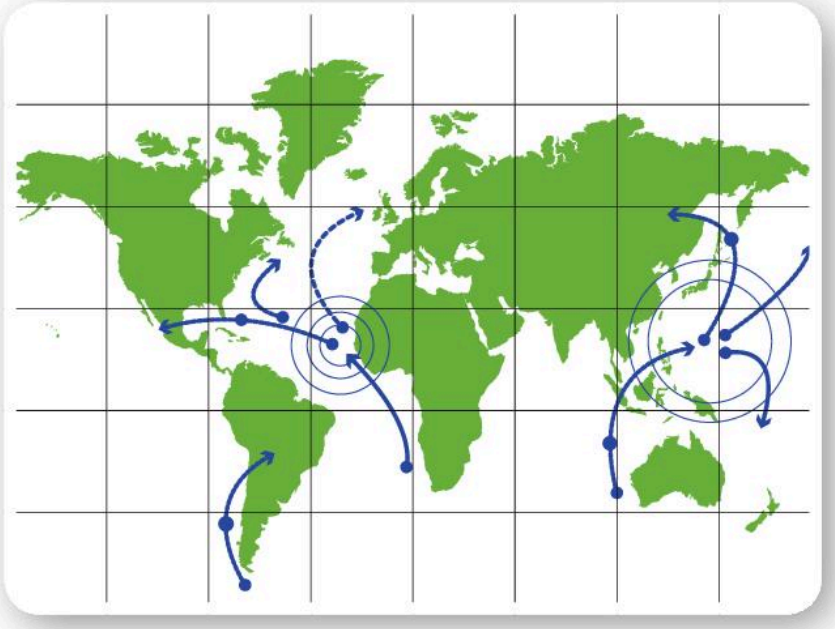
- The computer needs a lot of data.
- The data must be diverse and varied.
- Machine learning can go wrong.

For example, a scientist wanted to train a computer to recognise images of bacteria. He showed the computer lots of examples. But all the pictures were taken on the same background. The computer learned to recognise the colour of the background. That was not what the scientist wanted.

Uses of machine learning

You have seen how machine learning is used to recognise faces and make images of faces. It can be used for other purposes:

- diagnosing illnesses
- weather forecasting
- understanding speech
- spotting computer viruses.



By looking at lots of examples, the computer can learn to make predictions. For example, a computer could recognise the signs of a hurricane so people can take shelter.

Activity

Here are descriptions of different types of machine learning.

The computer is given data which has not been labelled or sorted. The computer finds clusters or groups in the data by looking for similarities. It learns how to sort the data into clusters.

The computer generates random or undirected output. Feedback tells the computer if it has produced the right output. It learns how to produce the right output.

This method requires a complex type of computer system called a neural network. It combines the other methods to produce the most powerful type of machine learning.

The computer is given lots of data. The data is labelled and classified. The data is already organised into groups. The computer learns what the members of each group have in common.

Match each description to one of these terms:

- supervised training
- unsupervised training
- reinforcement learning
- deep learning.

Extra challenge

Write a brief description of how each type of learning might be used to teach the computer to recognise good and bad signals. The first one is done for you.

1. Supervised training: The computer is given lots of example signals. The example signals have been labelled as good or bad signals. The computer learns what the different types of signal have in common.
2. Unsupervised training
3. Reinforcement learning

Test

1. What does machine learning mean?
2. State one advantage to Taz of using machine learning to spot bad signals.
3. In both supervised and unsupervised training, the computer gets lots of data. What is the difference between the two?
4. What type of computer system is needed for deep learning?

3.6 Training the computer

In this lesson

You will learn:

- to recognise some of the features of reinforcement learning
- to use random input to solve a problem.

Spiral Back

In this lesson you will use commands from Student Books 7 and 8, including using the Python Shell, using loops, and making random numbers.

This lesson uses programming commands that you have used before. It will test your understanding of programming. There is less help for you than in previous lessons. Do as much as you can in the time you have.

CASE STUDY

Taz has to check text strings to see if they are bad signals. Good signals are made of valid characters such as letters of the alphabet and punctuation marks.

Bad signals contain other random characters. For example:

΄HZɲÔ;>ħɟ¿□åØϒŋ

It can be hard to know which characters are valid letters. There are many different scientists on the base. They speak many different languages. Different languages have different characters and alphabets.

In this lesson you will look at a simple example of training the computer to recognise valid characters.

A simplified example

In this example you will create a simple program. It can remind you of some features of machine learning. It is not machine learning, just a simple Python exercise.

Remember the features of reinforcement learning:

- The computer makes random or undirected output.
- Feedback tells the computer if the results are correct (towards the goal).
- The process is repeated many times until the computer reliably reaches the goal every time.

You will write a very simple program to train the computer to recognise letters of the alphabet. You will develop it in three stages:

1. Generate a random character.
2. Get feedback on whether it is a valid character.
3. Repeat many times.

Make a random character

You will try out the commands to make a random character in the Python Shell. Then you will make a computer program.

Unicode characters

Unicode is a number code system. Every text character has a number code. Unicode includes many thousands of different characters including different alphabets and other symbols. You learned about Unicode in Student Book 7.

This Python command will make a Unicode character. Put any number inside the brackets and it will make the character that matches the number.

```
chr(99)
```

Try this out in the Python Shell. Put different numbers inside the brackets and see what characters you get.

To make it into a full program, store the character as a variable and then print the variable.

```
character = chr(99)
print(character)
```

```
>>> chr(99)
'c'
>>> chr(499)
'ǳ'
>>> chr(799)
'ϟ'
>>> chr(999)
'ϧ'
>>> chr(1299)
'ԓ'
```

Random number

To make a random number you must import a module called `random`. This will do all the work for you. The `random` module was created by Python programmers. They have made it freely available to anyone who wants to use it.

```
import random
```

You only have to give this command once at the start of a program or work session.

The `random` module includes a command called `random.randint`. This will give you a random integer (whole number). For example, this command will make a random integer between 1 and 99:

```
random.randint(1, 99)
```

Try this out in the Python Shell. Put different numbers inside the brackets to change the size of the random number.

To make it into a full program, store the number as a variable and then print the variable.

```
number = random.randint(1,99)
print(number)
```

```
>>> import random
>>> random.randint(1,99)
86
>>> random.randint(1,999)
689
>>> random.randint(1,100000)
41087
```

Combine the commands

Now you can combine the commands to:

- make a random number
- use the random number to make a Unicode character.

Try out these commands in the Python Shell. Here is an example.

```
>>> number = random.randint(1,9999)
>>> chr(number)
'.'
```

Make a program that learns valid characters

Now you have learned these commands, you can put them all together in a new program.

```
import random
number = random.randint(1,9999)
character = chr(number)
print(character)
```

Make this program and run it. You will see a random character. You can run the program several times. You will (probably) see a different character each time.

If your computer cannot show the character, you will see a plain square or an empty space.

Is the character valid?

Now you will provide feedback on the character. If the character is valid the computer will append it to a list.

Use your Python skills to add these commands to the program.

- At the top of the program, create an empty list called `valid`.
- At the end of the program, add a command to get user input. Ask the user if the character is valid (Y/N). Store the input as a variable called `answer`.
- Below this, add an `if` statement. If `answer` is `"Y"` append the character to the `valid` list.

You have learned all of these commands.

```
import random
valid = []

number = random.randint(1,9999)
character = chr(number)
print(character)

answer = input("Is this a valid character? (Y/N) ")
if answer == "Y":
    valid.append(character)

print(valid)
```

Run the program and see if it works.

Repeat many times

So that your computer can learn lots of valid characters, you must repeat the commands many times.

It is simplest to use a `for` loop. Make a `for` loop that counts up to 100.

Now look at the commands of your program. Which commands go inside the loop?

- Some commands happen only once – they go before the `for` loop.
- Some commands are repeated many times – they go inside the `for` loop.
- Add an extra command to print out all the valid characters that you found – this goes after the `for` loop.

Try to make this program without help.

Result

A student made this program and then ran it. This was part of the output.

This program prints out a list of valid characters.

```
Ɑ
Is this a valid character? (Y/N)
Is this a valid character? (Y/N)
Is this a valid character? (Y/N)
Is this a valid character? (Y/N)
Is this a valid character? (Y/N)
Ǵ
Is this a valid character? (Y/N)
Is this a valid character? (Y/N)
B
Is this a valid character? (Y/N) Y
Is this a valid character? (Y/N)
['o', '', 'i', '1', 'B']
```

Activity

Make the program described on this page. It should have these features:

- Create an empty list called `valid`.
- Loop 100 times:
  - Make a random Unicode character.
  - Ask the user if the character is valid.
  - If the character is valid, append it to the list.
- Print out the list at the end.

Extra challenge

To make this program more useful you could save the valid characters to a text file, stored on the computer. Then you could use the list of valid characters in other programs. Carry out your own investigation into storing data in a text file.

Test

1. This program loops 100 times. Explain how you would change the program to loop fewer times.
2. Which line of the program gets feedback from the user?
3. What happens to a character if the user identifies it as a valid character?
4. The list of valid characters will be lost when you close the program. Explain in general terms how this program could be adapted so the results can be used another time.

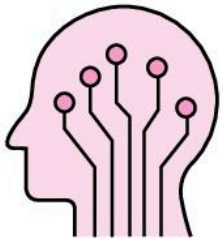
Check what you know

You have learned

- what artificial intelligence (AI) means
- how AI is used in real life
- some methods used to develop AI
- the benefits and limitations of AI.

Try the test and activities. They will help you to see how much you understand.

Test



1 Which of the following describes AI?
   - **a** Human beings can think like computers.
   - **b** Computers can make human-type judgements.
   - **c** Computers are made of artificial components.
   - **d** Logical tests are true or false.

2 Briefly describe one use of AI in the modern world.

3 Which of the following describes a heuristic?
   - **a** A decision tree
   - **b** An embedded `if` structure
   - **c** An estimate or guess
   - **d** A form of machine learning

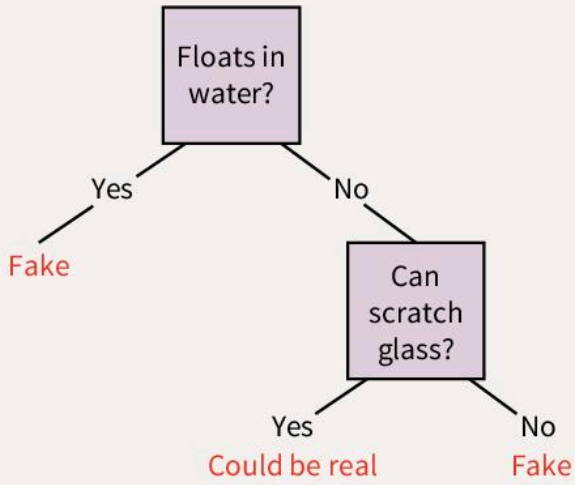
4 Explain what an expert system is.

5 Machine learning has benefits. Which two of the following are benefits of machine learning?
   - **a** The computer does not need any data to find a solution.
   - **b** The computer works out how to solve the problem.
   - **c** The computer never makes any mistakes.
   - **d** The computer develops solutions based on the data.
   - **e** The computer does not need any training.

6 Choose any AI technique you have learned and describe its limitations or problems.

Activities

Diamonds are worth a lot of money. There are pretend diamonds that look realistic. There are tests to tell real diamonds from pretend diamonds. Two of the tests are set out in this decision tree.



These tests are heuristics. They give a useful quick answer but they do not produce perfect accuracy.

1 **Use the algorithm to make a decision.** Izzy wanted to know if the stone in her necklace was a diamond. Here are the facts about the stone.

- The stone does not float in water.
- The stone does not scratch glass.

Use the decision tree to say if the stone is a real diamond or not.

2 **Create an automated expert system based on the heuristic.** Make a simple Python program that copies the decision tree. Run the program and check that it gives correct answers.

3 **Improve the accuracy of the algorithm.** The two tests in the decision tree will spot some fake diamonds. But some fake diamonds will pass both tests. Professional jewellers use other tests. For example, a real diamond does not conduct electricity.

Draw the decision tree, extending it to include the test 'Does the stone conduct electricity?'

Extend the Python program to include the new test.

Self-evaluation

- I answered test questions 1 and 2.
- I completed activity 1.
- I answered test questions 1–4.
- I completed activities 1 and 2.
- I answered all the test questions.
- I completed all the activities.

Re-read any parts of the unit you feel unsure about. Try the test and activities again – can you do more this time?

4 Programming: The fish pond plan

You will learn

- to build a model of a real-world system
- to use a model to find the answers to real-world problems.

In this unit you will build a program to model a real-world system. That means you will enter number values to stand for important parts of a system. The computer will process the numbers to show how the system will work in real life. In this unit you will enter values to represent a working fish pond on a farm. Your model will check the volume of water in the pond, and give the farmer a warning if the water might get too low. Making a mathematical model is a fast way to discover if there are problems ahead. For the farmers it is less risk to explore a computer model before doing the hard work of building a real-life fish pond.

Talk about...

In this unit you will model a fish pond system. The model will work out the volume of water in the pond. Computer models are used for many other purposes. For example, a model might be used to work out how much water and electricity, and how many houses will be needed as a city grows in size.

If you had the job of modelling the future growth of your community, how would you do it? What data would you collect? Do you think you could make an accurate model? Are there too many unknown factors?

Learning outcomes: Design an abstract model based on a real-world system; Use a program to find solutions to a real-world problem

Unplugged

In this unit you will input measurements of width, length and depth to a program. The program will calculate area and volume.

- **Area:** The size of a rectangular area is calculated as width * length. Width and length are measured in metres. Area is given in square metres. This is also written as m^2.
- **Volume:** The volume of a cuboid shape such as a room is calculated as area * height. Volume is given in cubic metres. This is also written as m^3.

Take measurements and calculate the floor area and volume of your classroom. If you have time, record and measure a range of other volumes. For example:

- the main hall in your school
- your teacher's desk
- a box or piece of furniture in your room.

You can use approximation if the shape is not regular or if it is not easy to measure exactly.

Did you know?

The FAO is the Food and Agriculture Organization of the United Nations. It is their job to help people around the world grow the food they need. The model of a fish pond in this unit is taken from the FAO Handbook on small-scale freshwater fish farming. This is available on their website (www.fao.org/home/en/) and as a CD.

By helping farmers to make and use fish ponds, the FAO have increased the prosperity of communities in many countries around the world. Fish are a good source of vitamins and protein, and can be sold to raise money for other needs.

To find out more, put these terms into a search engine:

FAO Aquaculture

mathematical model
algorithm user-friendly interface
abstraction assumptions
for loop while loop
nested structure

4.1 A model pond

In this lesson

You will learn:

- to use abstraction to make a mathematical model.

Spiral Back

In Student Books 7 and 8, you learned to plan and write Python programs. You analysed problems and worked out their inputs, processes and outputs. In this lesson you will think about the inputs and calculations that you will use to solve a problem.

CASE STUDY

The villagers of Redstone Valley have a problem. There used to be a gold mine in the valley. The villagers earned money by working for the mine. But the mine has closed. The villagers need to find another way to bring prosperity to their valley.

The solution is to raise a type of fish called tilapia. This is a fish that people like to eat. The villagers will dig fish ponds. They will put water into the ponds. They will put baby tilapia into the ponds. When the tilapia are full size, the villagers can sell them to market.

There is a limited amount of water in Redstone Valley. The villagers need to know how big the ponds can be, and how much water they need. These facts must be calculated accurately. In this unit you will plan a program to help the villagers find out the facts they need.

What do we need to know?

The villagers must decide on the size of each pond. They will decide the width and breadth and depth. They need to know:

- how much water there will be in the pond
- how many fish can live in that pond.

That will help them to plan the fish ponds for the village.

Real life or model?

One way to find out facts about the fish pond would be to make a real-life pond. Then you could make measurements of the pond. You could see if the fish stay alive in the pond, or if they die.

This is one way to find out. But there are big problems:

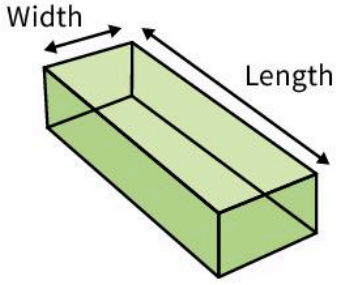
- It takes a lot of time and work to make a pond.
- It is hard to try out and test different sizes of pond.
- If the plan goes wrong, it is a waste of fish and other resources.

For this reason it is a good idea to make a model first. A model will include all the important facts about the system. A model is quicker, cheaper and easier to make. When the model has proved the idea will work then the farmer can make the pond in real life.

Mathematical model

To test pond ideas you will make a **mathematical model**. That means a model that uses numbers to stand for all the parts of the system. Instead of digging a real pond, with real water and fish, you can do all the working out using numbers.

In this unit you will find out how to make a model. You will use a computer program to make the model work and try out different number values.



Surface area = Width * Length

Abstraction

To make a model of a real-life system you will use **abstraction**. Abstraction means making a problem simpler by leaving out details.

Which details should you leave out? Which details should you keep? That depends on the purpose of the model.

- **Leave out details** that are not needed for the purpose.
- **Keep details** that are needed for the purpose.

Abstraction turns a big and complicated system into a few key facts. Those facts will help you make the mathematical model for a purpose.

Activity

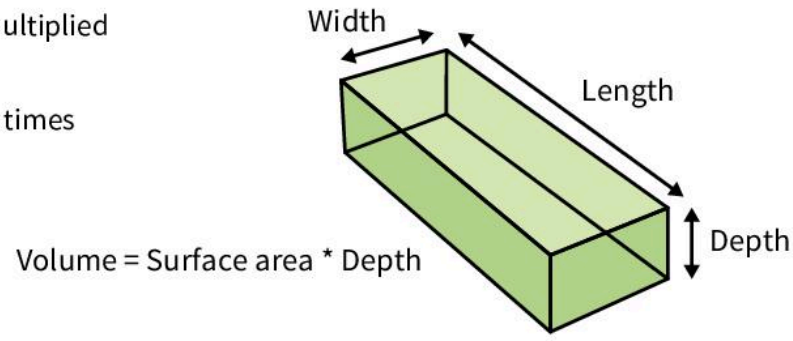
A farmer plans to make a pond on his land. He asks you to find out how much water the pond can hold. He also wants to know how many fish can live in the pond. Here are some facts that the farmer can tell you. Which facts do you need to make the mathematical model?

1. How wide and long the pond will be
2. The farmer's name
3. How many children the farmer has
4. The colour of the fish
5. How deep the pond will be
6. How many miles to market
7. If the farmer has a truck
8. The other crops the farmer grows on his land
9. How much water one fish needs to live in

Values used in the model

The villagers will dig ponds in the shape of a rectangle. They will input the width, length and depth of the pond. Your model will tell them the surface area and volume of the pond.

- The surface area of the pond is width multiplied by length.
- The volume of water is the surface area times the depth.



Volume = Surface area * Depth

This table shows the values used in this model.

The table is partly completed.

Value	Input	Calculated	Calculation	Units
Pond width	✓			
Pond length				
Pond depth				metres
Surface area		✓	width * length	
Volume of water				

Activity

1 Copy the table into your book, or make it using a word processor.

- Add ticks to show whether each value is input or calculated.
- If a field is calculated, say what the calculation is.

2 State the units used for each measurement. Pick one of the following choices for each:

- metres
- square metres
- cubic metres.

Extra challenge

Each cubic metre of water is enough room for two tilapia fish. Add a new row at the bottom of the table. The heading is 'Number of fish'. How is this value calculated? (You can leave the units column empty.)

Test

A farmer plans to make a pond. He wants to know how much water he will need to fill the pond.

1. Why is it a good idea to use a model to answer this question before you dig the pond?
2. Say one fact about the pond that you need to know to calculate its volume.
3. A model doesn't include all the facts about a real-life system. Why not?
4. How can you decide which facts to leave out of an abstract model?

4.2 Plan and make a program

In this lesson

You will learn:

- to make a program to match a mathematical model.

Spiral Back

In Student Books 7 and 8, you made Python programs that took user input. You learned to convert an input into a numerical data type (integer or float). If you have forgotten these skills, look back at previous books in the series.

CASE STUDY

You will make a program that models the features of a fish pond. You will use this model to give the villagers the facts they need.

The villagers will input:

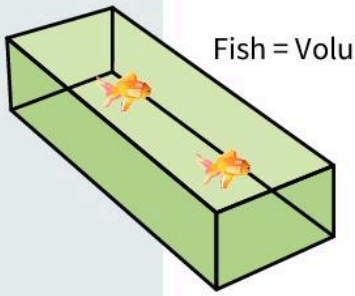
- the width, length and depth of the pond (in metres).

Your program will output:

- the surface area of the pond (in square metres)
- the volume of water in the pond (in cubic metres).

Each cubic metre of water is enough for two fish. Using this information the program can output:

- the number of fish that can live in the pond.



Algorithm

An **algorithm** is a plan to solve a problem. It sets out the steps in order. You can use an algorithm as a program plan. An algorithm should tell you:

- the inputs
- the processes that turn inputs into outputs
- the outputs.

You can set an algorithm out in a simple table like this. This is incomplete.

Inputs	width length depth
Processes	surface area =
Outputs	surface area volume fish

Activity

Copy the table on paper or with a word processor. What additional processes are needed to turn the inputs into outputs? Complete the Processes section of the table.

Python program

Now you will make a Python program to match the algorithm. It must cover all inputs, processes and outputs.

Inputs

The input values are the width, length and depth of the pond. You must make a Python program to input these values.

- Create a **user-friendly interface** – that means there are clear messages (prompts) to help the user.
- Store the data using suitable variable names.
- Convert the data to the right data type.

The variables hold numerical values. They could be integer or float data type. What is the difference? Which one would you choose?

Here is an example of a program with the width of the pond as an input. The value is converted to float data type.

```
width = input("Enter the width: ")
width = float(width)
```

Using this as an example, you can create a program to input all the values you need.

Processes

You must add calculations for:

- the surface area of the pond (width * length)
- the volume of the pond (surface area * depth)
- the number of fish that can live in the pond (volume * 2).

You will use Python formulas to calculate each value. Each value will be saved as a variable. Each variable must have a suitable name.

Here is an example of a program that calculates the surface area of a pond.

```
width = input("Enter the width: ")
width = float(width)
length = input("Enter the length: ")
length = float(length)

area = width * length
```

Using this as an example, you can create a program to calculate all the values.

Outputs

You must output the values. You will do this using Python print commands. Here is an example of a program that outputs the surface area of a pond.

```
width = input("Enter the width: ")
width = float(width)
length = input("Enter the length: ")
length = float(length)

area = width * length
print(area)
```

Using this as an example, you can create a program to output all the values.

