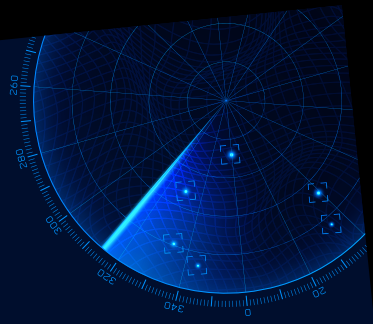
Royal Academy of Engineering

THIS IS ENGINEERING

CODE AND RESCUE

Student Guide

This resource teaches students how to code through a series of physical computing and practical activities which explore the essential role engineers have in search, save and rescue missions.



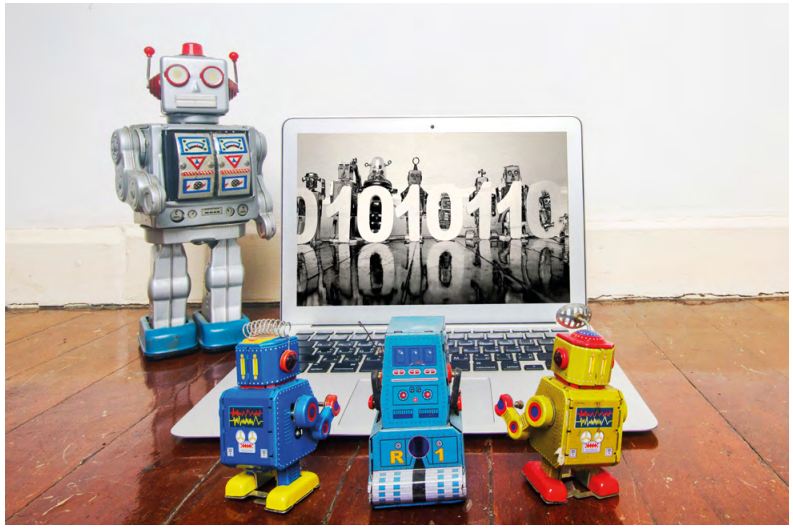
CODE AND RESCUE!

Engineers play a huge part in search and rescue operations all around the world. From working with emergency services such as Air Ambulance and the Coastguard, to disaster relief after natural disasters for search and rescue charities such as S.A.R.A.I.D (Search and Rescue Assistance in Disasters).

Engineers could be working behind the scenes, developing technology that helps save thousands of lives such as specialist vehicles, drones, robotics or optimising the way we communicate and are able to locate people.

They might be ready to respond 'on the ground' after major disasters looking at structural damage or using technology to search for missing persons. Or they could be involved with trialling solutions in preparation for future needs.

Check out the case studies in this resource pack for stories of engineers working in 'Code and rescue'.



We have two types of activities

Plugged in

Where you see this symbol, you will need to use the Crumble board and some of the hardware that's included in the box.