Try out the program

When you have made your program you can try it out. Enter these values:

- width: 10 metres
- length: 15 metres
- depth: 1.5 metres.

You should get these results:

- surface area: 150 m^2
- volume: 225 m^3
- fish: 450.

Abdul made a program to work out these values. He ran the program. The input and output commands appeared in the Python Shell. This is what Abdul's program looked like.

```
Enter the width: 10
Enter the length: 15
Enter the depth: 1.5
150.0
225.0
450.0
```

The program works. The results are correct. But the interface is not very user-friendly.

User-friendly interface

Abdul made changes to the program. He made a more user-friendly interface. He ran the program. Here is what it looked like.

```
Fish Pond Model
===============
Enter pond width (metres): 10
Enter pond length (metres): 15
Enter pond depth (metres): 1.5


Results
-------
Surface area of the pond is 150.0 square metres
Pond contains 225.0 cubic metres of water
Number of fish:  450
```

A program like this is more helpful for the villagers.

Limitations of abstraction

When you make an abstract model you leave out many real-life details. You have to do this. A computer program that recorded every fact about real life would take a very long time to write. You would need a very powerful computer to run it.

As well as leaving out details, an abstraction will make facts simpler and more regular. That means it won't match reality exactly. Here are some ways that a real-life pond will be different from the abstract model you made in this lesson:

- The pond might not be an exact rectangle.
- Measurements might not be exactly right.
- The depth of the pond might vary.
- Fish aren't all the same size. Big fish might take up more space.

However, our abstract model is good enough. It will give the villagers the information they need. It does not need to be exact in all details.

Activity

Create a Python program that takes as inputs the three dimensions of a pond (width, length and depth). It will output the surface area and volume of the pond, and the number of fish that can live in the pond.

Run the program and enter suitable input values. If there are problems then try to find and fix them.

Extra challenge

Add a loop to the Python program. With each loop the program will:

- ask for new inputs for width, length and depth values
- produce outputs based on these values.

This means you can try out many different input values.

Think of a suitable exit condition for the program. How will you stop the loop?

Test

1. An algorithm must include the inputs to a program. What else?
2. You need to work out how many fish can live in the pond. What value do you need to work out first?
3. A cubic metre of water contains 1000 litres. Write an extra Python command to calculate how many litres of water there are in the pond.
4. Write the Python command to output the number of litres as a user-friendly message.

4.3 Filling the pond

In this lesson

You will learn:

- to make a program to test the effect of changes to a model.

CASE STUDY

The villagers want to know how long it will take to fill each pond with water.

The time to fill each pond depends on two values:

- how much water the pond can hold (the volume)
- the speed of water going into the pond (the flow).

In the last lesson you made a program to calculate the volume of a pond. That is the amount of water it will hold. Now you will calculate how long it will take to fill the pond.

Simplification

In the last lesson you saw that an abstract model always simplifies a real-life system. You need to simplify or the model will be too complicated.

In this lesson, you will make an abstract model of a pond filling with water. The water goes down a pipe into a pond. You will leave out facts like the colour of the pipe and the name of the village. These facts do not relate to the purpose of the model.

Here are some other facts you will leave out of the abstract model:

- Evaporation might take some water out of the pond.
- Rainfall might add some extra water to the pond.
- There might be leaks out of the pond or the pipe (the name for this is 'seepage').

These extra facts do relate to the purpose of the model. But – for now – you will leave them out. This means the model will not be completely accurate.

Assumptions

To make an abstract model you sometimes need to leave out details that could be important. For example, rainfall could help to fill the pond more quickly. Instead you will assume rainfall, evaporation and leakage are zero.

These are **assumptions**. Assumptions are values that you decide to leave out, or set at a fixed level. You do this to simplify the model.

Assumptions might make your model less accurate. But they make the model easier to build. You should always share your assumptions with the people using the model. That way they know what details you have left out.

Calculating water flow

The villagers will use a water pipe to fill their ponds. How many days will it take to fill each pond?

The first step is to calculate how much water comes out of the pipe. The flow of water down a stream or a pipe is given in litres per second. That is the number of litres that comes out of the end of the pipe in one second.

Start a new program

Make a new Python program. It must do these things:

- The input to the program is the number of litres per second that comes out of a pipe. This could include a decimal, so save it as float data type.
- There are 3600 seconds in an hour. Using this fact, work out the number of litres per hour.
- Output the result of the calculation.

```
second = input("Enter litres per second: ")
second = float(second)
hour = second * 3600
print(hour,"litres per hour")
```

Extend the program

The program shown here converts litres per second to litres per hour. Here are two more facts:

- **There are 24 hours in a day.** Using this fact you can convert litres per hour into litres per day.
- **There are 1000 litres in one cubic metre of water.** Using this fact you can convert litres per day to cubic metres per day.

These facts will help you make a program that takes as input the number of litres per second. The output is the number of cubic metres per day.

```
second = input("Enter litres per second: ")
second = float(second)
hour = second * 3600
print(hour,"litres per hour")

day = hour * 24
day = day/1000

print(day, "cubic metres per day")
```

Example program in use

If you have put all this code together, you should have a working program. The image shows this program in use. It shows the inputs and the output of this program.

```
Enter litres per second: 0.5
1800.0 litres per hour
43.2 cubic metres per day
```

Enter these inputs into your program. If your program is working correctly, it should give the same output.

Activity

Create a Python program that takes as input the number of litres per second. It will output the number of cubic metres per day.

How long to fill a pond?

Now you will calculate how many days it will take to fill a pond.

Make one big program

In Lesson 4.2 you made a program to calculate the volume of a pond. Look back at that program. You need this code again.

Here is a program with both lots of code.

Run the program to make sure it works.

```
print("Size of pond")
print("------------")
width = input("Enter pond width (metres): ")
width = float(width)
length = input("Enter pond length (metres): ")
length = float(length)
depth = input("Enter pond depth (metres): ")
depth = float(depth)
area = width * length
volume = area * depth
print(volume, "cubic metres of water")
print("\n")

print("Filling the pond")
print("----------------")
second = input("Enter litres per second: ")
second = float(second)
hour = second * 3600
print(hour,"litres per hour")
day = hour * 24
day = day/1000
print(day, "cubic metres per day")
```

Calculate a new value

Finally you will extend the program to work out how many days it takes to fill the pond. The number of days to fill the pond is **the volume of the pond, divided by the water flow in one day**.

- What are the names of the variables you have used to store these two values?
- What operator will you use to work out the number of days?
- What name will you give to the variable that stores the answer?

Add final lines to your program to complete this calculation.

```
print(day, "cubic metres per day")
days = volume / day
print("It will take",days,"days to fill the pond")
```

Using the program

The image shows this program in use. It shows some example inputs. It shows the outputs.

```
Size of pond
------------
Enter pond width (metres): 10
Enter pond length (metres): 15
Enter pond depth (metres): 1.5
225.0 cubic metres of water


Filling the pond
----------------
Enter litres per second: 0.7
2520.0 litres per hour
60.48 cubic metres per day
It will take 3.7202380952380953 days to fill the pond
```

Enter these inputs to your program. If your program is working correctly, you should see the same output that you see here.

Activity

Open the Python program you made last lesson, which calculates the volume of a pond. Extend the program so that it:

- takes as input the water flow through a pipe in litres per second
- outputs litres per hour and cubic metres per day, and the number of days it will take to fill the pond.

Try the program with different inputs.

Extra challenge

The output of this program is a decimal number.

- Use this command to round the number to 2 decimal places before printing:

```
days = round(days, 2)
```

- Convert the output so that it shows the number of full days plus extra hours. This is a harder challenge.

Test

In this lesson you made a program to model how many days it will take to fill a pond with water.

1. If a pond contains 1000 cubic metres of water, and the flow is 100 cubic metres per day, how many days will it take to fill the pond?
2. Give one reason why this answer might not be quite accurate.
3. What are assumptions in a model? Describe one assumption in this model.
4. Why might you include assumptions when you make a model?

4.4 Evaporation and rainfall

In this lesson

You will learn:

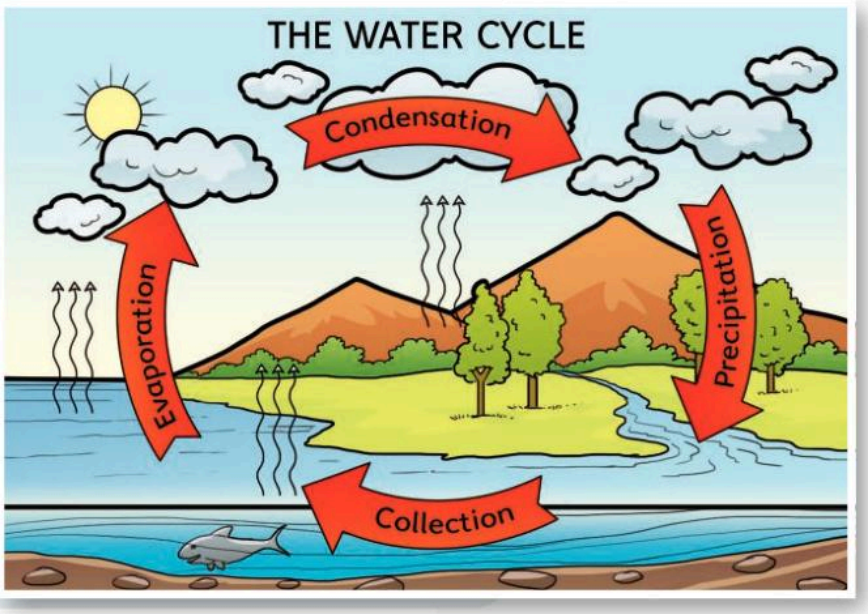
- to improve a model by removing assumptions.

CASE STUDY

In the last lesson you made a program to calculate how long it would take to fill a pond. The model included assumptions. You assumed that evaporation and rainfall were zero. In real life the level of water in a pool is affected by both factors:

- Evaporation means the sun shines on the pond and some of the water turns into water vapour. The amount of water in the pond goes down.
- Obviously, rainfall might increase the amount of water in the pond.

Both rainfall and evaporation are affected by the surface area of the pond. A wide, shallow pond will collect more rain, but also lose more to evaporation.



Need to know

The villagers need to know how these factors will affect their ponds. It is particularly serious if the weather is hot and there is not much rain. The water level will go down. If the water level goes down too far, the fish might die. To prevent this, the villagers will have to pipe more water into the ponds.

You will make a model of evaporation and rainfall each month. That will help the villagers to keep the ponds full of water. It will stop the fish from dying.

Evaporation

If you hang wet clothes outdoors they will get dry. If you leave a glass of water in a warm place, the water level will go down. This is caused by evaporation. Liquid water turns into water vapour and rises into the air.

Evaporation is affected by many factors:

- how hot the sun is
- how strong the wind is
- how dry the air is.

Evaporation lowers the level of the pond by a few millimetres every day. In this village the evaporation rate is 75 mm a month ('mm' means millimetres).

There are 1000 millimetres in a metre. To convert evaporation to metres you will have to divide by 1000.

Calculate water loss

Evaporation affects the whole surface of a pond. The bigger the surface area, the more water is lost. To calculate the amount of water lost by evaporation:

- calculate the surface area in square metres
- multiply by the evaporation rate in metres.

The result is a volume in cubic metres. That is the amount of water lost in one month due to evaporation.

Make an algorithm

This algorithm sets out the inputs, outputs and processes for calculating evaporation.

Inputs	width of pond length of pond
Processes	surface area = width * length evaporation = surface area * 75 / 1000
Outputs	evaporation (cubic metres of water lost per month)

Now make a Python program to match this algorithm.

```
print("Evaporation")
print("----------")
width = input("Enter pond width: ")
width = float(width)
length = input("Enter pond length: ")
length = float(length)

area = width * length
evaporation = area * 75/1000

print(evaporation,"cubic metres are lost per month")
```

Activity

Make a new Python program to match this algorithm. It should calculate the evaporation from a pond in one month as shown in this lesson.

Try out the program

This image shows this program in use. It shows some example inputs. It shows the outputs of this program.

```
Evaporation
-----------
Enter pond width (metres): 10
Enter pond length (metres): 15
11.25 cubic metres are lost per month
```

Enter these inputs into your program. If your program is working correctly, it should give the same output that you see here.

Rainfall

Rainfall is also shown as millimetres per month. You must multiply the rainfall by the surface area. Then divide by 1000 to turn it into cubic metres.

Here is the algorithm for calculating volume increase due to rainfall.

Inputs	width of pond length of pond rainfall (in millimetres)
Processes	surface area = width * length rain = surface area * rainfall / 1000
Outputs	rain (cubic metres per month)

Use your programming skills to make a Python program that matches this algorithm.

```
print("Rainfall")
print("--------")
width = input("Enter pond width (metres): ")
width = float(width)
length = input("Enter pond length (metres): ")
length = float(length)
rainfall = input("Enter rainfall (in millimetres): ")
rainfall = float(rainfall)

area = width * length
rain = area * rainfall/ 1000
print(rain, "cubic metres of rain goes in")
```

Combine both values

You can combine the rainfall program and the evaporation program to work out the change in the pond during the month.

Inputs	width of pond length of pond rainfall (millimetres)
Processes	surface area = width * length rain = surface area * rainfall / 1000 evaporation = surface area * 75/ 1000 change = rain – evaporation
Outputs	evaporation rain total change in pond volume

The image shows this program in use. It shows some example inputs. It shows the outputs of this program.

```
Change to the pond
------------------
Enter pond width (metres): 10
Enter pond length (metres): 15
Enter rainfall (in millimetres): 50
11.25 cubic metres of water evaporate out
7.5 cubic metres of rain goes in
The total change is:  -3.75
```

Enter these inputs into your program. If your program is working correctly, it should give the same output that you see here.

Activity

Create a Python program to calculate how the volume of water in a pond can change during one month from evaporation and rainfall.

- Assume that evaporation rate is 75 mm.
- Input the width and length of the pond, and how many millimetres of rain.
- Output the change in water volume during the month due to evaporation and rainfall.

Extra challenge

Some water will leak from the pond into the soil. This is called seepage. The amount depends on the type of soil. In this village the seepage rate is 20 mm.

Multiply seepage rate by surface area and divide by 1000. Add this value to your calculation of the change in the volume of water.

Test

1. The program in this lesson includes an assumption about evaporation. What is the assumption?
2. What Python data type will you use to store the loss of water due to evaporation: string, integer or float?
3. In this program, rainfall is entered as millimetres. Why do you have to divide this value by 1000?
4. How would you adapt the program to show the change in water volume as litres rather than cubic metres?

4.5 The pond through the year

In this lesson

You will learn:

- to extend the model to show change over time.

Spiral Back

In Student Books 7 and 8 you used loops in Python. In this lesson you will use a `for` loop to extend the program to every month of the year. If you need to remind yourself how to use loops, look back at previous books in this series.

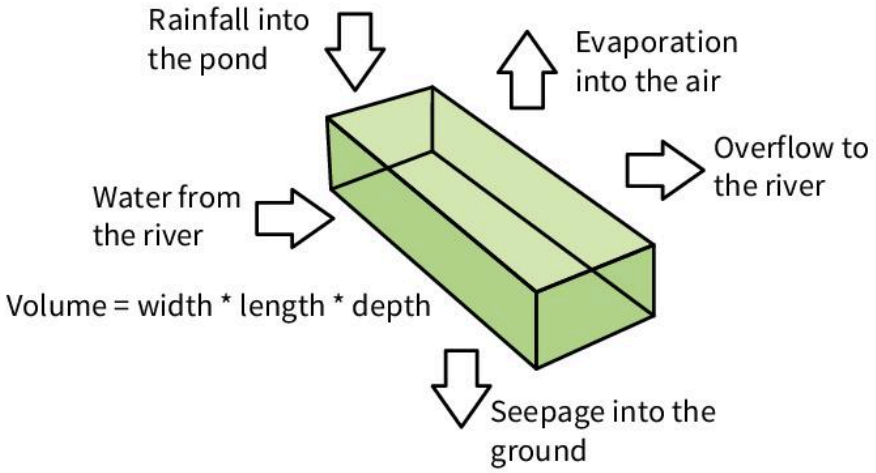
CASE STUDY

You have made a program that models the effect of rainfall and evaporation on the fish ponds in the village. Rainfall varies a lot in this village from month to month. The villagers are worried that the ponds might run out of water.

The model

The image shows all the factors that affect the level of water in a pond in a month.

For now we will assume that the same amount of water flows into the pond from the river, and back out to the river. This will keep the water fresh and clean for the fish. We will assume it does not change the amount of water in the pond.



Solving the problem

You will improve your mathematical model to help the villagers. Your new model will take all the factors that affect the volume of water in a pond. It will tell the villagers the total volume of water in a pond through the year.

Program challenge

The challenge is to make this program without help. You can use code that you have made before. You can retype the commands, or you can copy and paste from your old programs.

Input

Your program must take these values as inputs:

- width of the pond
- length of the pond
- depth of the pond.

Remember each input value must be converted to float data type.

Calculate volume

Add commands to calculate the surface area and volume of the pond. Output the volume.

Calculate changes

Add commands to calculate the evaporation and rainfall, and the total change. Output the change to the volume of the pond.

```
Change to the pond
------------------
Enter pond width (metres): 10
Enter pond length (metres): 15
Enter pond depth (metres): 1.5
The volume of the pond is 225.0 cubic metres
Enter rainfall (in millimetres): 50
The change in volume is -3.75
```

Activity

Make a program that calculates the volume of a pond, and the change in volume due to evaporation and rainfall.

Extend the program

You have written a program that:

- outputs the volume of the pond
- outputs the change in volume.

Now you will extend the program. It will work out the new volume, after all the changes.

Calculate the new volume

Add these commands to the end of the program

```
volume = volume + change
print("The new volume is", volume)
```

These commands work out the new volume, by adding all the changes. Then the program prints out the new volume.

This is the key fact that the villagers want to know.

```
Change to the pond
------------------
Enter pond width (metres): 10
Enter pond length (metres): 15
Enter pond depth (metres): 1.5
The volume of the pond is 225.0 cubic metres
Enter rainfall (in millimetres): 50
The change in volume is -3.75
The new volume is 221.25
```

Activity

Extend the program to print out the new volume of the pond.

Month by month

The program you made calculates the new volume of water at the end of one month. Now you will extend the program to calculate the volume at the end of every month for 12 months.

To repeat part of a program you will use a loop. There are two types of loop in Python.

- A **for loop** counts up to a set value.
- A **while loop** uses a conditional test.

Because we want to count to exactly 12 we will use a `for` loop. It must count up to 12. Here is the command to start the loop.

```
for i in range(12):
```

Which commands go inside the loop?

The next table shows the commands in your program. Tick the commands that must repeat every month.

Commands	Repeat every month?
Input the size of the pool	
Calculate the volume of water at the start of the year	
Input how much rain this month	
Calculate changes to volume this month	
Calculate the volume	
Output volume this month	

The commands that will repeat every month belong inside the loop.

Make the loop

Remember you must enter this command:

```
for i in range(12):
```

Find the first line that belongs inside the loop.

- Enter the command to start the loop before this line.
- Make sure all the other lines are indented to show they belong inside the loop.

```
for i in range(12):
    rainfall = input("Enter rainfall (in millimetres): ")
    rainfall = float(rainfall)

    evaporation = area * 75 / 1000
    rain = area * rainfall/ 1000
    change = rain - evaporation

    print("the change in volume is",change)
    volume = volume + change
    print("The new volume is",volume)
```

Activity

Create a Python program to calculate the volume of the pond every month for one year.

Run the program and make sure it works properly. Correct any errors you find.

Extra challenge

In Student Book 8 you made and used Python lists. Now you can use them to store monthly data.

- Create an empty list at the start of the program.
- Append the volume of water at the end of each month to the list.
- At the end of the program, traverse the list and print out each stored value.

```
month 1 225.0
month 2 221.25
month 3 217.5
month 4 219.75
month 5 211.5
month 6 200.25
month 7 189.0
month 8 177.75
month 9 166.5
month 10 155.25
month 11 144.0
month 12 140.25
```

Test

A student used this command to print out the volume of water in the pond:

```
print(volume)
```

1 Change this command so that it produces the following, more user-friendly output.

```
The volume of the pond is 250 cubic metres
```

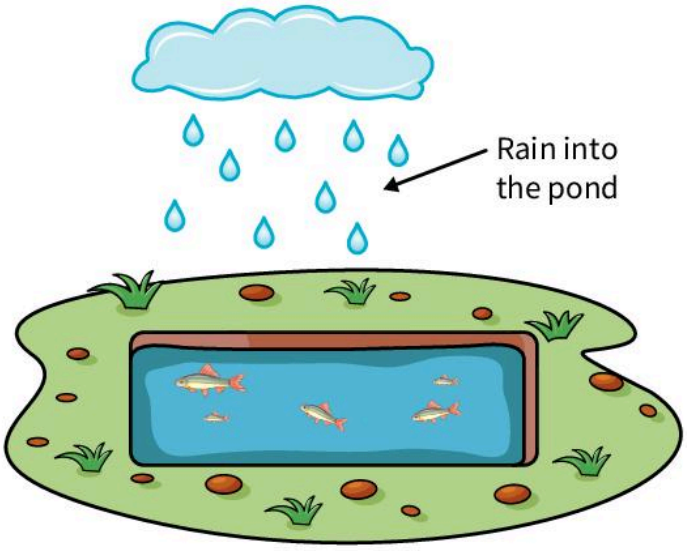
2 Why is a `for` loop the best choice for this program?

3 Which inputs are taken only once? Explain why.

4 The model makes an assumption about the flow of water between the pond and the river. What is the assumption?

Be creative

Make a picture to represent the pond model. Show the parts of the model using images instead of simple boxes. For example, you could draw a picture of rain falling on the pond, and fish living in the pond.



4.6 Warnings and advice

In this lesson

You will learn:

- to improve a model to help the user.

Spiral Back

In Student Books 7 and 8, you used if structures in Python. In this lesson you will use an if structure inside a loop. This is called a nested structure. If you want a reminder about the use of nested structures look back at previous books in this series.

CASE STUDY

If the water in a pond gets too low, the tilapia are crowded together. They can't get enough oxygen. They rise to the surface of the water and gasp for air. Unless the farmer puts more water in the pond, some of the fish will die.

The local government has made a reservoir to help the farmers. The farmers can ask for extra water from the reservoir. You will make changes to the program. It will tell the farmers how much water they need to get from the reservoir.

Your work

Try to work independently, using your programming skills. Unlike some earlier lessons, the code is not provided in full. This gives you an extra challenge.

The second part of this lesson is more difficult. This is an extension activity for students who are confident and capable. Do this extension work if you can.

Minimum volume

You will calculate the minimum volume of the pond. **Minimum** means the smallest possible value. You will work out the smallest amount of water you can have, without overcrowding the fish. To do this you need to input a new fact. Can you work out what it is?

You need to input the number of fish in the pond. If there are only a few fish, then the volume of water can get quite low without any overcrowding. But if there are lots of fish the pond needs to be full of water. The minimum volume is high.

Input the value

Open the program you made in the last lesson. Go to the input section at the top of the program. Add commands to input the number of fish that live in the pond.

```
fish = input("Enter number of fish: ")
fish = int(fish)
```

Work out the minimum

Tilapia don't mind some crowding. Two fish can live in one cubic metre of water. So the minimum volume is calculated as the number of fish divided by 2.

```
fish = input("enter number of fish: ")
fish = int(fish)
minimum = fish / 2
print("The minimum water is", minimum,"cubic metres")
```

Make changes to the program you made in the last lesson. Add extra commands to:

- take the number of fish as an input
- calculate and print the minimum volume of water needed to keep the fish alive.

These commands must go before the loop.

```
Change to the pond
------------------
Enter pond width (metres): 10
Enter pond length (metres): 15
Enter pond length (metres): 1.5
enter number of fish: 400
The minimum water is 200.0 cubic metres
The volume of the pond is 225.0 cubic metres
```

Monthly warning

You will adapt your program to show a warning if the volume of water falls below the minimum safe level.

Make an if structure

You will use an if structure. Remember that an **if structure** starts with a logical test. If the test is True then the commands inside the if structure will be carried out.

You can use an if structure in this program:

- Test if the volume of the pool is less than the minimum.
- If the test is True the program will print out a warning message.

The code might look like this:

```
if volume < minimum:
    print("W*A*R*N*I*N*G")
    print("Water level is below minimum")
```

Where does it belong?

You must put this code in the right place in your program. Here are two hints about where the code belongs:

- It must go inside the loop, because the test must happen every month. An if structure inside a loop is called a **nested structure**. It has double indentation. Look back at Student Books 7 and 8 if you have forgotten how to do this.
- You must enter this command after the new volume has been calculated. That is because you must test the volume after the changes for that month.

Using these two hints, enter the if structure in the right place in your program.

Activity

Make changes to the program. Add an if structure to display a warning message if the volume of water goes below the minimum.

Test the program

In a drought, the level of water in the ponds will fall. Check that your model shows this effect.

Run the program. Enter the following values:

- Width: 10
- Depth: 1.5
- Length: 15
- Number of fish: 400

Enter 0 rainfall each month. You should see the output shown here.

```
Month by month
--------------
Enter rainfall (in millimetres): 0
volume is: 213.75
Enter rainfall (in millimetres): 0
volume is: 202.5
Enter rainfall (in millimetres): 0
volume is: 191.25

W*A*R*N*I*N*G
Water level is below minimum
****************************
```

If your program includes water loss due to seepage, you will see a warning message more quickly.

Extra challenge

The program you made shows a warning that the pond is low on water. That tells the villagers they need to get water from the reservoir. But how much do they need? And how will that change the level of the water?

You can adapt the program to help with this problem.

1. Add extra commands to your program to show how much water is needed to bring the water up to the minimum safe level.
2. Input the amount of extra water that has been added from the reservoir (in cubic metres). Increase the volume of water in the pond by that amount.

```
Month by month
--------------
Enter rainfall (in millimetres): 0
volume is: 213.75
Enter rainfall (in millimetres): 0
volume is: 202.5
Enter rainfall (in millimetres): 0
volume is: 191.25


WARNING
Water level is below minimum
Extra water needed: 8.75 cubic metres
```

Test

1. How does this program calculate the minimum volume of water that the pond must have?
2. Write a logical test which is true if volume is below the minimum level.
3. The volume of a pond is lower than the minimum safe level. Write the Python calculation to work out how much water is needed to bring the volume up to the minimum safe level.
4. During the year, the fish get bigger and need more space. This fact is not included in the model. In your own words, explain how this could affect the model.

Explore more

A spreadsheet can be used to calculate the area and volume of the fish pond and work out the minimum volume of water.

You learned to use spreadsheets in Student Books 7 and 8. Working on your own, try to build a spreadsheet model of the fish pond. Your model should show the volume of water every month, and a warning message if the volume gets too low. Use the same values (pond size and number of fish) that you used in the Python program you made.

	A	B	C	D
1	**Fish pond model**			
2				
3	**Input values**			
4				
5	Length	10	metres	
6	Width	15	metres	
7	Depth	1.5	metres	
8	How many fish	400		
9				
10	**Calculated values**			
11	Area	150	length * width	
12	Volume	225	area * depth	
13	MINIMUM VOLUME	200	fish / 2	
14				
15	Monthly analysis	Jan	Feb	Mar
16	Enter rainfall (mm)	20	20	0
17	Start volume	225	216.75	208.5
18	Rain in	3	3	0
19	Evap out	11.25	11.25	11.25
20	Adjusted volume	216.75	208.5	197.25
21	WARNINGS			WARNING
22	Water added			
23	Final volume	216.75	208.5	197.25
24				

Digital citizen of the future

Computer models can help communities work together to achieve their goals. An important goal is to provide good food for everyone. As populations increase, computers are used to improve agriculture and increase food production.
Computer skills bring real world benefits. Computer models help us to reach our goals.

Check what you know

You have learned

- to build a model of a real-world system
- to use a model to find the answers to real-world problems.

Try the test and activities. They will help you to see how much you understand.

Test

The government of Redstone Valley make a reservoir to supply the fish ponds with water during the dry season. They build a model to work out the total amount of water that is needed in one year.

Here is the program.

```
#Redstone Valley Reservoir

volume = 0
ponds = 3
print("Enter cubic metres of water per year")

for i in range(ponds):

    print("Pond",i)
    water = input("Amount needed: ")
    water = int(water)
    volume = volume + water

print("Total requirement is")
print(volume,"cubic metres of water")
```

1. How many ponds are included in this model?
2. What information is input about each pond?
3. This model calculates the total water the reservoir has to provide to the ponds. It has been estimated that the reservoir must hold 1.7 times this total as a minimum. Explain or show how you would adapt the program to calculate and show the minimum.
4. The program simplifies the model of the reservoir using abstraction. State one fact about the reservoir that is left out of the model.
5. You identified a fact that is left out of the model. Does leaving it out make the model less accurate? Or does it have no effect on accuracy? Explain your answer.

Activities

The test shows the lines of a program. This program is provided as a file that you can download. Or you can type it in yourself.

Here is an example of the program in use.

```
Enter cubic metres of water per year
Pond 0
Amount needed: 1000
Pond 1
Amount needed: 500
Pond 2
Amount needed: 450
Total requirement is
1950 cubic metres of water
```

1 Run the program and enter the following values.

a 300 **b** 500 **c** 1000

What is the output of the program?

2 Adapt the program so the user is asked how many ponds there are. The program will loop that number of times.

3 Add a command to set the maximum volume of the reservoir to 2000 cubic metres. Adapt the program so that if the volume needed by the ponds is greater than the maximum, a warning appears.

Self-evaluation

- I answered test questions 1 and 2.
- I completed activity 1. I ran the program with the given input values.
- I answered test questions 1–3.
- I completed activities 1 and 2. I changed the program to ask how many ponds there are.
- I answered all the test questions.
- I completed all the activities.

Re-read any parts of the unit you feel unsure about. Try the test and activities again – can you do more this time?

5 Multimedia: Creating a multimedia news site

You will learn

- how to apply the media skills you have learned in this course in a real-world project
- how to combine different kinds of media using a multimedia platform
- how to choose appropriate platforms and services for your multimedia projects.

Multimedia projects combine different kinds of media. They provide the audience with information in the way that best meets their needs. Multimedia is used in journalism, entertainment and education, usually by delivering content on the world wide web. The web helps creators to share different kinds of content on a single platform, like a website. This technology has changed the way we communicate information and learning.

- Many newspapers now find most of their users online. The users prefer a website to a paper publication. This means that newspaper journalists have had to learn how to become multimedia producers. Many journalists also use social media, podcasts and video to reach their audience.
- Many teachers and lecturers now create learning materials that combine media. Instead of only talking to people in a classroom or lecture theatre, they now also create online courses that include audio and video presentations. This means that learners can access their teaching from anywhere in the world.

Creating a multimedia school news site

Throughout this course, you have learned how to plan and create digital media content. In this unit, you will use the skills you have developed to create a true multimedia project that combines text, images, audio and video.

Learning outcome: Create and combine multimedia content

You will use your skills to create a school media project that informs and entertains students, staff and parents at your school. The project can create an online or an offline product. For example:

- an online product like a blogging website featuring media content that is hosted on streaming services
- an offline product like a multimedia newsletter that contains media content in a file you can share directly with your audience.

The examples in this unit will show an online product, using a blogging website template to present a school news site.

Planning your media content

You have learned how important it is to plan media projects by thinking about your audience first: What are they interested in? What is the best way to tell them the information they want? Answering these questions helps you choose the right way of working and the right technologies and services to use. Throughout this unit, you will be able to use your planning skills to make sure you deliver a great multimedia product.

Talk about...

When you upload multimedia and other content to a public site, you can share your ideas with the world. But sharing content on these platforms also has some risks. Talk about the risks and ways in which you can avoid them.

Unplugged

In this unit, you will work in a team to make content for the school news site. Have a meeting with your team to plan your content – this is called an 'editorial planning meeting'. Write down your ideas for:

- at least two text articles with images – write down the subject of the article and suggestions for images
- one audio production, in the form of a podcast or news report – write down the subject and suggestions for contributors, such as interviewees
- one video production – write down the subject and suggestions for contributors and scenes to include.

Discuss and agree on which ideas to include in the project. Write down the results of your discussion in as much detail as you can. You will need to refer back to this information. These are the pieces of work you will deliver throughout this unit.

Did you know?

Sharing multimedia content via the web is more popular than ever. Today, there are over 1.6 billion websites in the world. More than 500 million of these are 'blogs'. Their authors account for over 2 million blog posts daily. Blog posts can include text, images, audio and video content.

embed widget
multimedia platform
posts pages
hosting service

5.1 Creating a multimedia platform

In this lesson

You will learn:

- how to set up services to present your text, audio and video content
- how to bring the content together through a multimedia platform.

Spiral Back

Throughout this course you have learned how to work with text, images, audio and video. In this unit you will use all of these skills to collaboratively plan and deliver a true multimedia project.

Choosing a platform

Multimedia is any digital content that combines different forms such as text, images, sound, video and more. You can create your content with your own device and software. You can share it with others directly by sending files or sharing access to fileshare or cloud storage sites. To share your content with a wider audience and bring together the different content types to make a true multimedia product, you need to use a multimedia platform. **Multimedia platforms** are the spaces that you can use to make, share or view multimedia content.

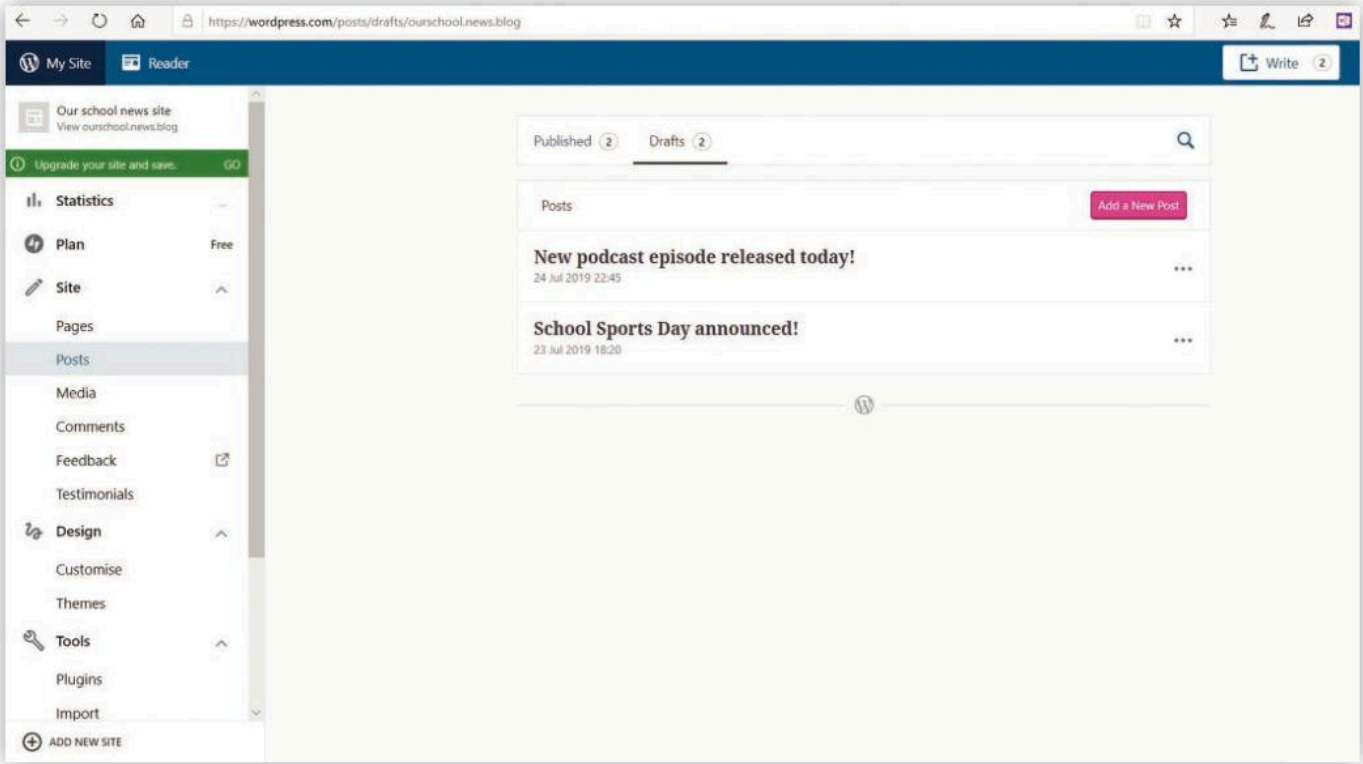
Examples of multimedia platforms include:

- website hosting services that provide easy templates for text and image pages. They often have **widgets** to add audio, video and social media to web pages
- social media services such as Facebook, Twitter, Weibo and Instagram. These services allow you to add text, video and audio content. They might restrict the way you can show your content
- offline applications such as Microsoft PowerPoint or Prezi. These applications are designed for presentations, but they allow you to add audio and video to pages.

When you are choosing a platform, it can be helpful to think about these issues:

- **Who is your audience and what is your content?** An online platform is better for reaching a wide audience. But you should also think about privacy and security. You can choose platforms that provide 'private' sites that only friends can see.
- **How well will your content work on the platform?** If you are producing long text articles then a blogging website will be easier than Twitter.
- **What is the cost and availability of the platform?** Most platforms provide a free service, but the amount of customisation and storage space might be limited.

The examples in this unit use WordPress.com. It provides free website templates that are easy to use. You can add audio, video and social media content to your site using simple tools and functions.



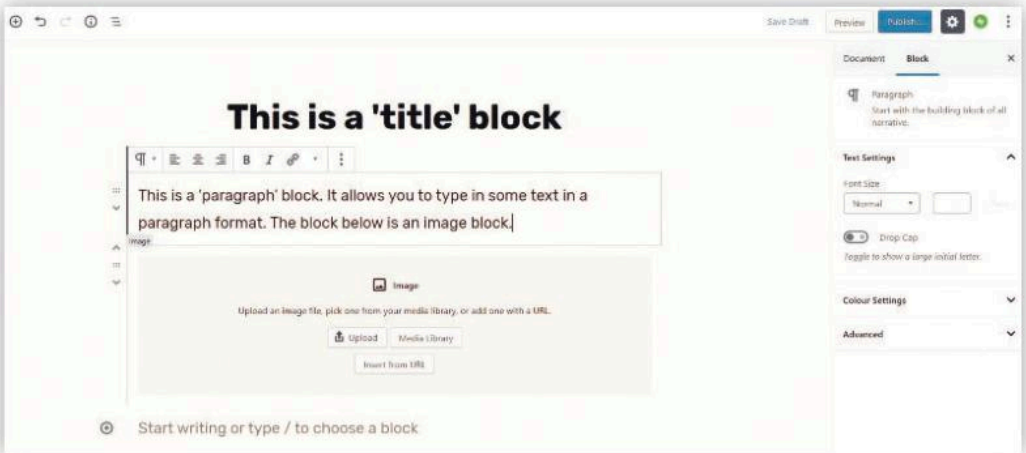
Setting up your multimedia platform

You can set up a multimedia platform such as WordPress.com, Blogger or Twitter by creating a new account with an email address. Go to the service's sign-up page and enter your details. Choose a free plan or the option that best suits your project.

Services like WordPress.com and Blogger let you choose a template for your pages. Choose a simple template that allows you to add posts and pages.

- **Posts** are separate items you can add on a scrolling page.
- **Pages** are separate pages for items that you want to stay visible.

The example in this unit uses the template called 'Friendly Business' on WordPress.com. This template supports post and pages. This will make it easy to add content.



Choosing services for media content

Some multimedia platforms will let you upload material other than text and images. They will let you save media like video and audio files in a media library that is linked to your site. But many platforms give you this option only if you pay for storage space. Some sites limit the file size for your media. You might also need to use some HTML code to make media players work on pages.

It can be easier to use a **hosting service**. Then you can **embed** a media player from that service in a page in your site. This means that you benefit from the hosting service's streaming capacity and functions.

There are many hosting services for media files. You should investigate the best services for your needs. You can use the methods you learned in Student Book 8 to make this technology choice.

The examples in this unit use:

- YouTube for video
- SoundCloud for audio.

Other options include Vimeo and Dailymotion (for video), and Mixcloud and Podbean (for audio, especially podcasts and spoken word).

Setting up your media hosting services

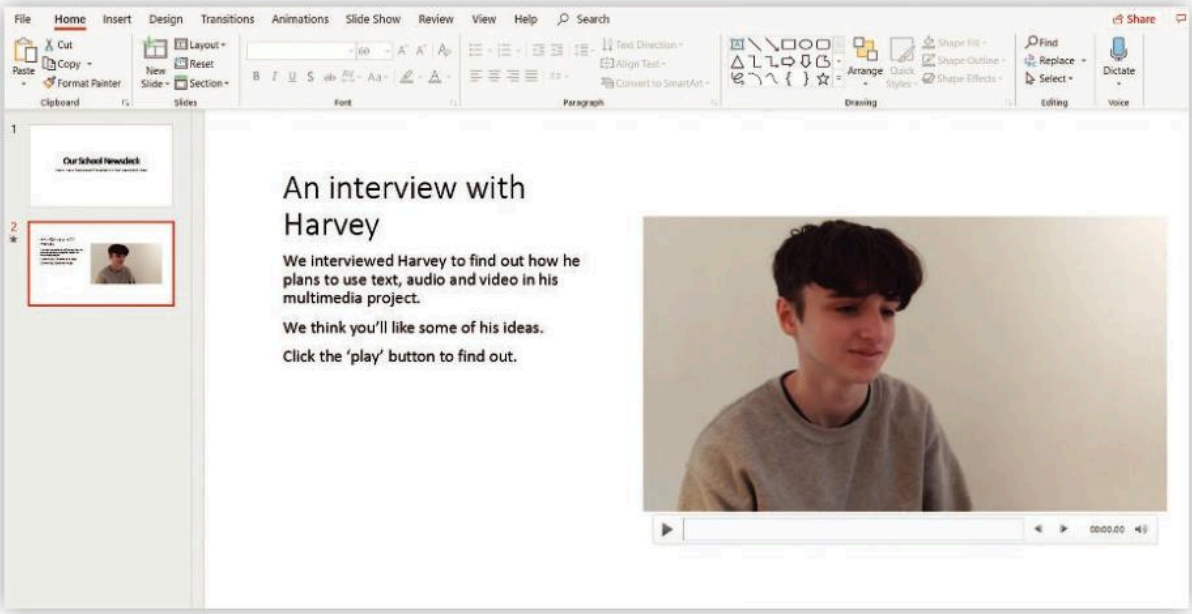
You have already discussed ideas for your media content. You can use this list of ideas to explore the best media hosting services for your project.

When you have decided on which services to use, you can sign up using an email address. Most services provide a free option that will let you upload media files for streaming. This example shows the SoundCloud service. You can upload audio files to the service. Then you can embed the audio content in your platform page by using a link.

Using an offline platform

If you are not able to use an online platform and online media sharing services, you can still create a true multimedia project. Use any application that lets you combine text, images, audio and video on pages that can be displayed on a computer, tablet or smartphone. For example, you can use Microsoft PowerPoint (or another presentation application that allows embedded media content) or Microsoft OneNote.

This example shows a video embedded in a Microsoft PowerPoint slide.



When you embed a media file in this kind of platform, the media content is saved inside the project file. This can create very large file sizes that are difficult to use and share. You need to think carefully about what media to include. You should also use compressed media files whenever possible.

Activity

Use the brief you created in the Unplugged activity to investigate the best platform and media hosting services for the content you plan to create.

Create one or more accounts with the services you need or familiarise yourself with offline alternatives.

Follow the set-up instructions of your online services to create a simple platform that contains at least one main page for posts.

Extra challenge

Test your media hosting services. Create or find a short video and audio file and upload it to your chosen services. Check that the content uploaded successfully. Check that you can copy a URL (a web address beginning with http or https) for the media content.

Test

1. What is a 'multimedia project'?
2. Name three things you need to think about when choosing a platform for your multimedia project.
3. Explain the benefits of using a specialist media streaming service to host your audio and video files.
4. Write a short paragraph describing how you decided which platforms to use for your project. What options did you consider? Say why you made your choices.

5.2 Creating news stories

In this lesson

You will learn:

- how to collaborate on writing and editing text content
- how to add your content to an online platform and publish it.

Spiral Back

In Student Book 4, you learned about using collaborative editing tools. In this unit you will use these skills to edit the text for your multimedia project.

Creating text for your project

In the Unplugged activity, you held an editorial meeting. You created a brief for the text content for your project launch. In this lesson you will create the text. You will write text individually. Then you will collaborate with classmates to edit the text until you all agree on a final version. The final version can be published on the project platform.

Professional writers often call the text they write for a published document, like a website, their copy. You can create your copy for the project directly in your platform applications. If you are using an online service like WordPress or Blogger, you can type your copy into the page templates they provide. If you are using an offline platform such as Microsoft PowerPoint, you can type directly onto the slide templates.

Working directly with platform templates is usually fine for small pieces of text. But you might find it easier and more convenient to type longer pieces into a simple word-processor document. A word processor will usually have more powerful editing capabilities than other applications.