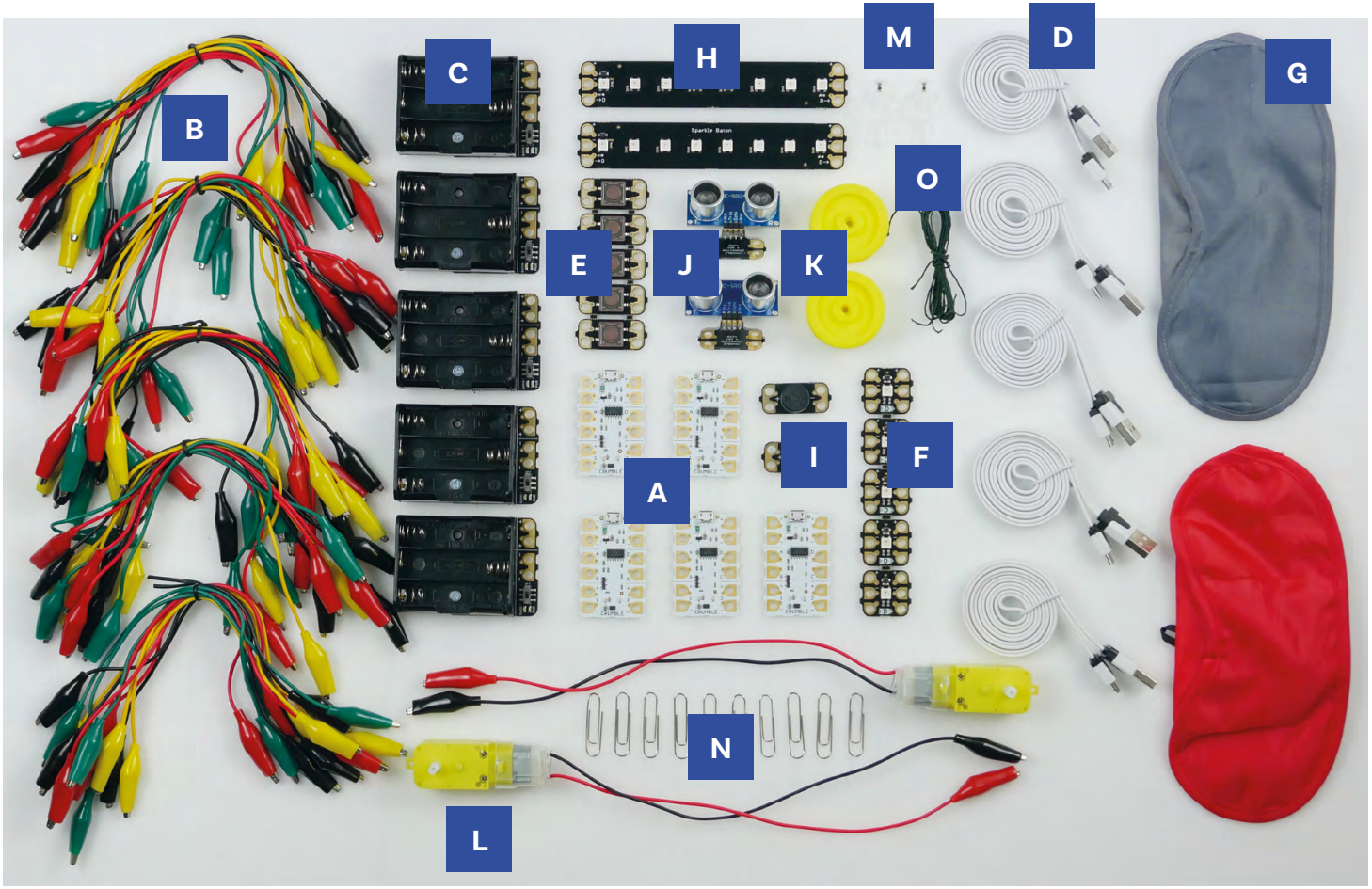
Unplugged

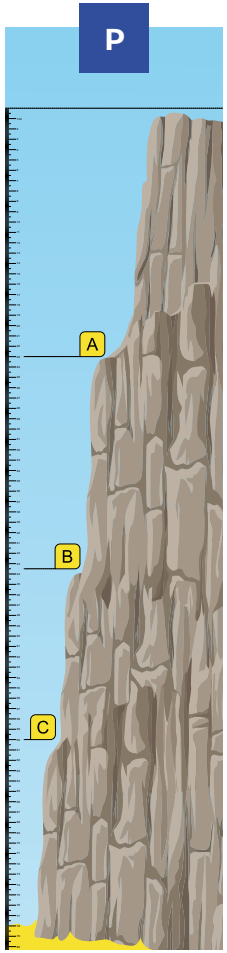
Where you see this symbol, you will not need to use the Crumble board or any hardware, however they might still need access to a computer.