Word processors also have some other functions that can be useful when writing and editing collaboratively:

- proofing functions, such as a spellcheck dictionary and thesaurus
- a word count function to check you have kept to any word limit
- tracking functions, such as 'Track Changes', and commenting tools that allow different people to suggest changes and corrections to your copy.

You can create and edit your copy using a word processor. Then copy the final version into your online or offline project template.

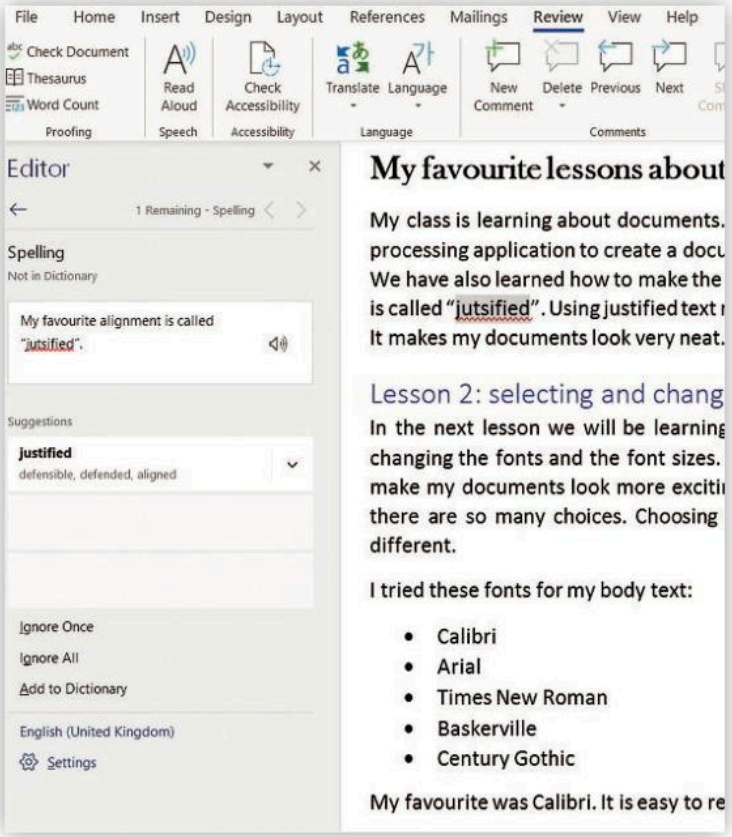
Beware though: many online platforms will copy the text only. The templates are designed for web pages. They will not copy any special formatting. You might need to format the text again in the online template if you have used tables, text boxes or other complex formatting.

Editing as a team

You can use your word processor to collaborate with others. You can share your document while you are creating it. You can share your document by email. You can also use a shared drive or store it in the cloud.

In Student Book 4 you learned how to use the collaborative editing tools your word processor provides. You will find these functions useful in this unit. Look back at Student Book 4 to remind yourself how they work.

- **Track Changes** can help you make suggestions for changes to a shared document. Changes will be shown as 'mark up' so that you can see what the reviewer or editor is suggesting. You can choose to accept or reject the suggested changes.
- **Comments** can help you share ideas and thoughts about parts of the text. A reviewer or editor can add comments to the margin of the page.
- **Find and Replace** can help you quickly make 'global' changes to words or phrases.



Proofing your text

When you have finished editing your text, you should do a final proof. This means that you check the spelling and formatting of the final version. You can use your word processor's proofing tools to do this. The most useful tool is the spelling and grammar checker.

Adding content to the project platform

When you have a final version of your text, you can add it to your project. If you are using an online platform, you can add the text as a new post or as a page.

- Use a post if the text is a news item. It will appear at the top of the site's main page. Any new posts published later will appear above it.
- Use a page if the text is an item that you want to keep separate from the main page. For example, if it contains background information like an 'About Us' or 'Contact Us' page.

The image below shows a post being added in a WordPress template.

The title and body text are added as blocks. Each block can contain text or other media. Add a new block using the '+' function.

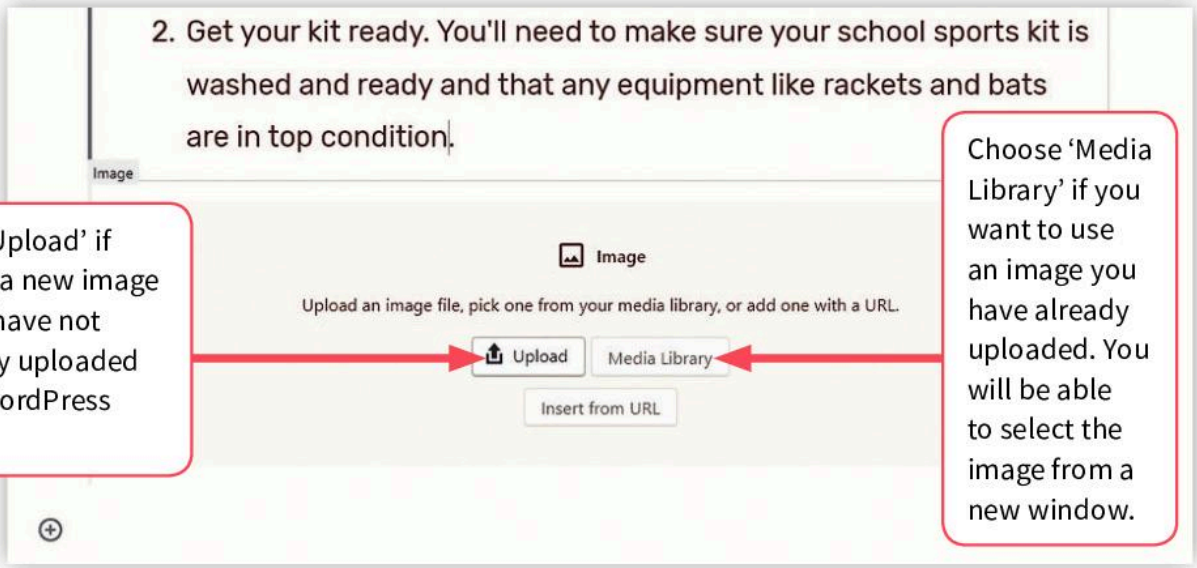
Use the formatting controls in each block to change the way your content looks.

Adding images to your text

You can add images to your text by uploading them to the media library of your online platform. Then you can add the images to the post or page using your platform's function. This example shows the WordPress interface. When you add the new block, select the type 'image' from the menu.

Choose 'Upload' if you have a new image that you have not previously uploaded to your WordPress service.

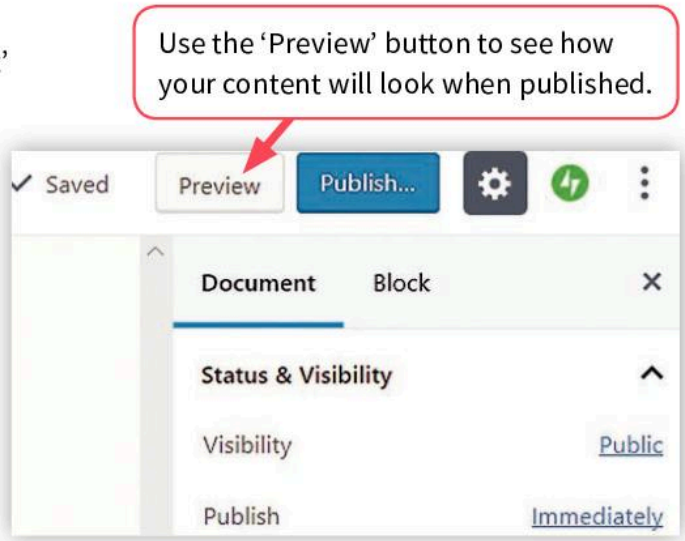
Choose 'Media Library' if you want to use an image you have already uploaded. You will be able to select the image from a new window.



If you are using an offline platform such as Microsoft PowerPoint, you can add the images using the 'Insert' menu. Or you can copy them and paste them into the document.

Previewing your content

When you have created your post or page, you can preview it before you publish it. When you publish the content, it will be publicly available on the web. Preview the content first to check that it looks OK.



Activity

Use the brief you created in the Unplugged activity to write the text for a post or a page.

Ask your team members to review your text. They can suggest changes and corrections using Track Changes and comments.

Edit the document until all team members agree it is ready for publication.

Copy the text to your project platform. Format the post or page and add any images.

Preview the content to ensure it is correct, then publish.

Extra challenge

Explore the block types that are available when you click on the '+' function. If you have more than one image for your page or post, try using the 'Gallery' option. If you have a longer text, try using formatting options like a 'Separator' or 'Pull quote' to break up your text.

Test

1. What does 'proofing' a document mean?
2. Explain the difference between a post and a page on a blogging platform.
3. Explain why it can be easier to use a word processor rather than a website template to write and edit copy.
4. Describe two collaborative editing tools that your word processor provides. How can you use them to edit documents with team mates?

5.3 Plan and record a school podcast

In this lesson

You will learn:

- how to plan your audio content
- how to record the audio content you need.

Spiral Back

In Student Book 7, you learned about planning and recording audio content. Now you will use these skills to create a podcast for your multimedia project.

Plan your recording

Your podcast should have a structure. You need to carefully plan the order of the different parts of the podcast. In media production, the parts of a show are sometimes called segments.

Make an outline plan

In Student Book 7, you learned how you can use an outline to help you structure a podcast. An outline lists the content of each segment and their order. Here are some segments that you could include in this project:

- **Intro:** Explain who you are and what the show is about.
- **Jingle (or 'sting'):** A short piece of music to help people recognise and remember your podcast.
- **Topic segments:** Use one or more segments to cover the subjects you have chosen. Segments can have different types of content, such as an interview or solo presentation.
- **Closing remarks:** Thank the audience for listening and encourage them to listen to the next episode.

When you have completed your outline, you can decide on the exact content and style of each segment. This includes writing any scripted parts you need to create.

Write a script

Most podcasts sound informal and conversational. But it can still be useful to write a script for some segments. Your script can include some or all of the exact words you want to say in a segment. When you write a script, remember to write like you speak. Use short sentences and avoid jargon. Jargon means specialist words and abbreviations that your listeners might not know.

Music

In your outline plan, write down ideas about the type of music you want to include. Where do you want to use music in your podcast? What kind of mood are you trying to create? This will help you search for music clips later.

Set up and record your show

In the editorial planning meeting at the start of the unit, you gathered ideas for the podcast content for your project. In this lesson you will set up your recording equipment and create the recording. Follow these steps.

- For 'studio' recordings, set up your recording equipment in a quiet place. For outside recordings, use a voice recorder app on a smartphone or tablet. Make a test recording to check the sound quality.
- Practise each scripted segment at least once before you record. You will feel more relaxed if you know your content.
- Record your segments.

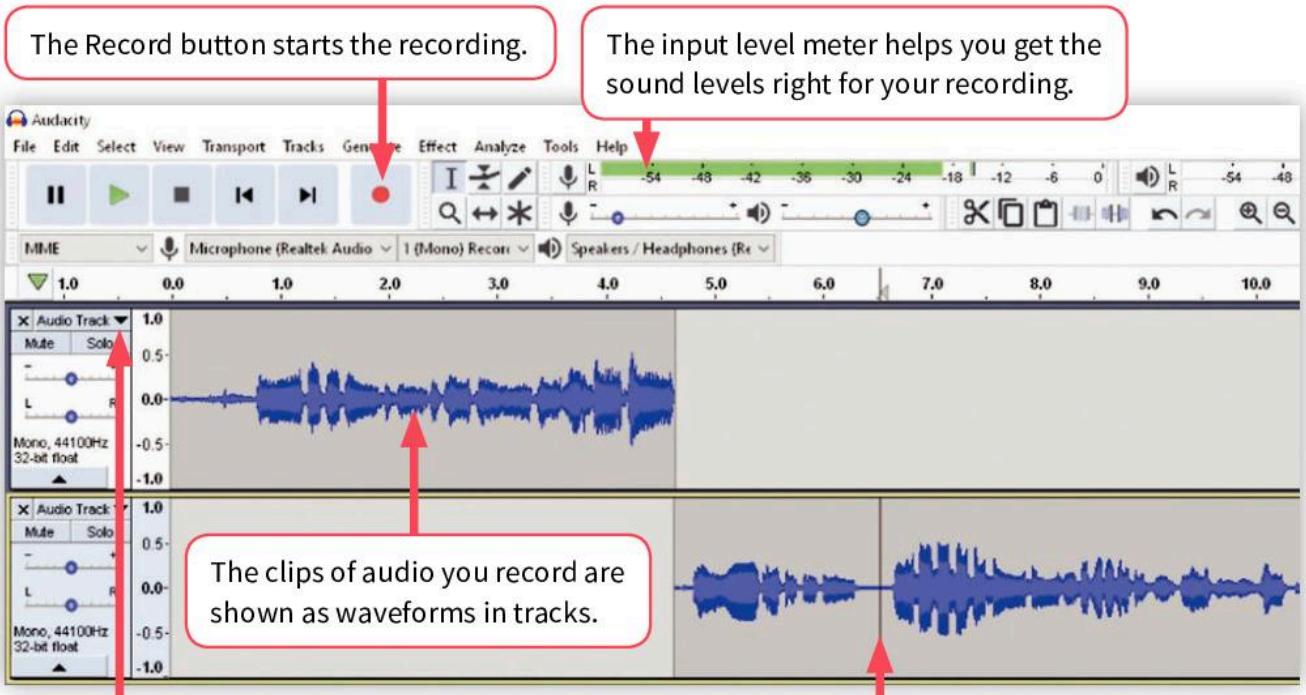
Record your audio segments

In Student Book 7, you learned how to record audio using digital audio workstation (DAW) software. You can remind yourself about the process by reviewing Unit 5 in Student Book 7.

Using DAW software to record on a device

If you are making a studio recording, start by recording your first segment as Track 1 in your DAW software.

Most DAWs present your project as a series of tracks from the top to the bottom of the screen. Audio content in each track is shown as a waveform along a timeline, from left to right on the screen. The sections of content are sometimes called clips. A cursor moves from left to right as you record or play the audio. The image shows the Audacity DAW and its main functions.



Set the recording levels

Before you start recording, make sure that your microphone and speakers or headphones are correctly set up. Activate the input level meter or make a test recording. You should make sure that the meter stays in the green area and does not turn a yellow or red colour. If the meter 'goes into the red' your recording may become distorted.

Check your plosives! Recording speech without distortion

Human speech has a high dynamic range. This means that there is a big difference in volume between the quietest and loudest parts of our speech. For a microphone, the loudest parts of our speech are the sounds of the letters 'p' and 'b'. These sounds are called plosives.

A plosive is a speech sound that is made with a sharp blowing out of breath. Try holding your hand in front of your mouth and saying the words "apple", "banana" and "pear". You will feel the force of your breath on the 'p' and 'b' sounds. The force of this air can cause distortion if you are too close to the microphone when recording. Stand a little further away to prevent your 'p's and 'b's ruining your recording. And remember: when you check your recording levels, check your plosives.

Using other recording devices

If you are using a handheld device to make a recording on location, record each segment as a separate file. You can transfer the files to your DAW later.

Activity

Plan your podcast. You can do this part of the activity in lesson time.

Your teacher will give you an outline template for your recording.

Review your audio ideas from the Unplugged activity at the start of the unit. Use the outline template to complete an outline for your podcast.

- Write down the aim of your podcast and the timing of the pilot episode. It should be no more than five minutes long.
- Complete the 'Outline' column for each segment of your show, including the music.
- Complete the 'Script' column for each segment that you think needs some scripted content.
- Save your work.

Record your segments. You can do this part of the activity in lesson time or in your own time.

- Record the segments of your podcast as separate tracks (in a DAW) or clips (on other devices).
- Save your work.

Show notes

Podcasts and internet radio shows often have a web page with notes for listeners, called show notes. The show notes are often mentioned in the show, so listeners know where to find them. Show notes can include text, images, graphics and links to other websites.

Extra challenge

Make a list of material you think will be useful to include in show notes for your audience.

Test

1. What do the letters DAW stand for?
2. What is the purpose of a test recording made before the actual recording session?
3. Explain the difference between an outline and a script for a podcast.
4. What is the purpose of a show notes document?

5.4 Edit and publish your audio content

In this lesson

You will learn:

- how to edit and assemble a final programme by arranging segments
- how to upload your audio content to a streaming service
- how to add a media player to your multimedia platform.

Editing audio in your DAW

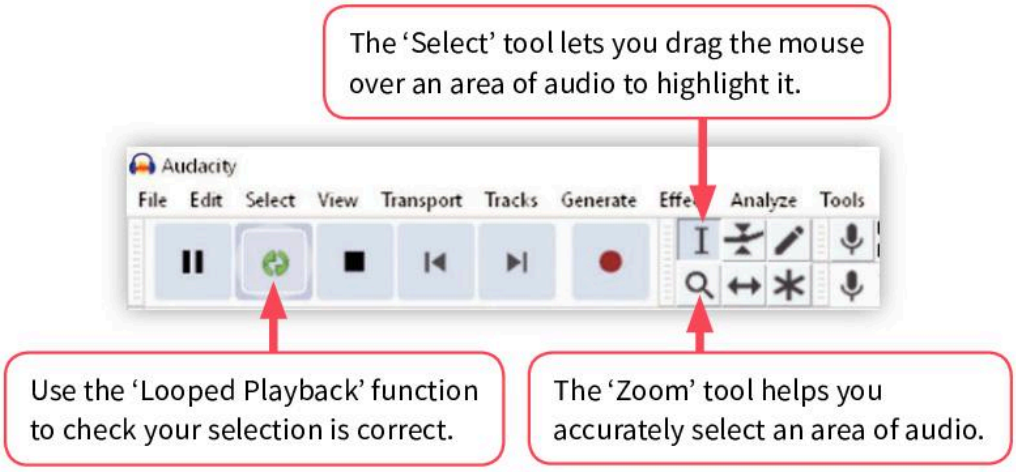
In Student Book 7 you learned how to edit audio clips and arrange them into a podcast. You can check Student Book 7 again to remind yourself of the techniques you can use to make these edits.

Trimming track starts and ends

You can trim your tracks to delete any unwanted silence at the beginning and the end of the tracks. You can select an area of a track to delete by using the mouse, or you can use selection options like 'Cursor to track end' to select larger areas of the clip.

Editing audio in a track

You can quickly fix any mistakes by editing a track. Use the playback controls to play your audio file and listen for parts you want to edit. When you have found a part you want to remove, select it with the mouse and delete it. You might need to use a zoom tool to make an accurate selection. You can also use looped playback to play the selected area over and over until you have got the selection right.

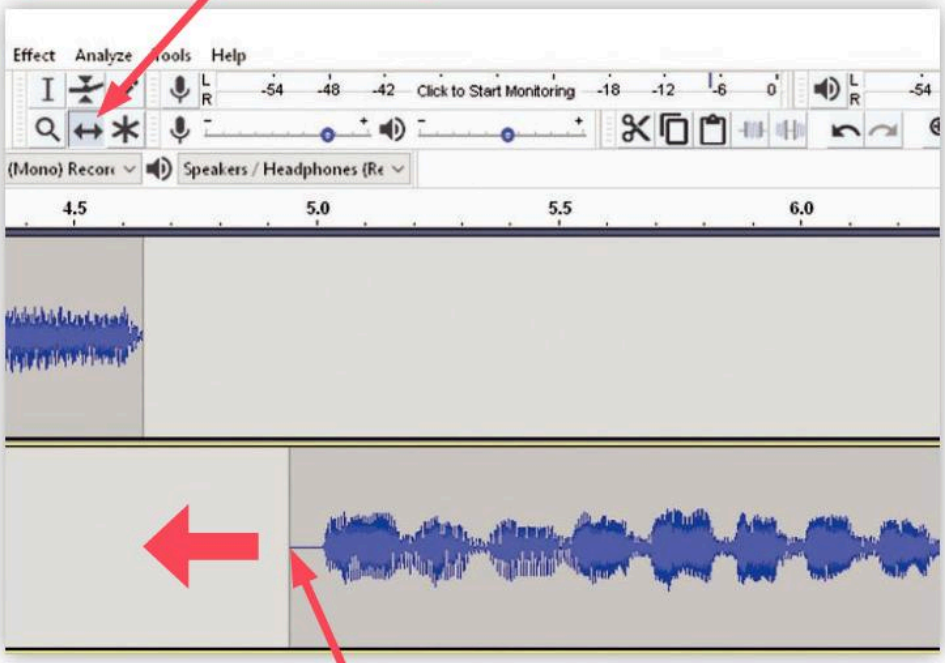


Moving audio in a track

When you have edited audio in a track, you might find that the track no longer lines up with other tracks you have recorded. You can move the audio in a track to make it line up again.

Select the audio that you want to move and drag it left or right until the position is correct. In Audacity, you can use the 'Time Shift' tool for this.

The 'Time Shift' tool allows you to move audio in a track.



You can drag the audio to the left to close the gap between the clips in the tracks.

Mixing your final audio

When you have edited your original recordings and put them in the right order, you can mix the sound. You can change the volume level of each track so that the whole podcast sounds right. You need to find the right balance between the volume levels of the different parts of the project: speech, music and sound effects.

To balance the audio volume levels, play the audio and use the 'Level' (or 'Gain') sliders to increase or lower the volume of individual tracks until they sound right. Pay attention to the transitions between clips. Try to avoid big changes in volume level.

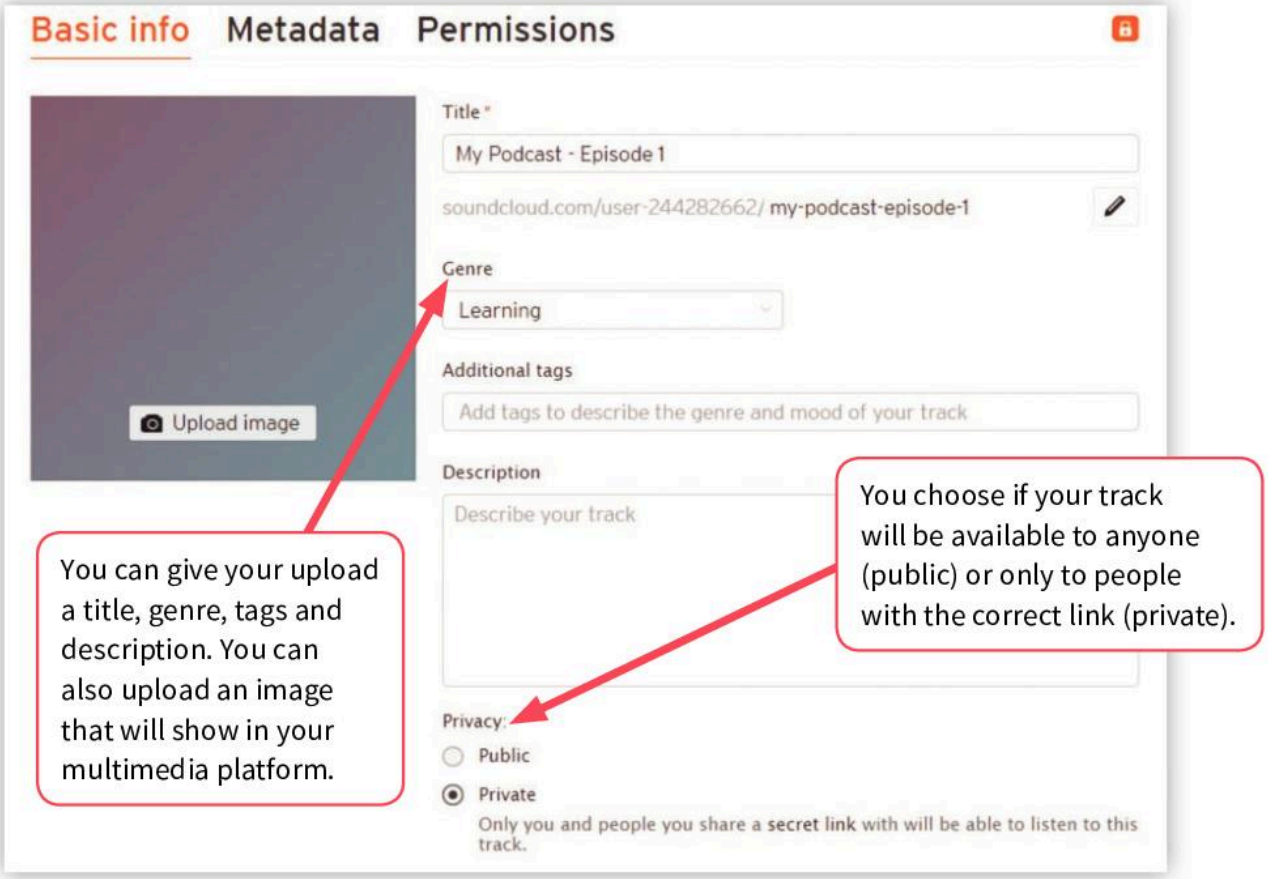
Exporting your project

You can now export the project from your DAW software. This will create a sound file that you can embed in another project or stream online. For recordings that mainly contain speech, a compressed file format like MP3 is the most common choice for exporting.

Uploading your file to a streaming service

If you are using an online platform for the project in this unit, you can upload the MP3 file to a file hosting service. You can then use the URL of the file to play the content from a page on your site.

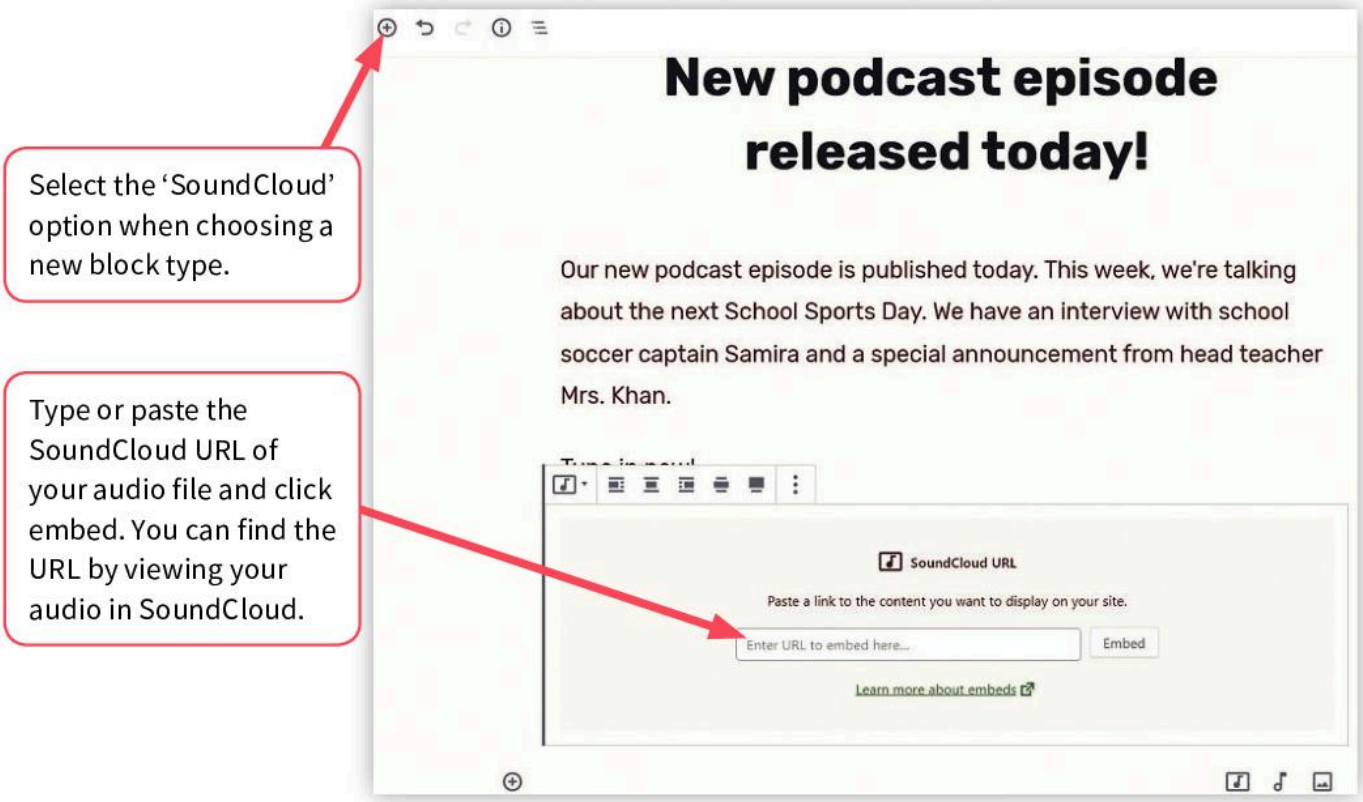
To upload your audio to a streaming host, you will need to create an account with the service. When you log in to the service, you can choose to upload a file that is stored on your device. The image shows the upload function of the SoundCloud service.



Embedding your audio in your multimedia project

When you have uploaded your audio file to a streaming service, you can create a link from your multimedia platform to the streaming host. This will embed the audio in the page or post on your platform.

The image shows how you can use a block on a page in the WordPress service to embed a SoundCloud audio track.



After you have embedded the audio, you can preview the page or post on your platform. You should see that a media player appears on the screen. When you click 'Play', your audio will start.

Activity

Edit your segments to create a final version of the programme.

Export the programme as an audio file.

If you are using an online project platform, upload your file to a suitable hosting service and use the URL to embed the content in your site.

Extra challenge

Create a page of notes to display with the audio on your site or project file. Create a short document with descriptions and notes about one or more segments. Add the notes to the page with the audio player.

Test

1. Explain what the 'Trim' tool is used for in your DAW.
2. What does 'embedding' media in a multimedia project mean?
3. Explain why it is a good idea to record segments of a programme on separate tracks.
4. Write a short paragraph explaining how the edits you made to your audio recording improved the product for your audience.

Explore more

Ask your family and friends what podcasts they listen to. Ask them what they like about the content and style of each one of the podcasts. What can you learn from their likes and dislikes?

5.5 Plan and create video content

In this lesson

You will learn:

- how to collaborate on a video project by agreeing content and style
- how to create a shot list to help you make your video.

Spiral Back

In Student Book 8, you learned about framing interview shots. You can use these skills when you create the video content for your multimedia project.

Agree content and style

To make your project more exciting and informative, you will now begin to add video content.

In the Unplugged activity you held an editorial planning meeting. You agreed the subject of your video article in this meeting. Professional film-makers often have separate teams, called crews, who make different parts of the film. You can use this approach with your classmates.

When you work like this, you need to agree:

- **how the content should be recorded:** the technical standards
- **what should be filmed:** the content
- **how the content should look:** the style.

Technical standards

The crews need to agree the technical standards they will use, so that the editor can work with the material in the next stages of production. Here are the most important technical details to agree:

- **The screen format (or 'aspect ratio').** Most video cameras and editing software can work with different formats. But the result will not look consistent if there are changes in the aspect ratio between different shots in your video. 16:9 format is the most common high-definition widescreen format. Most modern cameras and monitors will display this format well. Remember to specify the screen orientation too: landscape format is usually the best way to show video content to audiences.

- **Resolution and file type.** Most video cameras and smartphones can record video at different resolutions. Full HD (1920 by 1080) is the modern high-resolution video standard. It will display perfectly on 16:9 format screens.

Content

To make sure that crews create content that meets the brief, they decide on a division of work.

In your project you might agree to split the work up like this:

- Crew 1: Interviews with people
- Crew 2: Exterior shots
- Crew 3: Interior shots.

Each crew needs a brief for their work. The brief sets out what the crew should film. The brief can include a shot list. A shot list is a list of specific scenes or items that the crew needs to capture on video.

This is an example of a shot list for a crew filming the exterior of a school.

Shot No.	Scene No.	Camera movement	Camera angle	Description	Notes
1	1	Pan	Wide	Day time exterior of school building (front). No students.	
2	1	None	Wide	Day time exterior of school building (front). Students leaving at home time.	At least 20 seconds duration.

Each crew uses the shot list to capture the clips of video they need. Then the editor assembles the finished video from the clips.

Style

You can use the shot list to help the different crews achieve a consistent look in all the clips they record. Use the camera movement, camera angle and description boxes to give as much detail as you can. You can add instructions about:

- **location and background.** Will you film indoors or outdoors? Will interviewees sit or stand? What should be in the background?
- **shot type**. Tell the crew if you want a wide angle shot or a close-up. Most videos mix the two options to make them more interesting.
- **camera movement.** Moving the camera while recording can be difficult unless your camera has motion stabilisation. But even a simple sideways movement will make your clips more exciting. A sideways movement is called panning.
- **framing.** Where will you place the subject in the frame?

Shot types and movements

A wide shot shows all of the subject and some of the surroundings. Sometimes this is called a long shot. You can use a wide shot to show the viewer the place where the action in the video takes place.

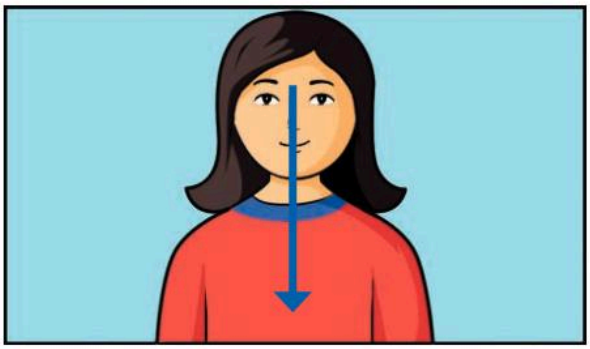
A close-up shot is made much closer to the subject. It only shows part of the subject, for example the upper body. You can choose close-up shots when you want to tell the audience that the scene is important.

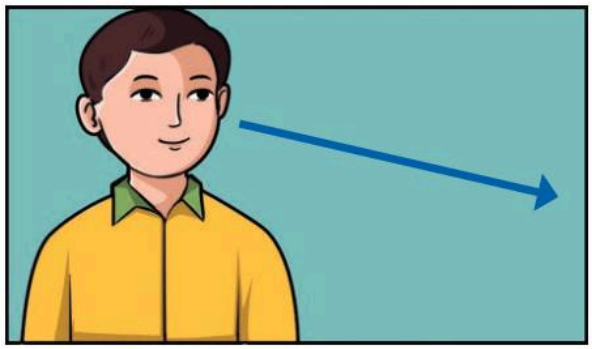
A panning shot is a type of camera movement. The camera swivels on its vertical axis, changing the audience's view of the subject. Panning shots create the same effect as a viewer turning their head. You can use panning shots to add interest through movement, for example by panning towards a subject.

A tracking shot is also a type of camera movement. The camera moves position while recording. You can use a tracking shot to follow a moving subject or to change the framing of a subject while shooting. Because of camera shake, tracking shots can be difficult to create without specialist equipment. If your camera has a motion stabiliser function you may be able to make good tracking shots.

Framing interview shots

In Student Book 8 you learned about different ways of framing an interview shot: the 'piece to camera' and an 'off-cam conversation'. The diagrams below show how these styles are framed. Check Student Book 8 for more help.





Activity

Your teacher will give you a template file for a shot list.

Divide your team into different crews.

Create a shot list, with shots for each crew.

Working in your film crews, create the video content according to the shot list and agreed technical standards.

Save the video files in a fileshare or other safe location.

Extra challenge

If you have time while filming your content, try to get different varieties of the same shot. This additional content might be useful when you edit the video later. Try different framings, movements or positions for the shots. For interviews, for example, switch from a piece to camera to an off-cam conversation.

Test

1. Name two things that a team must agree on before starting a video project.
2. Explain how a shot list can help the project team to plan a video project.
3. What does it mean to 'frame' a video shot?
4. Framing is one of the styles you can add to a shot list. Name another three. Explain what is meant by each.

5.6 Edit and publish your video

In this lesson

You will learn:

- how to use a video editing app to arrange video clips
- how to add still images to your video.

In the last lesson you worked as part of a film crew to create the video clips for your project. Now you will use the skills you learned in Student Book 8 to assemble the full video using a video editing app.

You can use the shot lists you created in the last lesson to help you bring together all the video clips and still images. You can put them in order in your video editing app. You can create an early version of the video by assembling the clips along your video editing app's timeline or storyboard. This is called a rough cut. When you review the rough cut, you can decide if you need to edit individual clips or put them in a different order.

Assemble and edit your clips

A storyboard or timeline editor lets you change the order of your clips and images. This means you can try different ways of putting your video together. You can quickly see which way works best.

When you start to assemble your rough cut, review the shot list to help you put clips in a rough order. Use the shot list as a guide, but remember that you can make changes to your video at this stage too.

Try these ideas.

- Change the order of scenes to see if they work better. You don't have to tell a story step by step. You can break up the structure by using flashbacks or cutaways. A flashback is a scene showing something that happened in the past (before the last scene shown). This might seem confusing, but many films use flashbacks to add interest.
- Insert a cutaway for added detail. A cutaway is a short shot of something in the environment where the scene is happening. It does not show the subject. You can insert the cutaway shot into the scene, between two other shots. Cutaways add interest and detail that help keep the audience engaged. The table shows some examples of possible cutaway shots.

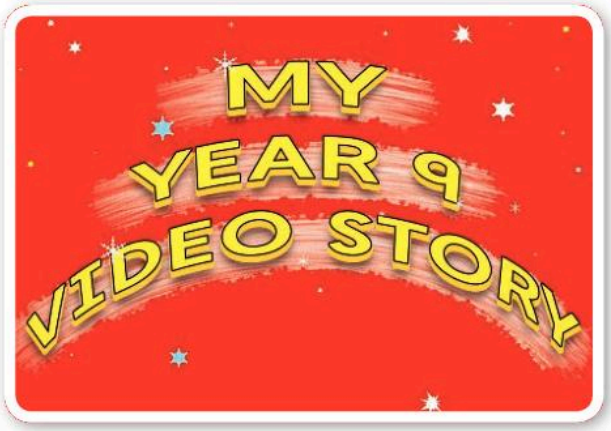
Scene	Possible cutaway
An interviewee talking to camera	Extreme close-up on interviewee's hands as they talk
A student walking along a school corridor	Close-up of a poster on the wall

- Put still images in different places, for example between the interviews. This breaks up the video and adds interest.

Try different ways of ordering your clips and other content. Keep referring back to your shot list so that you keep the overall structure of the finished video in mind.

You can use images and clips you have made yourself. You can also use images shared on the web. Remember to investigate the copyright of all content that you haven't created yourself. Look for content that is 'public domain', 'royalty free' or licensed under 'Creative Commons'.

Add titles



You can add a title before any clip or still image.

- Use a title card at the start of your video to make it clear what the video is about. For example: 'My Year 9 Video Story'.
- Use sub-titles for each section of your video. For example, 'Interviews with my classmates'.
- Show a list of credits near the end of the video.

If you are using Microsoft Photos, add a title by right-clicking on a clip or still image and selecting 'Add title card'. The app will add a title card to your storyboard. Select the title card and add your text. You can choose a background colour and set the length of time that the title card will be shown.

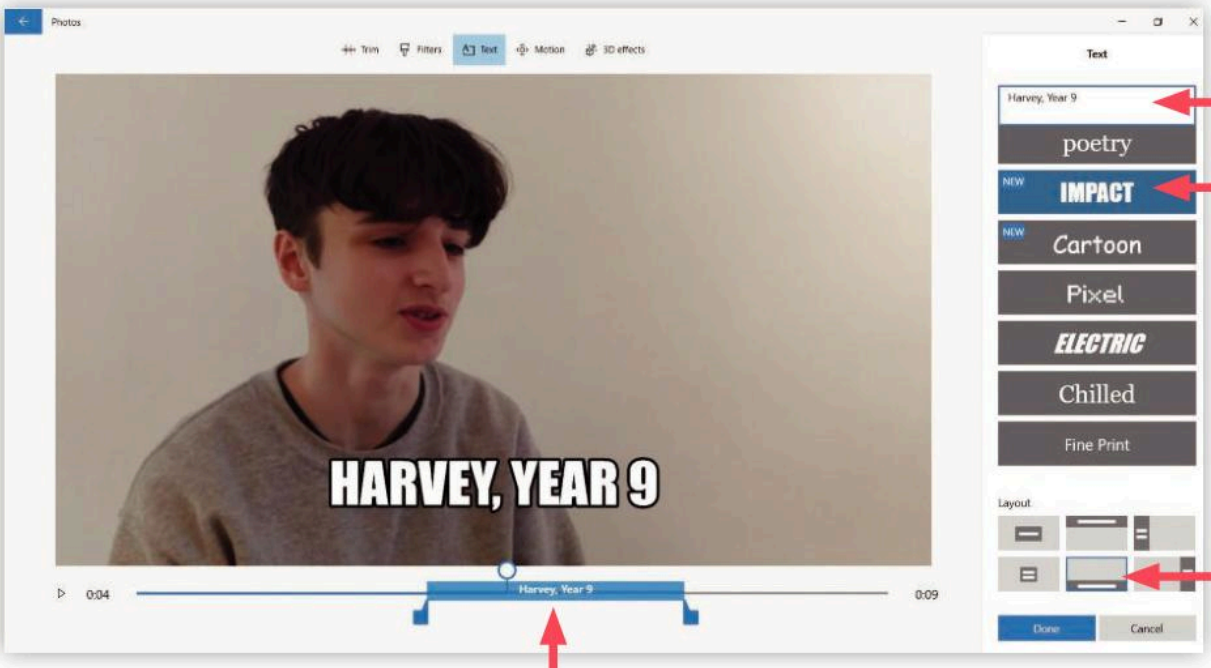
Use the 'Duration', 'Background' and 'Text' menu options to design your title card.

Add captions

To add a caption, select the clip or still image and choose 'Text' from the menu. A caption is text that will be shown while the clip or still image is being played. Captions are useful for things like:

- naming a person being interviewed
- explaining what a scene is about or where the action is taking place.

In Microsoft Photos, use the slider to control when your caption will be displayed. Use the 'Playback' controls to experiment with the best settings for your video.



Export and share your final cut

When you have finished editing your video, you can export it. Exporting means saving the video as a file that other people can watch on their devices.

Your video editing software may have many options for file formats and resolutions. Choose a format that will work for streaming and saving to computer drives.

Upload your video to a sharing platform

If you are using an online host as your project platform, you can upload your exported video to your preferred host or streaming platform. Once the video has uploaded, you can use the URL of the video to put the video onto a page on your project site.

Activity

Add your clip and images to the project library in your video editing app.

Edit the clips into a rough cut of your video.

Add a title at the start of the video.

Export your completed video.

If you are using an online platform, upload your video to a hosting site.

Extra challenge

If you have time, add a caption to one or more of your clips or still images.

Test

1. What does 'rough cut' mean?
2. Explain how you can use captions to improve your video.
3. What is a cutaway shot?
4. List the types of shot (wide, close-up, panning, tracking) you used in your video. Explain how you used them to create a more interesting final product.

Be creative

Use your video editing app to explore filters, transitions and motion effects on clips and still images. If you use these carefully, they can make your video look more exciting and professional.

Check what you know

You have learned

- how to apply the media skills you have learned in this course in a real-world project
- how to combine different kinds of media using a multimedia platform
- how to choose appropriate platforms and services for your multimedia projects.

Try the test and activity. They will help you to see how much you understand.

Test

1. What is a multimedia project?
2. Write a sentence describing the steps you took to create and edit digital content in your project.
3. Describe at least two tools you can use to plan audio or video content for a project.
4. Describe the advantages of using a streaming service to host your audio or video content in a multimedia project.
5. Describe how you collaborated with your team mates in the project in this unit. How did you use technology to work together?
6. Write a short paragraph describing how you made sure that the content in your project was right for your audience.

Activity

Your teacher will give you a worksheet. It contains a brief for a multimedia project for The Tropical Beach Dive Shop. Read the project brief and requirements section. Then complete these tasks.

Use the template in the worksheet to create a project proposal. Include sections about:

- media content such as text and images, audio and video
- a suggestion of platforms to use to meet the needs of the audience.

Self-evaluation

- I answered test questions 1 and 2.
- I filled in at least one section in the worksheet.
- I answered test questions 1–4.
- I filled in at least four sections of the template in the worksheet. I added at least two different media types.
- I answered all the test questions.
- I completed the activity.

Re-read any parts of the unit that you feel unsure about. Try the test and activities again – can you do more this time?

6 Numbers and data: Managing projects

You will learn

- how IT project teams work together using different methods
- how to use tools like mind maps, personas and process diagrams to plan a project
- how to use tools like use case diagrams, user stories and kanban boards to manage a project
- how to manage a project using the plan-do-check-act project life cycle.

In this unit, you will learn how IT professionals work together on projects. You will practise using many of the tools and techniques that teams use in different kinds of projects.

Planning and delivering a project creates a lot of data and information. A project manager must manage this information. Project managers can use IT tools to help. This unit will show you a toolbox of things you can use in your technology and digital projects.

Learning outcome: Use software to plan a project and track its progress

This unit uses an example project for a business called The Cake Factory. The project will create a way for customers to buy custom-made birthday cakes. You will learn how a team can create ideas and understand what the customers want. You will also see how you can manage a project to deliver what The Cake Factory needs to make its birthday cake business a success.