Page	Activity	Plugged/unplugged
1	**Talk like a programer**	Unplugged
2	**Think like a programer**	Unplugged
3	**999 – what's your emergency?**	Unplugged
4	**The search is on...**	Unplugged
6	**Mission planning**	Unplugged
8	**Emergency lighting**	Plugged
10	**Light the way**	Unplugged
12	**Efficiency of codes**	Unplugged
13	**How much power?**	Unplugged
14	**LED lifejacket**	Plugged
15	**Sending out an SOS**	Plugged
16	**Sound Morse code**	Plugged
19	**Ultrasonic object finder**	Plugged
21	**Winch rescue plan**	Unplugged
22	**Winch to safety**	Plugged

WHAT'S IN THE BOX

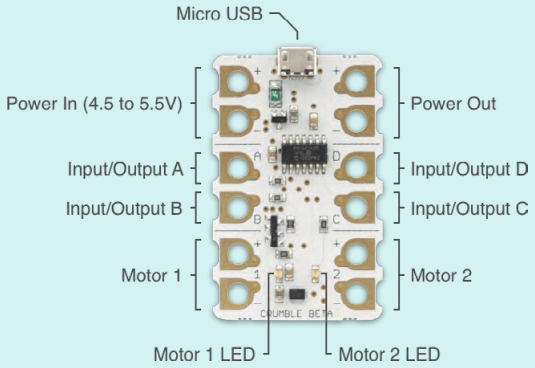
A. Crumble board x 5
B. Croc leads x 5 bundles of 12
C. Battery box x 5
D. USB x 5
E. Push switch x 5
F. Sparkles x 5
G. Blindfold x 2
H. Sparkle baton x 2
I. Buzzer x 2
J. Ultrasonic x 2
K. Pulley x 2
L. Geared motor x 2
M. Magnetic person x 2
N. Paper clips x 10
O. Metre of twine
P. Cliff face
Q. A4 cardboard crumble cutout





THE CRUMBLE CONTROLLER BY REDFERN ELECTRONICS

The Crumble is a programmable controller that can be coded to drive outputs such as motors and lights known as sparkles. It uses crocodile leads for simple connections and once programmed it can be easily embedded into a design or product. A useful output component is the sparkle baton consisting of eight LEDs that can be programmed to display interesting light sequences.



https://redfernelectronics.co.uk/crumble/

The '**getting started guide**' available from the Redfern website is an excellent starting point for those that haven't used Crumble before or need a refresher!

TALK LIKE A PROGRAMMER

Although you do not need to have any coding experience to carry out these activities, it is good to know about some of the technical words used in coding and programming.

Make your programming glossary

Match the definitions to the technical term and write up in alphabetical order.

NESTED	To investigate and fix mistakes in a program.
VARIABLES	To perform the instructions written in code.
DEBUG	A set of instructions to achieve a specific goal.
LOOP	A full piece of software that is ready to be run.
ALGORITHM	Contained within something else.
PROGRAM	A piece of code that runs itself repeatedly.
RUN	A mistake in a program.
BUG	Data values that change depending on the input.

Stretch and challenge

Find an example in this resource that explains each of the words in the glossary.

THINK LIKE A PROGRAMMER

Computational thinking

Although we can use computers to help us solve problems, we need to be able to understand what the problem is and the ways in which it could be solved.

We can build our *computational thinking* skills to help us to do this.

Computational thinking is a set of problem-solving methods that allows us to understand a problem and develop possible solutions. These solutions are then presented in a way that a computer can understand.

We will now look at four main skills that together make up computational thinking in more detail.

- Decomposition
- Pattern recognition
- Abstraction
- Algorithms

Computational thinking doesn't just stop at computing as the skills and approaches we learn here can be applied to problem solving across and beyond the school curriculum including those working in the emergency services!

The team at **Hampshire and Isle of Wight Air Ambulance** will be using computational thinking skills as part of their mission planning.

Match the computational thinking skill to the description of the different steps you might take when tackling a problem or project.