Unplugged

Think about large and small projects:

- decorating a house
- building a boat
- sending an astronaut into space.

Discuss how you would plan each of these projects. What do you need to think about before you start? Whose help will you need? What tools will help you manage each project?

Talk about...

All IT projects try to deliver a solution to a problem that the client wants to solve. These problems can be complicated. IT projects require many different skills to solve the problems. Building an IT solution can be as complicated as building a bridge.

Talk about the different skills that are needed to build a bridge. Compare them to the skills that are needed to build a website.

Did you know?

The 'Linux' open source computer operating system is probably the largest software project in the world. The software has over 21 million lines of code. Over 4000 software developers from around 400 different companies have worked on the project.

defect
scenario test case
stand-up kanban board
velocity story points
backlog agile sprint
Gantt chart

6.1 What is a project?

In this lesson

You will learn:

- what a project is
- what jobs there are in a project team.

Spiral Back

In Student Book 8, you worked with classmates to create media assets and use them in a product. In this unit you will build on your experience of project work and learn more about how IT professionals manage digital and technology projects.

What is a project?

All kinds of organisations and individuals work in projects. When people work on a **project** it means they have a specific goal and are doing a set of tasks to reach that goal.

At home, a family might have a project to decorate their living room. Their goal would be to have a beautiful room. The tasks to reach their goal might include reading magazines for inspiration, buying paint and brushes, and painting walls.

Projects and business as usual

Organisations in business, government and public services also do projects. These organisations use projects as a way of changing things they do and the way they work. This makes projects different from their normal activities. The normal activities are sometimes called 'business as usual' (or BAU).

Projects are different to BAU activities because they are:

- **temporary:** a project has a start and end date. It must achieve its objectives within these dates
- **cross-functional:** a project usually involves a team of people with different roles, responsibilities and skills
- **unique:** each project is different. Every project aims to solve a particular problem
- **uncertain:** a project often involves more uncertainty and risks than BAU activities.

The graphic shows the difference between BAU and project work in a business making cakes.

The Cake Factory

Business as usual activity	Project activity
▶ Buying ingredients	▶ Developing and testing a new cake recipe
▶ Baking cakes	▶ Designing new packaging
▶ Packaging cakes	▶ Building a new factory
▶ Delivering cakes to supermarkets	

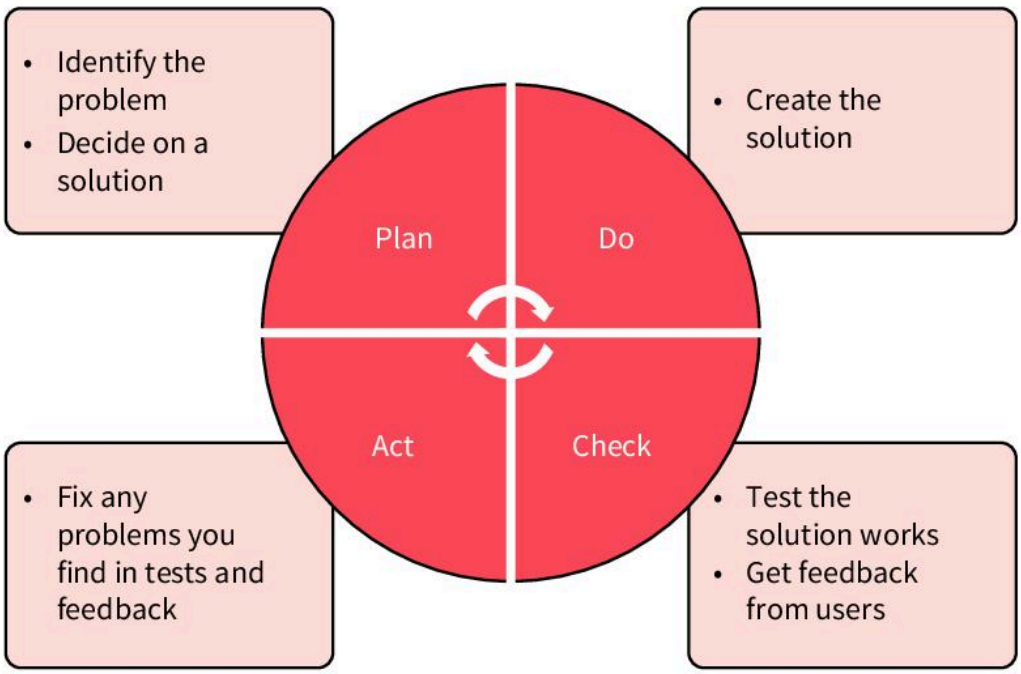
Business as usual activities create income, for example through the sales of products. Projects usually create cost, because they develop and change things. Sometimes you can't be certain that the result of a project will help increase income in the future.

- What if customers don't like the new cake recipe?
- What if the new packaging is not appropriate in some countries?
- What if the new factory has technical problems?

These 'what ifs' are called **risks**. Every project has risks. It is important that projects are properly planned and managed, so that the risks can be reduced. In this unit you will learn some of the techniques and tools you can use to manage projects at every stage.

The project life cycle

You can divide a project into stages to help you manage it. The most common way of dividing a project into stages is called the project life cycle. The project life cycle has four stages.



All projects start with a planning stage. Once a plan has been agreed, project teams move on to the 'Do', 'Check' and 'Act' stages. The stages are grouped together in a cycle because a project can go through all the stages and back to the beginning. When projects cycle one after another like this, people often call it a 'continuous improvement cycle'.

The project manager

The project manager's role is to control the project in each of the project stages. The project manager monitors these issues.

Costs Project managers have a certain amount of money to spend on the project. This is called the budget. This money must pay for everything the project needs.

Timescales Projects should always have a fixed start and end date. Project managers must make sure that the project reaches its goals in the time available.

Quality Project managers must check that the project team are meeting the quality standards set by the project.

Scope Project managers must know exactly what the project needs to deliver to achieve its goals. This is called the scope. Many projects are delayed or go over budget because project teams add things to the scope. This is often called scope creep.

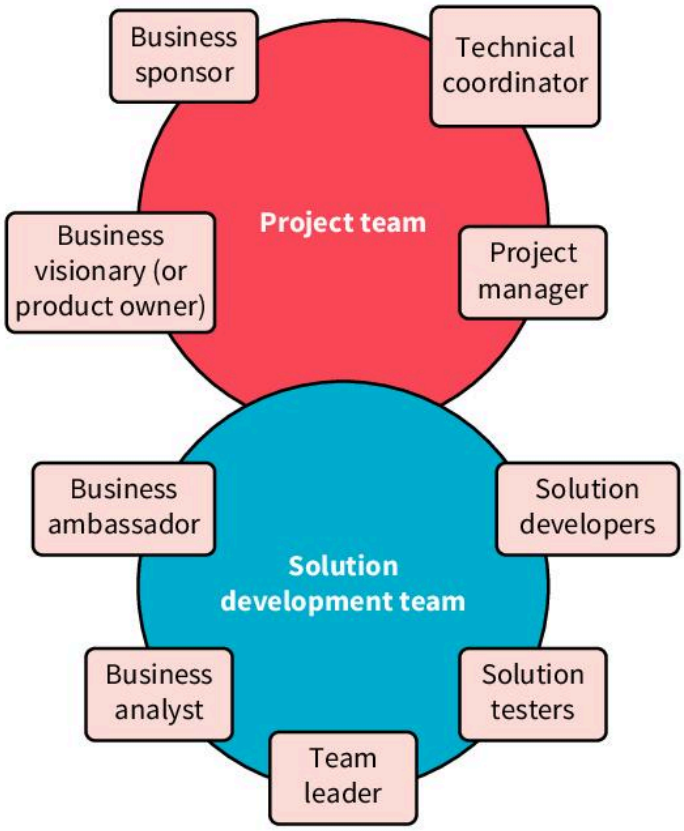
Risks All projects have some risks. Project managers must understand the risks and help the project team avoid them.

Benefits Projects must have a benefit. Something in the organisation must change and become better as a result of the project. Project managers must understand the benefit, so that they can make sure the project delivers it.

The project team and stakeholders

Projects often bring together people who don't normally work together. It is important to understand the roles and responsibilities of everyone working on a project so that the team can work well together. There are many ways of organising a project team. In IT projects, a model like this is often used.

The people who have an interest in the project's outcome are called stakeholders. This model divides the stakeholders into two groups.



The project team

Role	Responsibility
Business sponsor	The person who controls the money that the project gets.
Business visionary	A senior user of the product or service that the project is working on. Responsible for making sure that the project delivers benefits to the business.
Technical coordinator	Makes sure the project delivers a product or service that will work with the organisation's IT systems. Usually a senior IT worker in the organisation.
Project manager	Makes sure the project keeps to its budget and timescale.

The solution development team

Role	Responsibility
Business analyst	Makes sure that the project delivers the right service or product for the organisation.
Solution developers and testers	The people who build the product or service.
Business ambassador	Someone who will be a user of the product or service. They can look at the solution as it is being developed and make suggestions on how to improve it.
Team leader	The solution development team often has a team leader. This person organises the work of the solution development team.

Activity

Your teacher will give you a worksheet about projects. Complete activity 1. If you have time, complete activities 2 and 3.

Extra challenge

Make a table with two columns. Write the business as usual work of your school in one column. Write some ideas for projects that the school could do in the second column.

Test

1 What does 'business as usual' mean in an organisation?

2 Explain one way in which a project is different from business as usual.

3 Put these stages of the project life cycle in the correct order:

Do **Plan** **Check**

4 Explain the role of a project manager.

6.2 Planning a project

In this lesson

You will learn:

- how to use a mind map to create ideas for a project
- how to use personas to understand what people want from your project
- how to use process diagrams to understand how a project can help a business.

The discovery phase

The planning stage of the project life cycle is often called a 'discovery' phase. This is an important part of a project. Everything else depends on the outcomes of the discovery.

The purpose of the discovery phase is to understand what the project needs to achieve. If anything is overlooked in this stage it will be harder to achieve the project's goals. The project team will do research so that they better understand:

- **the project goals and objectives** Project goals need to be divided into objectives. An objective is something that can be measured so you can easily tell when it has been achieved. When you have met your objectives, you will have achieved your goal.
- **the requirements** These are the instructions for the solution development team.
- **the users or audience of the project's product or service** If you understand your users, you can make sure your product or service works for them.

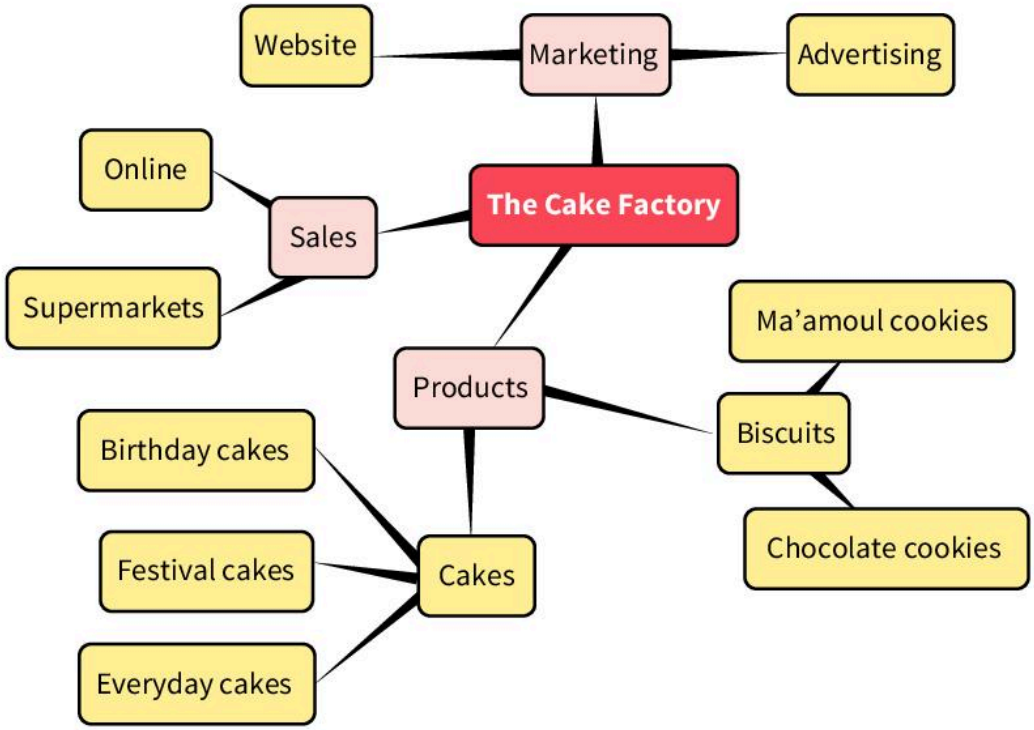
Creating ideas

When you start your project, you might not have a very clear understanding of what you need to deliver. You can use a mind map to create and record ideas of things to research and do.

You can create mind maps on your own or as a team. You can create them using an application or on paper. Start at the centre of your map. Write down an idea or problem. Then add other related ideas as branches. Carry on adding new ideas that relate to the central problem (a new branch) or to an idea in a branch (a twig).

The image shows part of a mind map for a project to start a new business called The Cake Factory.

There are many mind mapping applications available online. You can also use the drawing tools in your word processor or presentation application.

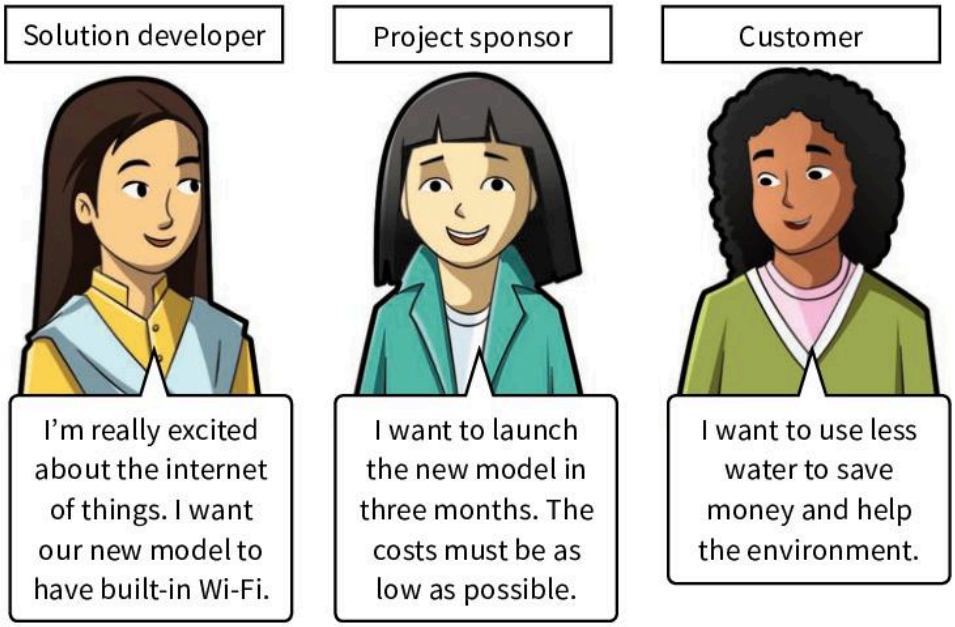


Analysing needs

Most IT projects deliver a product or a service that people will use in business as usual in the future. This could be people inside the organisation, who will use a new tool or system you develop. Or it could be customers, who will use the new product or service you develop.

Everyone in your project needs to understand who these people are and what is important to them. They will all have different needs and different expectations. Here's an example of how the ideas and needs of a user can be different to those of the project team. The project is to design a new model of washing machine.

If the project team had listened only to the solution developer, then the product might have had many features that the customer didn't need or want. The project cost might have been too high for the project sponsor.

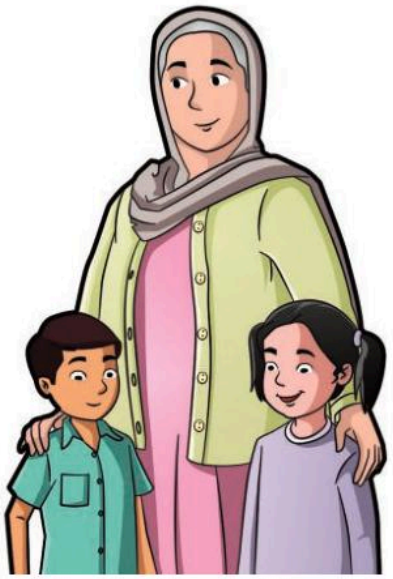


Personas

A persona is a tool that can help a project team record and share their understanding of their users. A persona is an imaginary person, based on known facts about users and customers. At every stage of the project the team can use the persona to plan their product or service.

Here is an example of a customer persona for The Cake Factory's birthday cakes.

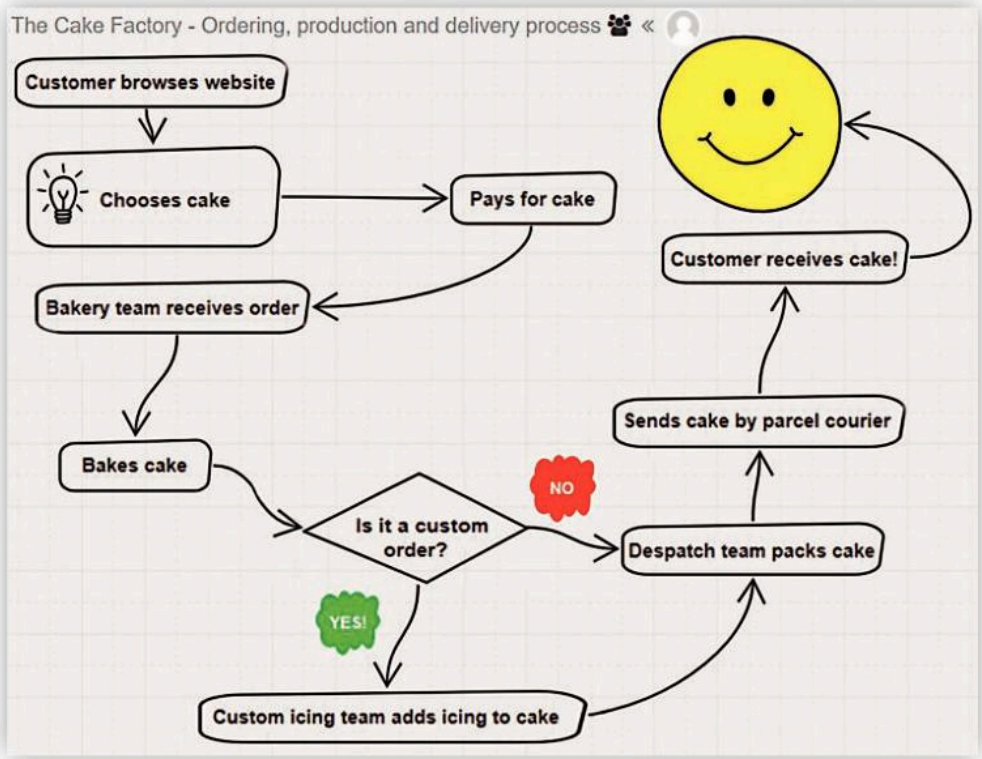
Name	Mrs Khan
Job	Account manager at The International Bank
Family	Married, with two children
Personality and behaviour	Outgoing, friendly and kind but often rushed because she is very busy.
Why would she buy from The Cake Factory?	She loves to treat her children on their birthdays. She doesn't have enough time to bake a cake herself.
Why would she NOT buy from The Cake Factory?	She is concerned that it might be too expensive. She is concerned that the cake might be delivered too late. She could ask her mother to bake the cake for the children instead.

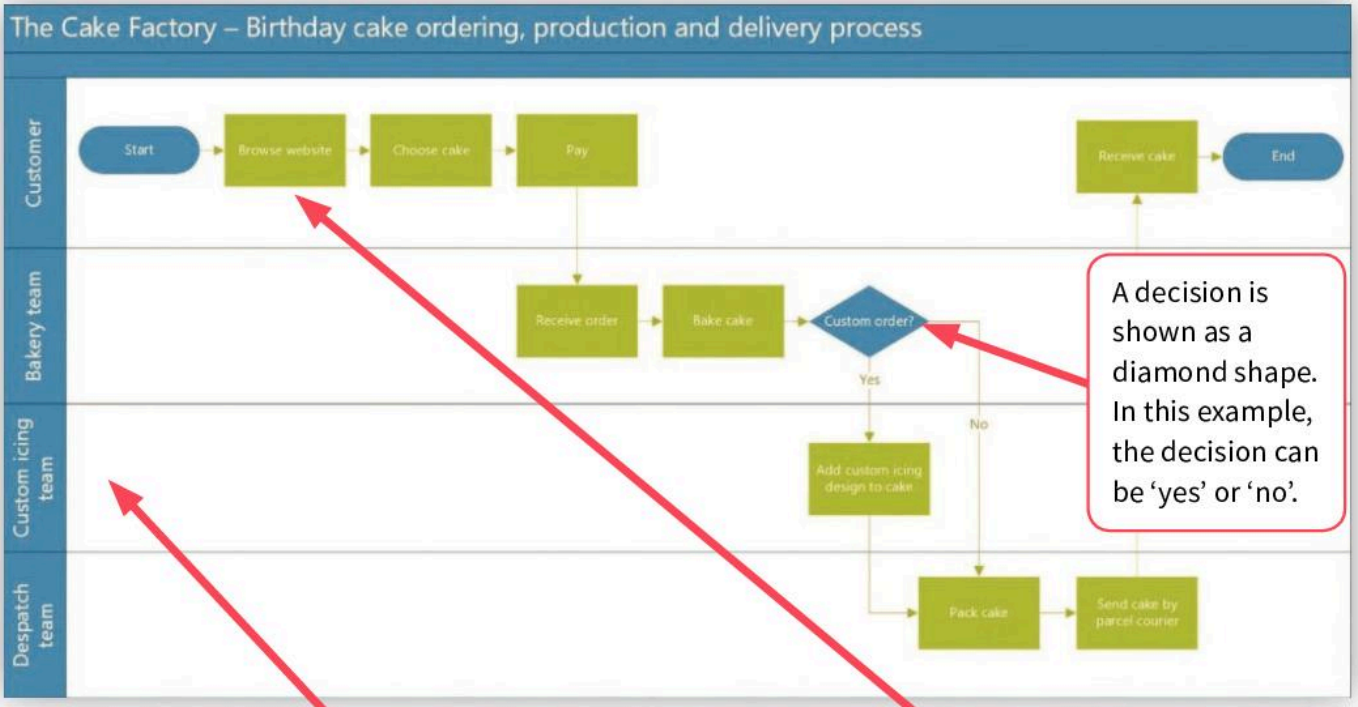


Mapping business processes

Sometimes a project needs to develop or improve a process, such as selling a product online. It can help to model the process. A business process model is like a flowchart. It uses symbols to show activities and decisions in a similar way. Some business process models also show how different people work together. These are called cross-functional diagrams.

The two images show the same process.





Activity

1 Look at the cross-functional diagram shown on this page. What are the four roles identified in the diagram? (The first is 'Customer'.) List the activities carried out by each of the four roles. Put the activities in the right order.

2 Your teacher will give you a worksheet. On one page it shows the roles and tasks involved in buying lunch in the school canteen. On the other page is a cross-functional diagram.

- Label three swimlanes to show the three roles.
- Put the tasks into the diagram in the right order and join them with arrows.

Test

1 What is a persona?

2 Explain how a mind map can help you write down ideas.

3 Which of these is a valid project objective?

- "I want my customers to be happy."
- "I want to improve customer satisfaction by 25% in three months."
- "I think we should be measuring how happy our customers are."

4 What is the main difference between a flowchart and a cross-functional diagram?

Extra challenge

Review the persona created by The Cake Factory's project team. Write down three things that The Cake Factory can do to help Mrs Khan decide to order a custom cake for her children.

6.3 Creating requirements

In this lesson

You will learn:

- how to use a use case diagram to describe a system
- how to write user stories that help the team build a solution
- how to prioritise requirements so your project can focus on the most important things.

Requirements

A requirement is an instruction to the project team about a problem they need to solve for the user. A requirement doesn't tell the project team how to solve the problem. The project relies on the ideas and skills of the team to work out how it should be solved.

Requirements are written down in a way that is easy for everyone in the project team to understand. This means they can be prioritised by the team, using the 'Must-have' and 'Should-have' method you learned about in Book 8. When all the 'Must-have' requirements have been met, the product or service is ready. The project can still carry on working to deliver the requirements that have a lower priority.

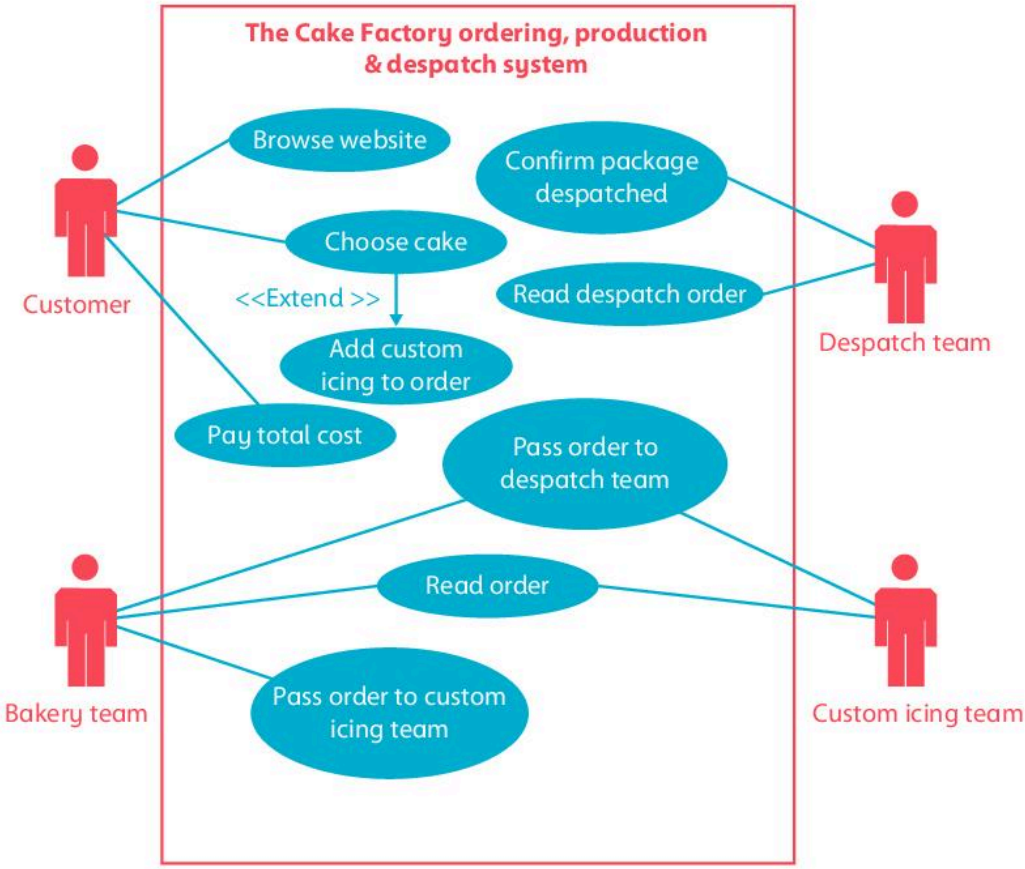
Use case modelling

In projects that develop an IT system, it can be helpful to start with a **use case diagram**. A use case diagram is a drawing that shows the system, the users and their requirements.

A use case diagram shows four important parts of the requirements.

- **Actors** are the types of people using the system. Usually they are grouped by roles, such as a customer or a salesperson. Actors are shown as stick figures in the use case diagram.
- **Use cases** are things that an actor wants the system to do. For example, browse the website or place an order.
- **A system boundary** is a box around all the use cases. You leave the actors outside the box. The system boundary helps show the scope of the system. Anything inside the box is part of the system. Anything outside the box is not.
- **Associations** are lines between the actors and the use cases. They show which actors want to do which things with the system.

This use case diagram shows a system that helps customers of The Cake Factory order a custom birthday cake.



You can create a use case diagram using any software that allows you to draw using shapes.

Drawing a use case diagram is a good way to share information about requirements and check that everyone in the project team understands and agrees the scope of the project. You can draw use case diagrams while you are talking to people to help illustrate the design of a system. You can use your use case diagram to help you develop more detailed requirements for your project.

User stories

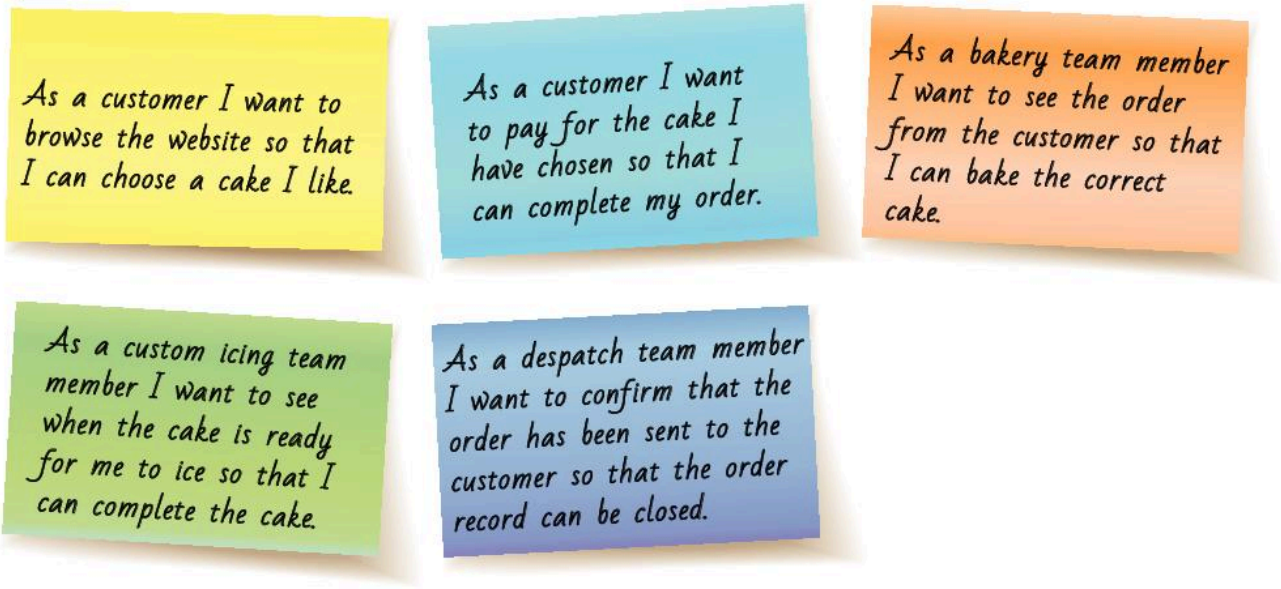
There are many ways of writing down the requirements for a technology project. In software development, designers and developers often use **user stories**. A user story states what an actor wants the system to do. It also states why the actor wants this. A user story is written down in a sentence like this:

As a [actor], I want to [requirement], so that I can [benefit].

In many projects, the project team write down user stories on cards or sticky notes during a workshop. The cards are stuck to a board or the wall. When the team prioritise the user stories and begin working on developing the product or service, they can move the cards around to track their progress.

The Cake Factory's user stories

Here are some example user stories for The Cake Factory's online ordering system.



The actors are the ones that the project team identified in the use case diagram. The user stories relate to the use cases in the diagram.

Prioritising your requirements

In Student Book 8, you learned that users often have many requirements. Sometimes a project cannot meet all the requirements at first. Prioritising the requirements can make it easier to decide where the team should start. You can prioritise requirements by using the MoSCoW technique. You can use it to divide your requirements into:

- **M**ust haves: things your technology or service must be able to do. If you don't have these things, your project will fail
- **S**hould haves: things you should have but do not absolutely need. For example, there might be another way to meet the requirement
- **C**ould haves: things that would be nice to have, but you can do without
- **W**on't haves: things that you know you cannot have this time. They might become possible later, so it's useful to make a note of them now.

Add the letter M, S, C or W to each user story card. Now you can order your cards by priority. Put the Ms at the top, then the Ss, Cs and Ws.

Activity

Your school wants to develop an application for students so they can order their lunch in advance.

- Students will use the app to see the lunch menu. They can use the app to order their lunch for that day.
- Parents will use the app to see their child's account, showing how much they have spent on lunches that week. They can use the app to pay the bill.
- The school chef will use the app to publish the lunch menu. The app will tell him how many students have ordered each lunch choice.

Your teacher will give you a template for a use case diagram. Use the template to draw a use case diagram to show these actors and how they will use the app.

Extra challenge

Create one or more user stories from the use cases in your diagram. Remember to use the format "As a [actor], I want to [requirement], so that I can [benefit]".

Test

1 What does a stick figure represent in a use case diagram?

2 Put these three levels of priority in the correct order.

Could have **Should have** **Must have**

3 Which of these examples uses the correct format for a user story?

a "As a customer I want to add items to my shopping basket so that I can buy the things I want."

b "I must be able to put things in my basket."

c "BasketTotal = (BasketTotal + ItemNumber)"

4 Describe the purpose of a user story.

Explore more

Many people live very busy lives. They often need to make decisions about what things they have time to do.

Talk to family members and friends about the things they need to prioritise at work, in the home or at school. What methods do they use to prioritise the things they want to do?

6.4 Planning a project timetable

In this lesson

You will learn:

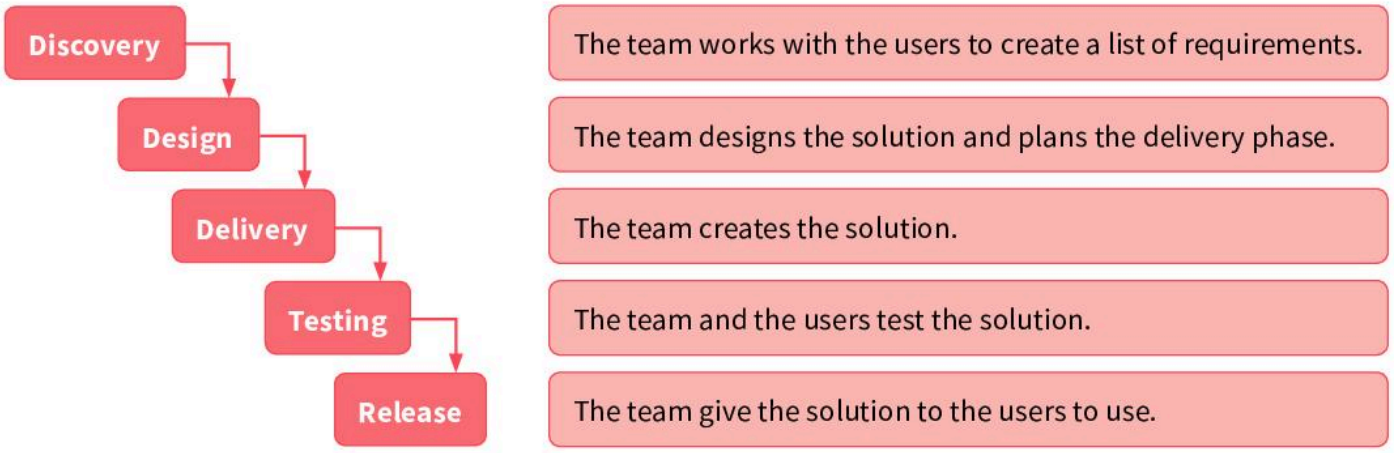
- how to choose a method to deliver your project
- how to create a project timetable using a Gantt chart.

Methods to deliver projects

There are two common ways to deliver IT development projects. These are called the waterfall and agile methods. The choice that a project team makes affects how they will plan the delivery of their work.

The waterfall method

The **waterfall method** divides the project into phases that follow after each other. Project teams use this method when they have a very clear understanding of the requirements before the work starts.



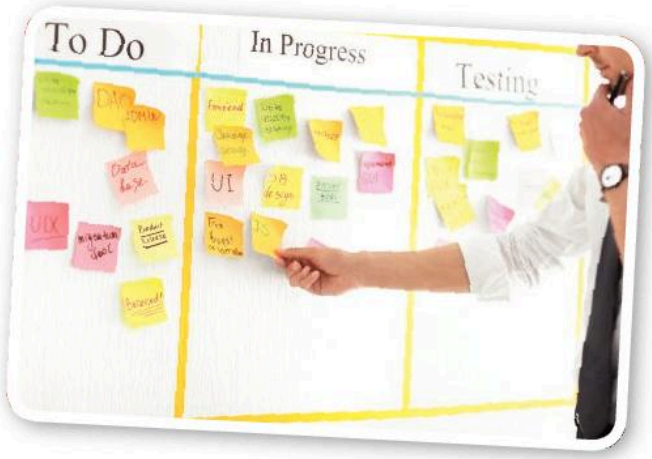
The method is not very flexible. Each phase must be complete before the next starts. If a requirement changes during the delivery phase, it is difficult to return to the discovery phase to change it.

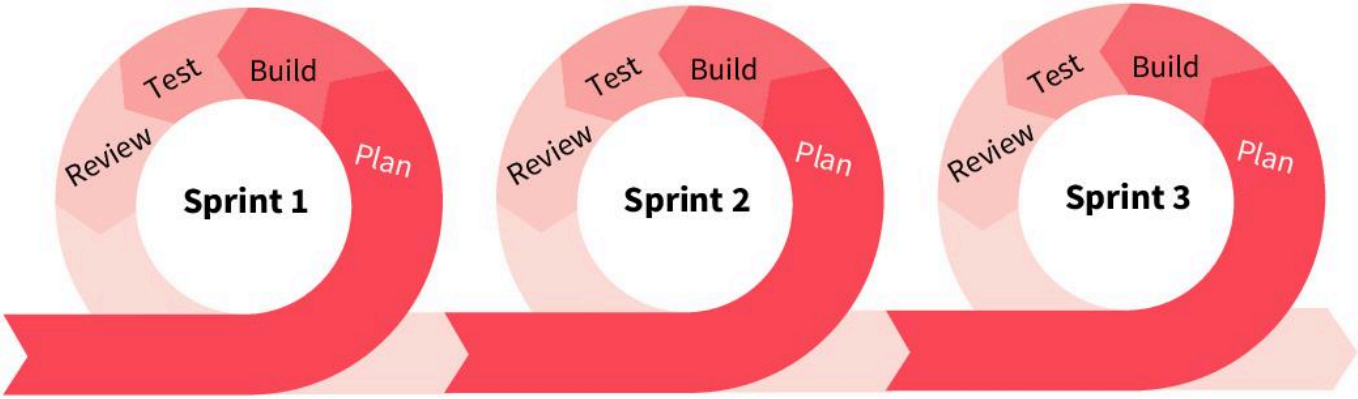
The agile method

The **agile** method is a more flexible way for teams to plan and manage their projects. This method helps project teams divide their work into smaller parts, called **sprints**. Sprints usually last about two weeks. A sprint includes the discovery and testing for all the work that the team is doing at the time. Agile teams work together very closely during sprints. They have a meeting every day called a **stand-up**. In the stand-up they tell each other about their progress and their plans for the day. A project team will often use cards and sticky notes on whiteboards or walls to record their tasks and their progress. This is called a **kanban board**.

At the end of each sprint, the team can show their work to the users. This is called a show and tell. Sometimes they can release what they have delivered in the sprint to the public. When a project releases their work early like this, it's called a beta version. Beta versions of a product or service might not yet have all the functions. But users can expect that an improved version will soon arrive.

Project teams using the agile method can get regular feedback from their users. This helps the team to respond to feedback and changes in the requirements more easily and quickly.





Choosing a method

Teams can choose the method they want to work with. There is no right or wrong choice. The team must choose the method they think fits best with their project and their team.

Here are some guidelines that teams can use to choose a method.

Choose waterfall if...	Choose agile if...
You are certain the requirements won't change.	You think that requirements could change.
Your project can be delivered in a short time.	Your project is likely to take a long time.
Your project team is not in one place or available at the same time.	You can bring the project team together in one place, at the same time.

Activity

The last lesson introduced a project idea. Your school wants to make a lunch order application. You will plan the work involved in this project. Work in a small group. Discuss the agile and waterfall methods. Which would you use for this project?

Creating a Gantt chart

When your team has decided what method it will use to deliver the project, you can make a project timetable. Your project timetable shows each task that needs to be completed. It also shows when the tasks should start and end. You can use the timetable to track the project's progress.

One common way of making a project timetable is called a Gantt chart. A **Gantt chart** shows the project plan as a series of tasks on a timeline. Each task is shown as a bar on a graph.

You can create a Gantt chart that shows the main group of tasks or you can create a more detailed chart that shows every single task. This example shows the main groups of tasks in a project using the agile method.

	A	B	C	D	E	F	G	H	I	J	K	L
1	**My project Gantt chart**											
2												
3		**Project Name**	**Project duration (days)**	**Project start date**	**Project end date**							
4		The Cake Factory custom cake order system	33	03 June 2019	05 July 2019							
5												
6	**Task ID**	**Task description**	**Task duration**	**Task start date**	**Task end date**	**03 June 2019**	**04 June 2019**	**05 June 2019**	**06 June 2019**	**07 June 2019**	**08 June 2019**	**09 June 2019**
7	1	Project start meeting	1	03 June 2019	03 June 2019							
8	2	Planning workshop 1	1	04 June 2019	04 June 2019							
9	3	Planning workshop 2	1	05 June 2019	05 June 2019							
10	4	Sprint 1	14	06 June 2019	19 June 2019							
11	5	Demo Sprint 1	1	20 June 2019	20 June 2019							
12	6	Sprint 2	14	21 June 2019	04 July 2019							
13	7	Demo & Release 'beta'	1	05 July 2019	05 July 2019							

There are many specialist applications that help you plan projects. They can make Gantt charts from the data you enter. You can also create Gantt charts in a drawing program. The example in this lesson was created using a spreadsheet. You can use the charts functions of a spreadsheet application to create Gantt charts from the data you enter.

A Gantt chart can be useful for different purposes in your project.

- It helps you plan the order and the duration (length) of each task by modelling the impact of changes in your project plan data.
- It helps you share the project plan with the project team in a way that is easy to understand.
- It helps you react to changes and delays. You can change the dates and durations and see how it affects your project timeline.

Activity

Your school has decided to develop the lunch order application. All the project tasks are listed in a Gantt chart. Your teacher will give you this chart. It is a spreadsheet file.

Read the Gantt chart and answer these questions.

1 How many days will it take to develop the app?

2 What is the project end date?

3 What is the first task? How many days will it take?

4 How many days are allocated for testing?

5 Give all the dates when there will be user training.

The Gantt chart is incomplete. Use green shading to show the dates of Sprint 1 and Sprint 3.

Extra challenge

The business sponsor is concerned about the project costs. She wants you to reduce the number of days spent on the project by 10%. Use the Gantt chart to create a new timeline. Explain what changes you made and how you decided on them.

Test

1 Put these three stages of the waterfall method in the right order.

delivery **release** **testing**

2 A Gantt chart lists the tasks in a project. What information does it show about each task?

3 What is a beta release of a product or service?

4 Write down three advantages of using a Gantt chart to plan a project timetable.

6.5 Working on an agile project

In this lesson

You will learn:

- how to use a backlog to store your project's requirements
- how to plan an agile sprint using story sizes
- how to manage daily work in a sprint using stand-up meetings.

The backlog

When you have written the user stories that describe all of your requirements, they become known as the **backlog** for the project. The backlog is like a to-do list for the project.

Each agile sprint runs for a fixed period, usually two weeks. Before a sprint starts, the project team must decide which user stories to take from the backlog and put into the sprint. This decision is made in a sprint planning meeting.

Planning a sprint

In the sprint planning meeting, the project team looks at all the user stories and thinks about three things to help them decide which ones to take into the sprint.

- The priority of the user story. Is it a Must-have?
- The logical order of the stories. Sometimes it is clear that one story needs to be delivered before another. This is usually because one of the stories will build on something in the other one. For example, the code to put an item in a basket cannot be developed until the code for the basket has been developed.
- The amount of work that the story will take to be delivered. Because a sprint has a definite end date, project teams need to know how much they can do in that time. They do this by estimating the size of a story.

Sizing user stories

At a sprint planning meeting, the project team reviews each story that could go into the next sprint. Working together, they give the story a size. They use this size to decide if they can fit the story into the sprint.

Story sizes are usually given in numbers, called **story points**. Story point numbers are used to estimate the difficulty of the story in comparison to other stories.

The project team discusses the story and the possible solutions they could deliver for it. Then they play a story sizing game to help them agree on a size number. The

planning game works like this:

1. After discussing the story and the solutions, each member of the team picks a size number that they think best matches the difficulty of the story.
2. Every team member holds up their number. If all the numbers are the same, then that number becomes the story size. It is added to the user story card on the backlog.

3. If the numbers are different, then the team members each explain why they chose their number. After that, everyone picks a number again. The team repeats this step until everyone agrees on a final story point number.

Using velocity to fit stories into sprints

When the team agrees on all the story sizes, they can add stories from the backlog into the sprint. They can only add stories until they reach the total number of story points they can deliver in one sprint. This total number is called the team's **velocity**.