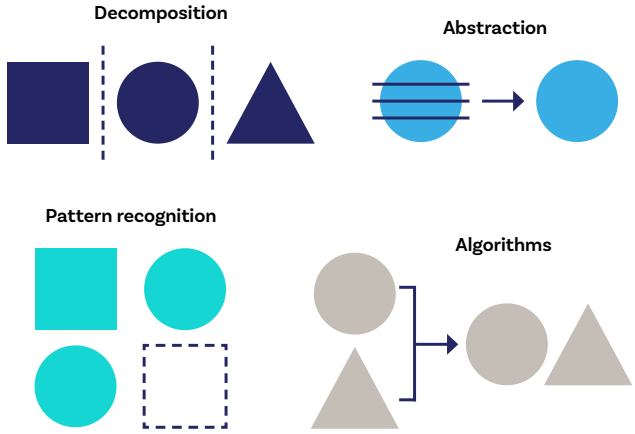
Stretch and challenge

Think and share examples of when you use computational thinking skills in your life.

Find examples in the resource of when you need to use different computational thinking skills.

Stretch and challenge

Explain how you came to your decision.



MATCH THE COMPUTATIONAL THINKING SKILL TO THE DESCRIPTION

Take a difficult problem and break it down into smaller problems.	Abstraction
Work out the steps or rules for getting things done.	Algorithms
Focus on the key details of a task.	Pattern recognition
Spotting and using similarities.	Decomposition

999 – WHAT'S YOUR EMERGENCY?

Algorithms are an important part of computing and for those working in the emergency services. Algorithms are a clear set of instructions that can help us solve problems or complete tasks.

Every time you write code, you are creating an algorithm.

Emergency Communication Centres (ECC) are buildings or rooms where control room operators receive incoming calls through the 999 emergency telephone service.

The role of the control room operator is critical as they need to quickly determine how to get the right help to those who need it as soon as possible.

There are four emergency services that operate full-time ECC.

- Police service
- Ambulance service
- Fire service
- Coastguard

Using a flow chart (see table for symbols), work in pairs to write an algorithm to show different possible routes a 999 call might take.

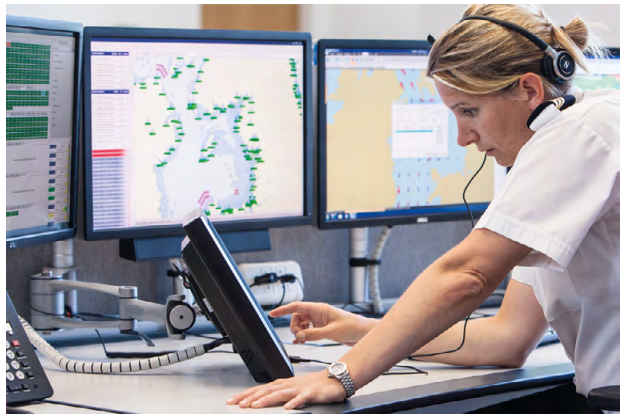
If you have access to a computer, laptop or tablet have a go at using draw.io, Microsoft Word or PowerPoint to build your flowchart.

Things to consider

- What information do you think the control room operator needs to collect?
- What are the different emergency services?
- Swap your 999 flow chart with another pair.
- What different 999 journeys can you/they follow from the flow chart?

Time to think

- What computational thinking skills do you think a call room operator needs to demonstrate?
- What technology and equipment do you think they might use?



FLOWCHART SYMBOLS

Name	Symbol	Usage
Start or stop	Start/Stop	The beginning and end points in a sequence
Process	Process	An instruction or a command
Decision	Decision	A decision, either yes or no. For example, a decision based on temperature that turns a central heating system on or off.
Input or output	Input/Output	An input is data received by a computer. An output is a signal or data sent from a computer.
Connector		A jump from one point in the sequence to another
Direction of flow		Connects the symbols. The arrow indicates direction.

THE SEARCH IS ON...

Working out the location of a casualty is one of the most important jobs for the emergency services.

This can be particularly difficult in rural areas, coastlines and mountains. Hikers or those that spend time at sea are advised to have a **Personal Locator Beacon (PLB)**.

PLBs work in seriously remote areas and in treacherous conditions. They send a distress signal to the Search and Rescue authorities (such as the Coastguard) who can locate casualties using **GPS** (Global Positioning System) technology.

GPS is a system that can pinpoint exactly where you are by using satellites that orbit the Earth. It works by calculating your distance from at least three satellites (the technical term for this mathematical technique is **trilateration**). It only works if there is nothing obstructing your signal to the satellites.

LOCATE THE CASUALTY

You have received an emergency notification that someone has activated their PBL.

You know that they are 370km from Canterbury, 670km from Aberdeen and 700km from Dublin.

Give the grid reference where you think the casualty is located.

Create a similar problem for a classmate.

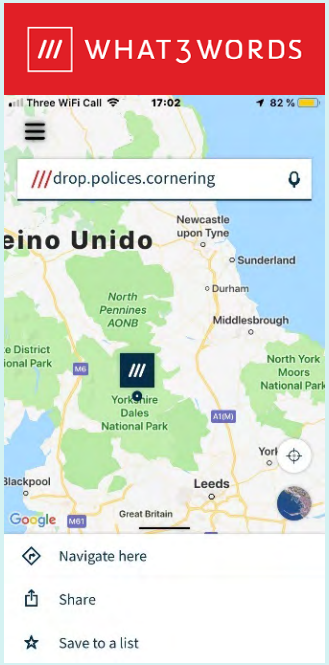
See map first to get dimensions.

What 3 Words

Technology is being developed to help locate victims or casualties as quickly as possibly even without PBL devices.

A new location technology has been developed that divides the world into 57 trillion squares (that's one million multiplied by one billion!), each measuring 3metres by 3metres, each of which have a unique, randomly assigned three-word address.

Emergency services in the UK have been using this app to help respond to incidents quickly.



Find your three-word address

Download the app – What3Words – on your mobile phone (or ask your teacher, parent or guardian) or you can visit the website on a computer, laptop or tablet.

- What is the three-word address of Stonehenge?
- What is the three-word address of Bletchley Park, home of the WW2 code breakers?
- What location are the three words **marble.messaging.hacksaw** linked to?

Stretch and challenge

You are based at **entitles.merit.spirits**.

There is a casualty at **grafted.games.varieties**.

You are travelling by helicopter travelling at a speed of 260kmh

Approximately, long will it take you to reach your destination?

MAYDAY BROADCAST

'Mayday' is a procedure word used internationally as a distress signal in radio communications.

The call is always given three times in a row – "Mayday, mayday, mayday".

The National Maritime Operations Centre handles all calls for the Coastguard from across the UK.

MISSION PLANNING

Details are given below about two of the search and rescue vehicles available to HM Coastguard: helicopter and lifeboat.

Sikorsky S-92

Crew: 4
Air speed: 145 knots (260kmh)
Fuel capacity: 3200 litres
Fuel consumption (endurance): 600 litres per hour

Survivor capacity: 21 persons
Endurance: 4 hours
Twin hoist (winch)

Atlantic 85 B-Class

Crew: 4
Max speed: 35 knots (65kmh)
Fuel capacity: 210 litres
Endurance: 3 hours

Survivor capacity: 20 people
Length: 8.44m
Beam/width: 2.85m

It takes approximately 1 minute to rescue each passenger on the boat or helicopter.

Refuelling the boat or helicopter takes 5 minutes.

The Coastguard (as well as other emergency services) regularly use 'speed/distance/time' calculations to plan their rescue missions.

Speed = Distance ÷ Time

Finding out the time it will take each vessel to reach the distressed boats will be an important part of mission planning!

URGENT: We have two ships in distress.

- The blue ship has 18 passengers on board.
- The orange ship has 52 passengers on board.
- We have coastguards fully equipped at station A, B and the helipad.

Using the map and space on the next page, prepare a search and rescue plan to get everyone back to shore as quickly as possible.

What to include:

- Time taken to get to site for boats/helicopters
- Time taken to rescue people from the vessel
- The range/endurance of the helicopters/boats (will they need to refuel?)
- Is anyone overboard? If so, they need to act quickly to help them to prevent hypothermia.