In the first sprint of a project, the team will estimate their velocity. After the first sprint they will know how many of the stories they were able to finish. Then they can add up all the story points. This number will be their velocity for the next sprint.

Activity

Your teacher will give you a worksheet with some user stories for the school lunch app project. All the stories have points. The number of points tells you how much time and effort it will take to complete the task.

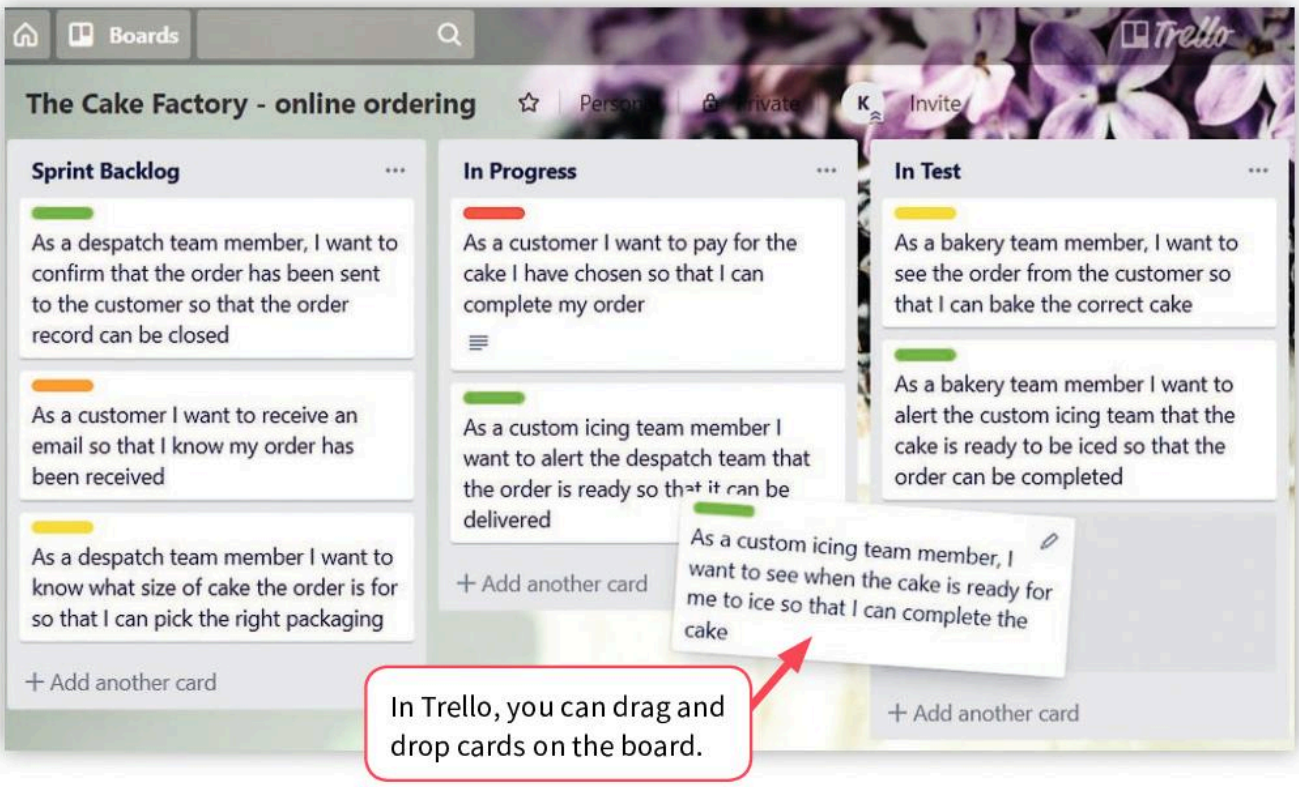
Working in small groups, play the story planning game. Choose the tasks for your first sprint. The total story points for all the tasks you choose must add up to no more than 12. Choose the tasks that are most urgent.

Working in sprints

The main way of managing an agile project during a sprint is through the kanban board. This is a board or a software application that shows what stage the user stories are in.

- **Backlog:** shows the user stories that are not yet started.
- **In progress:** shows the user stories that the team has started to work on in the sprint.
- **In test:** shows the user stories that the solution developers have completed and that the solution testers are now testing
- **Done (or complete):** shows the user stories that have been finished. This means that the solution has been delivered and tested and it is ready to show to users.

The team might also have a separate column for user stories that are blocked. This means that they can't be delivered until some other problems are solved.



This image shows a kanban board for The Cake Factory's project to build an online sales service. You can use an online service, such as Trello, or an application to create a kanban board. You can also use a wall or any surface that has enough space to stick up your user story cards.

As each stage is completed, the card is moved to the next stage. This means that the project team can use the board to see how they are progressing. They can also use the board to plan their daily work.

Daily stand-ups

To deliver a successful agile project, every member of a project team must be able to plan their work. They also need to be able to respond to changes in the plan if things go wrong or get delayed. This is what we mean by agility.

One of the ways that a project manager can help the team stay informed about the project is called the daily stand-up.

The stand-up is a meeting that happens every morning during a sprint. It is called a stand-up meeting because it is very short. People don't need to sit down.

The team gathers together, usually around the kanban board. Taking turns, each team member says three things:

- what they achieved yesterday
- what they are planning to do today
- what are the problems that might stop them from achieving their goals today – these are called blockers.

Extra challenge

Carry out online research into how kanban boards are used in business. Software is available to help teams to make and use kanban boards. Do you prefer to use software or to make a real-life board with cards pinned to it?

Test

1 What is the purpose of a daily stand-up meeting in an agile project?

2 Which of these columns would you find on a project's kanban board?

Recycle bin **Delay** **In test**

3 Why do agile project teams play the story sizing game at the start of every sprint?

4 Explain how a project team can calculate its velocity at the end of a sprint.

6.6 Testing software

In this lesson

You will learn:

- how different types and levels of tests can be done at each stage of the project
- how a test scenario can help find problems and defects
- how positive and negative tests check how the system behaves.

All IT projects must thoroughly test the products and services they create. The project team needs to know that its product or service works. It also needs to know that the users are happy with it. Different kinds of tests help to find this out.

Levels and types of testing

On larger projects, software testing is usually done by a specialist team of testers. In smaller projects, members of the solution development team can do the tests. When the project team are happy with the quality of the product or service, they will invite a group of users to test it. The product or service can't be released until it passes all these tests.

Tests are carried out at different levels.

Unit testing

The team tests small parts of the product. In an agile project, a team can do unit tests during sprints.

Integration testing

The team tests two or more parts together. This kind of testing is very important when a project is developing a product or service that uses more than one technology, for example a website and a database of products.

System testing

The team tests the finished solution. The test will show if the system meets the requirements. The test simulates an end-to-end process using all the solution's parts. For example, browsing a website, selecting a product, making a payment, receiving an email confirmation.

Acceptance testing

The users test the product or service from end to end. The users check that the product meets their requirements and that they agree it is ready to be released.

At each level, the project team might decide to use different testing methods. This table shows the main types of test.

Test type	Purpose	Used in levels
Smoke testing (or 'build verification testing')	A quick test to check that the most important functions work. Testers check for signs that the product isn't working. Testers call this smoke testing because when you see smoke coming from a machine, you know immediately that it's not working properly.	Unit, Integration
Functional testing	Tests that the product or service meets the functional requirements and specifications.	Unit, Integration, System, Acceptance
Usability testing	Tests if the system is easily usable.	Unit, Acceptance
Security testing	Tries to find security problems. Tests that any data used by the product or service are protected from being stolen or misused.	Integration, System
Performance testing	Tests and measures how a product or service performs. Does it respond quickly to users? Does it crash or fail when busy?	Integration, System
Regression testing	Tests if changes or fixes to the product or service have worked and that they do not cause other problems.	Unit, Integration, System
Compliance testing	Tests that the product or service meets all the non-functional requirements set by the users and regulators. This might include legal requirements.	System

Using scenarios to test

Software testers use scenarios to do most types of testing. A **scenario** is a simulation of how a user would use the product or service. The test designer creates scenarios from the requirements and uses them to create a document called a test case. A **test case** has step-by-step instructions for the testers. A test case tells the testers what to do and how the system should respond. The testers follow the instructions and record if the system does something that is wrong or unexpected.

This example shows a test case for a scenario in The Cake Factory's new online ordering service.

Test case 1: Customer adds a customised birthday cake to their order

Test steps	Expected result	Actual result?	Pass/ Fail?
1 Select cake type from drop-down list	*System displays three cake options. Cake options can be selected. Order price is updated.*	*As expected*	*P*
2 Choose two options from list	*User can select one or more options. Order price is updated to include cost of options.*	*As expected*	*P*
3 Select to add personal icing message	*User can select option only if icing option (Step 2) is NOT 'Chocolate'. System displays text entry box.*	*As expected*	*P*
4 Enter message text	*User can enter text up to 25 characters including spaces. User can NOT enter any special characters.*	*I was able to add characters # and %*	*F*

Positive and negative tests

A test designer can use two types of test in a scenario: a positive test and a negative test.

A positive test checks the behaviour of the system when the tester is using it correctly. For example, the test for entering the number of cakes to add to the shopping basket could be to enter the numbers 1, 2 and 100 in the amount box.

All of these values are valid, because the requirement is 'the user can add any number above 0 to the amount box'.

A negative test checks the behaviour of the system when the tester uses it incorrectly. The test case will ask the tester to deliberately add invalid data, for example: enter 0, −10, 'abcdefg' in the amount box.

The test designer will use a combination of positive and negative tests to check that the system meets the requirements.

Recording defects

When a tester finds that the system behaves in a wrong or unexpected way, they record the behaviour as a defect. A **defect** is any behaviour that does not meet the requirements. At the end of the test, the list of defects is passed back to the solution developer. The solution developer must fix each defect. When the defect is fixed, the tester repeats the test case to check that it now passes the test.

Activity

Your teacher will give you a spreadsheet application. Use the test cases table on the second sheet of the spreadsheet to perform the tests. Record any defects you find.

Extra challenge

Review the test cases and the application. What other tests do you think could help the project team find errors in the application? Add one or more new test cases to the second sheet of the spreadsheet.

Test

1 Explain why project teams must test their products or services.

2 What is a defect?

3 Which of these is **not** a type of software test?

Positive test **Negative test** **Indifferent test**

4 Describe how a scenario can help a user test a system.

Check what you know

You have learned

- how IT project teams work together using different methods
- how to use tools like mind maps, personas and process diagrams to plan a project
- how to use tools like use case diagrams, user stories and kanban boards to manage a project
- how to manage a project using the plan-do-check-act project life cycle.

Try the test and activities. They will help you to see how much you understand.

Test

You have been asked to make an app for students so they can see a list of after-school activities at their school. They can also use the app to sign up to an activity.

1. Is the work of developing the app business as usual or is it a project?
2. It is your job to make the app. It will take 5 days to find out the information you need, 3 days to plan, and 10 days to make the app. Think about today's date. If you start tomorrow and work every day, what day will you finish the work?
3. Give three items of information you need to find out before you can start making the app.
4. The tasks in question 2 did not include testing your app. How many days would you allocate for testing? What is the new project end date?
5. You planned to take 5 days to find out the information you need. But when you do this task it takes 7 days. Write a revised project timetable with the start and end days for each task.
6. The head teacher of your school is the project sponsor. Write an email to the head teacher. Set out the revised project timings and the date you will deliver the app. You don't have to really send the email!

Activities

Your teacher will give you a half-completed Gantt chart called Tropical Beach Gantt Chart. In this activity you will read the chart and add extra information to the chart.

Aliya is the new IT Project Manager at the Tropical Beach Dive Shop. She has joined the team to help deliver a project. The Dive Shop wants to increase sales

by offering a new online booking service to customers. The service will allow customers to book a dive trip before travelling to Tropical Beach.

Aliya wants to start the project on 1 November. She has agreed with her team that they will need three sprints. Each sprint will be 10 days. There will be a five-day acceptance test after the last sprint.

1 Open the Gantt chart. Use the chart to find answers to the following questions:
- What is the start date of the project?
- What is the end date of the project?
- How many days does the project last?
- How many tasks are there in the project?

2 The Gantt chart shows four tasks. Add the start and end dates for tasks 2, 3 and 4. Shade the cells to show the tasks in the Gantt chart.

3 There will be a demo on the last day of every sprint. Write down the dates of the demos.

4 Aliya needs to bring forward the project end date by five days. Change the Gantt chart to suggest a way of doing this that still leaves at least three days of acceptance testing.

Self-evaluation

- I answered test questions 1 and 2.
- I completed activity 1. I used the Gantt chart to answer questions about the project.
- I answered test questions 1–4.
- I completed activities 1–3. I added information to the Gantt chart, and used it to find dates.
- I answered all the test questions.
- I completed all the activities.

Re-read any parts of the unit you feel unsure about. Try the test and activities again – can you do more this time?

Glossary

abstraction making a problem simpler by leaving out details that you do not need

addictive design social media designed to make using the platform a habit

agile a method of delivering projects in short cycles of work, called sprints

algorithm sets out the steps to solve a problem. An algorithm can be used as the plan for a program

AND gate a way of controlling data by combining two inputs. An output of 1 happens only if both inputs are 1

arithmetic and logic unit (ALU) the component part of the CPU that performs all arithmetic and logical operations

artificial intelligence (AI) computer systems that can solve problems using human-like judgement

assumptions values that you decide to leave out, or set at a fixed level, in a mathematical model. You use assumptions to simplify the model

automated something that can work on its own without a human user

backlog a list showing all the work that needs to be done in a project. Backlog items can be moved across a kanban board as they are worked on

buses high speed data links that carry instructions and data to and from the CPU

cache a small area of primary storage that holds data and instructions that are about to be processed by the CPU

central processing unit (CPU) another term for a computer processor. The term is used to describe the main computer processor. There may be other processors in a complete computer system

circuit a set of logic gates used together to perform a complex action

clock (CPU) a small quartz crystal in the CPU that emits a regular pulse. The pulse of the clock is used to synchronise the CPU's processing cycle

cluster a group of items that have something in common. In some types of machine learning the computer will learn how to put data into clusters

computer system a computer with input, output and storage devices making a system to carry out a task

conclusion (in logic) the outcome of one or more propositions

content things that are made and shared online. These could be ideas, thoughts, images, videos or writing. The things you make using social media are called user-generated content

control unit a component part of the CPU. The control unit manages other components and the processing cycle of the CPU

cookie a text file put on your computer, phone or other device by the websites you visit. The cookie collects information about you for the company

curate group together content in ways that make sense for the user, and make it easier for the user to find what they are interested in

decision tree a diagram that shows a connected series of decisions. By following the 'branches' of the tree, you can get to the right final result

deep learning a form of machine learning that combines many methods into a highly complex learning process. Deep learning typically uses a type of computer structure called a neural network

defect any behaviour of a system that does not meet the requirements. Sometimes called a bug

digital footprint the mark you leave when you are online. It is all the information about you that you have posted about yourself, or other people. Your digital footprint includes information that you mean to share, and information that you share without realising

drone a flying robot that can be remotely controlled or that operates autonomously

embed display content from another source or service in an application or web page. For example, you can embed videos and audio from streaming services in other web pages

embedded processor a small processor embedded inside any device. Embedded processors allow robots to carry the processing power they need with them

ethics of care three key ideas about how to look after yourself and others on social media: We depend on each other. Not everyone feels strong all of the time. What we say, type, share and do every day on social media should protect and promote better lives for everyone

expert system an algorithm that represents the knowledge of an expert

fetch-execute cycle the actions that take place in a CPU during a single processing cycle

for loop a loop is a structure that repeats commands. A for loop is a type of loop used in Python. It repeats the commands a set number of times

Gantt chart a visual form of timetable using a bar chart format

gates components in a processor that allow a computer to perform logic

heuristic a rule that helps you make a quick decision. A heuristic is like a guess, or a rough estimate. But it is a guess based on careful thinking about the problem

hosting service a service that stores software, multimedia content, files and other digital assets online, so that it can be accessed and used by people over the world wide web. Filesharing applications, media streaming services and websites rely on hosting services to store their content and make it accessible to users

humane design making software that tries to make lives better for people

if structure a program structure that starts with a logical test. If the test is True the commands are carried out

interactive a flow of information or activity between people, or between computers and people

kanban board a board, wall or software application that shows work in progress during a project

logical argument an argument with one or more premises leading to a valid conclusion

machine learning a way of making the computer solve a problem without needing to write an algorithm. The computer has to learn how to solve a problem for itself

mathematical model a model of a real-life system that uses numbers to stand for all the parts of the system

microprocessor a small chip of silicon with all the components of a computer processor built onto it

minimum the smallest possible value

multimedia platform an application or online service that allows users to make, share, or view multimedia content. Multimedia platforms allow users to combine media like text, images, audio and video

nested structure one program structure put inside another. A nested structure has double indentation

natural language processing (NLP) a method used to allow robots to recognise human language, such as spoken commands

NOT gate a way of controlling data by reversing a single input. For example, an output of 1 happens if the input is 0

OR gate a way of controlling data by comparing two inputs. An output of 1 happens if either or both of the inputs are 1

pages (in blogs and websites) separate locations for items that you want to stay visible. They are sometimes called 'static pages' because their content does not often change. A typical static page in a blog might be an 'About us' or 'Contact us' page

parallel processing using two or more processors at the same time to increase the power of a computer processor

post share content on a social media site

posts (in social media and blogging) separate items you can add on a scrolling page. On most platforms the most recent post is the first one that users see on the page or feed

primary storage storage close to the computer processor that is used by the processor to store instructions and data that are due to be processed

privacy being protected from being watched or listened to by other people. The protection can be from individual people, or groups like the government, or companies

project a piece of work that has a start and end date, and a specific set of goals. Projects often bring together people in teams to work to deliver the objectives

proposition (in logic) a statement that is either true or false

Random Access Memory (RAM) a large area of primary storage that holds application programs and data ready to be used by the CPU

real time operating systems (RTOS) operating systems designed to work in real time applications where input data must be processed immediately

reinforcement during machine learning the computer is given feedback that lets it know if it has moved towards the right goal

risks factors that might cause a project to fail

robot a computerised machine capable of performing one or more tasks automatically

robotics the study of robots. Robotics combines computing and engineering knowledge

scenario a simulation of how a system might be used. Testers use scenarios to create test cases

secondary storage peripherals such as storage drives. Secondary storage is used to save user data files and program files in a non-electrical form until they are needed by the processor

shot type the framing of a video image created by the position of a camera relative to the subject. Typical shot types (sometimes also called 'camera angles') include: wide (or long), medium and close-up. These shots differ by how much of the subject and background/foreground is seen in the frame

social media interactive technologies that you can use to make and share things online. You can share ideas and thoughts, images, videos and writing

sprint a short cycle of work in a project. A sprint always has a defined start and end date. At the end of a sprint, the project team will show the work they have done in a demo

stand-up a short meeting of a project team to share updates about the project

story points a way of measuring how difficult and time-consuming a user story is to deliver

test case a script that a tester follows to test the behaviour of a system. A failed test means that there is a defect

training the first stage of machine learning. The computer is given access to example data and sometimes feedback or labels. The computer must work out how to solve a problem

traversing visiting each element in a list or other data structure

truth table a way of presenting a logic statement in table format so that it can be easily read and understood

two-state anything that can be in one only of two states. For example, a logical statement can be true or false. A binary digit can be 0 or 1

Unicode a number code system. Every text character has a number code. Unicode includes many thousands of different characters including different alphabets and symbols from all over the world

use case diagram a diagram showing how actors (users) want to use a system that is being developed. Use case diagrams help IT project teams understand the scope and requirement of their projects

user-friendly interface an interface is what you use to work with a program or other software. If the interface is user-friendly it is helpful and easy to use

user story a way of writing down a user's requirement that a system needs to meet. User stories are written in plain language to help project teams understand exactly what they have to deliver

velocity the number of story points a team can deliver in one sprint

vision guided robotics (VGR) use of 2D and 3D cameras to give robots 'vision' to recognise and navigate objects and environments

voice recognition a method used to allow robots to recognise spoken commands

waterfall method a method of delivering projects in phases that follow on from each other in order

while loop a loop is a structure that repeats commands. A while loop is a type of loop used in Python. The number of repeats is controlled by a logical test

widget an application or a small part of an interface that allows you to perform a function or access a service. Widgets can be embedded in web pages or on the home screen of computers, tablets or smartphones

OXFORD
UNIVERSITY PRESS

Great Clarendon Street, Oxford, OX2 6DP, United Kingdom

Oxford University Press is a department of the University of Oxford. It furthers the University's objective of excellence in research, scholarship, and education by publishing worldwide. Oxford is a registered trade mark of Oxford University Press in the UK and in certain other countries.

First published in 2020

British Library Cataloguing in Publication Data

Data available

ISBN 978-0-19-849787-5

1 3 5 7 9 10 8 6 4 2

Paper used in the production of this book is a natural, recyclable product made from wood grown in sustainable forests. The manufacturing process conforms to the environmental regulations of the country of origin.

Printed in Great Britain by Bell and Bain Ltd. Glasgow

Acknowledgements

The publisher and authors would like to thank the following for permission to use photographs and other copyright material:

All photos © Shutterstock, except: **p5:** Mike Stone/Alamy Stock Photo; **p18:** ALBERTO PIZZOLI/AFP/Getty Images; **p33(b):** FatCamera/Getty Images; **p35(tc):** Aydinozon/123RF; **p51(t):** Pixelfit/Getty Images.

Cover illustration by Patrick Hruby. All other artwork by QBS Media Services Inc.

Oxford International Lower Secondary

Computing 9

Student Book

This **new edition** of ***Oxford International Lower Secondary Computing*** has been designed to teach students the vital computing skills they need for today's digital world. Across the levels, students grow into digital citizens with the confidence to apply their knowledge and skills in real life situations.

- **More project-based work** better promotes **active learning**, encouraging every student to participate in lessons
- The new **spiral approach to learning** sees students revisiting key concepts to build their digital literacy skills
- New in-built, **three-level differentiation** allows teachers to cater to the needs of every student
- A new focus on **computational thinking** prepares students for the demands of the rapidly evolving digital landscape
- New enhanced Teacher Guides make the course content even more **accessible for all teachers**, whether a computing specialist or not

Also available:

9780198497790 9780198497806 9780198497813 9780198497820 9780198497837 9780198497844 9781382007450 9781382007467

Leading on to:

9780198497851 9780198497868 9781382007474

OXFORD UNIVERSITY PRESS

How to get in touch:
web www.oxfordprimary.com
email schools.enquiries.uk@oup.com
tel +44 (0)1536 452610
fax +44 (0)1865 313472

ISBN 978-0-19-849787-5