You will have a set amount of time to complete this task.

You will work in groups to complete this time.

Decide on how you will tackle the challenge before you start to make sure you use the time effectively.

Stretch and challenge

As part of your mission planning, here are some other variables that you need to consider!

Weather

- Wind speed is 20 knots / 15 knots / 30kmh / 15 kmh (choose one)
- Wind direction is from the south / from 275° / 045° (choose one)

Passenger information

- 7 passengers have fallen off the blue ship.
- 21 passengers have fallen off the orange ship.
- The water is currently 12°C. Expected time before exhaustion at this temperature is 1–2 hours. Expected time of survival at this temperature is 1–6 hours.

Time to reflect

- What computational thinking skills are you using in this activity?

EMERGENCY LIGHTING

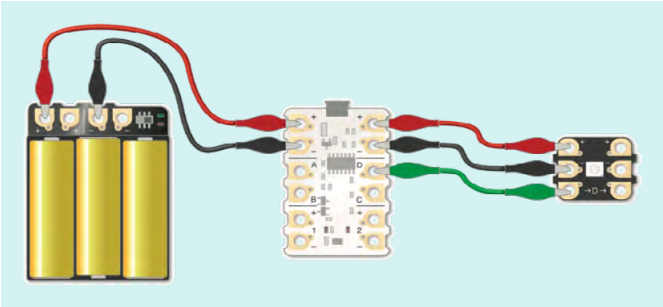
Emergency vehicles often have multiple flashing patterns for their lights.

In your groups, describe an emergency services vehicle as it rushes to an emergency.

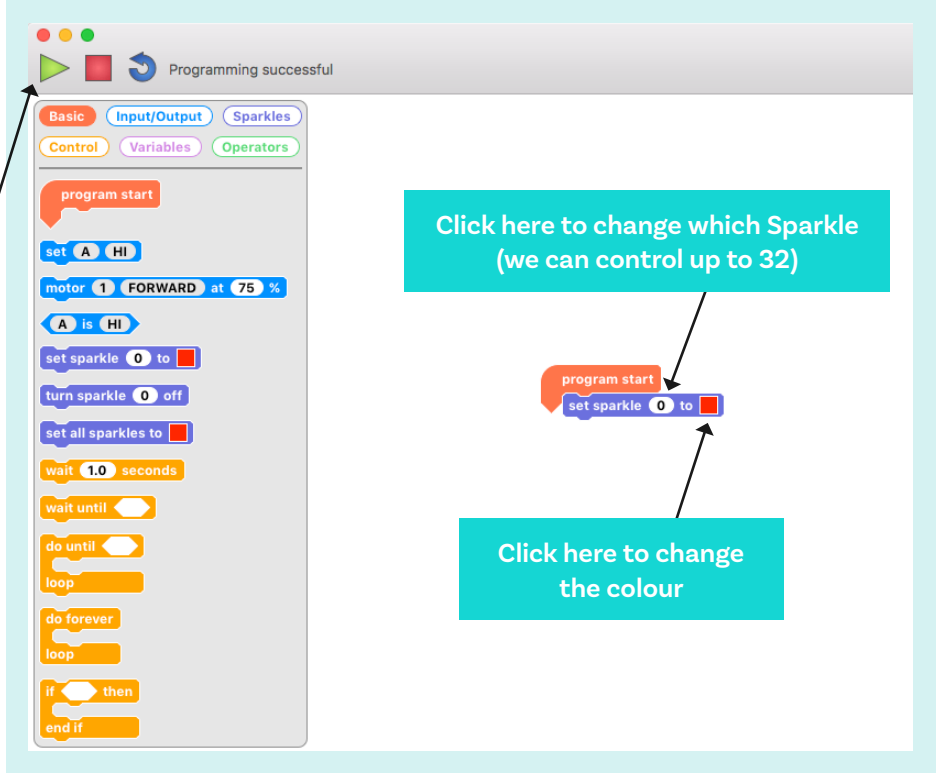
- Why are the lights so important? What colours flash for different emergency vehicles?

Using the Crumble board and the Sparkles, create your own flashing light sequence. Follow the steps below to get started.

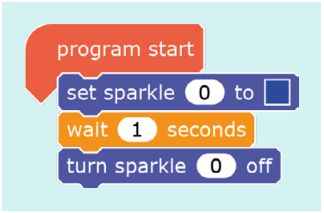
1. Connect your Crumble, battery box and Sparkle as shown.



2. Program a Sparkle to turn on red.



3. **If we want to only keep the Sparkle on for a set amount of time, we can do the following:**



4. **Now think about the lights on an ambulance – they alternate between white and blue.**

Can you write a program that alternates between white and blue, repeatedly?

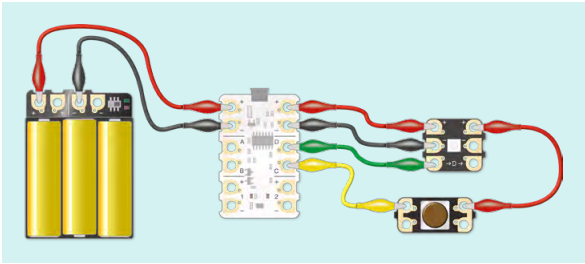
This loop may be useful!

5. **Different emergency vehicles often have multiple flashing patterns for their lights.**

Can you program the following? Leave a 100ms gap between changes.

6. **Now come up with your own flashing pattern! You can use the template below to help.**

7. **Connect the switch to your circuit. Write a program so that your flashing light sequence is activated by using the push switch as an input.**



Handy hint! Use the input/output coding blocks for this task!

Ceri Breeze / Shutterstock.com

LIGHT THE WAY

Effective lighting systems and lighting technology have been, and continue to play an important role for emergency services as well as search and rescue missions.

Time to think

In groups, think of different situations where lights are used to support emergency services.

Lighthouse patterns

A lighthouse is both a tower and a beacon serving two primary purposes. Firstly, they are used to illuminate waterways made treacherous by shoals, reefs, rocks and other hazards as ships pull into port.

Secondly, before the days of GPS, lighthouses were used as a reference point for mariners. No two lighthouses have been built the same and can be distinguished by the colour schemes and patterns on the tower during the day.

By night time, lighthouses can be distinguished by their **light signature** – every lighthouse has its own unique sequence. For example, a lighthouse might emit two flashes every three seconds to distinguish it from a lighthouse that emits four flashes every three seconds.

Even with GPS, people who work and/or spend a lot of time at sea will be familiar with this and have a guide that will let them know.

LIGHT CHARACTERISTICS – DESCRIPTION AND SYMBOLS

Description	Characteristic
Flashing Light is off longer than it is on	
Occulting Light is on longer than it is off	
Isophase Light is on and off for an equal amount of time	

If you have access to a computer, laptop, smartphone or tablet, visit Wikipedia – Light Characteristics to see a visual representation of the different light characteristics.

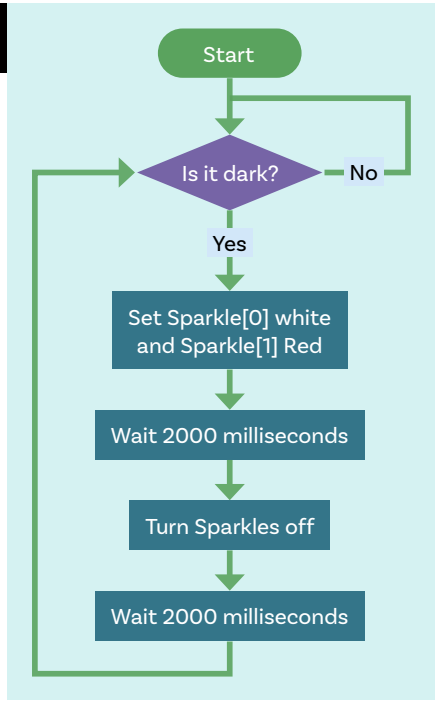
Matching activity

Match the lighthouse sequence (shown on the table) to the code/ algorithm/description (some sequences have more than one algorithm attached).

A

```
while True:
    sparkle.on()
    sleep(0.1)
    sparkle.off()
    sleep(2.9)
```

B



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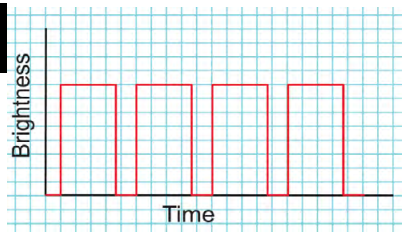

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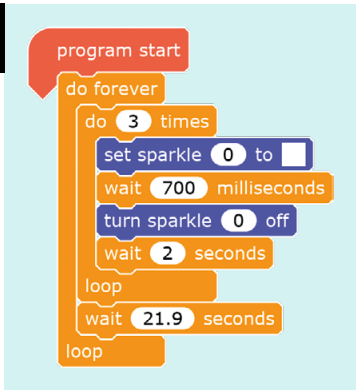

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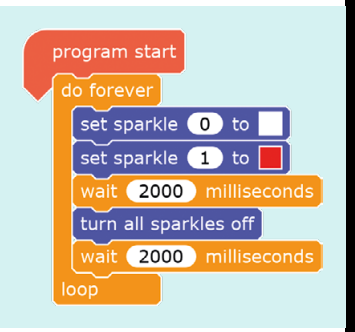

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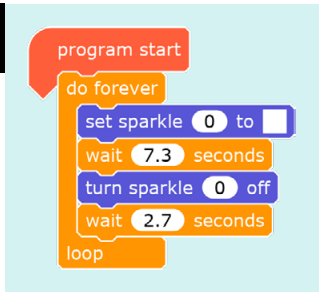

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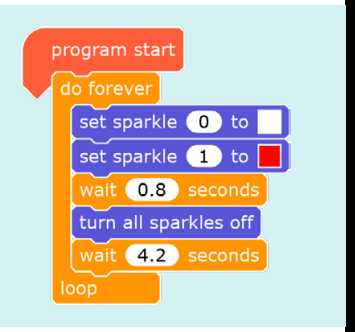

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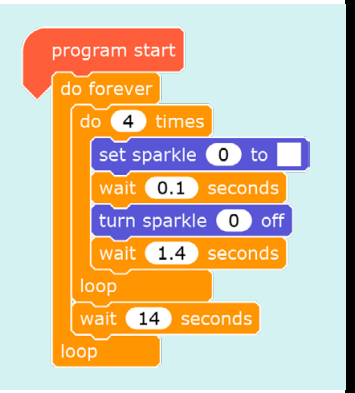


Lighthouse	Sequence	Algorithm
Lizard Point, Cornwall	**Flashing** sequence in a 3 second loop	
Whitby, Yorkshire	**Flashing** white and red in a five second loop	
Donaghadee Harbour, Northern Ireland	**Isophase** white and red in a four second loop	
Portland Bill, Dorset	**Flashing** four times white in a 20 second loop	

Stretch and challenge

Rattray Head, Aberdeenshire	**Flashing** three times in a 30 second loop	
Point Lynas, Anglesey	**Occulting** white sequence in a 10 second loop	

Handy hint! Calculate how long each loop is in the algorithms to help with this task.

EFFICIENCY OF CODES

Computer scientists might be involved in writing code for programs that support emergency services. It is up to them to make a program run smoothly and efficiently.

Time to think

- Why do you think this is important?

Look at each of the Crumble programs shown to the right.

What do you think their output will be when you use the Crumble board and sparkles?

Each of the programs has redundant code. Rewrite each program (using the Crumble software if possible) to make it more efficient. There might be more than one way to do this. Share your answers with your group to compare your solutions.

If you have access to a computer, tinker with writing more efficient code using the Crumble software.

Handy hint! Look for repeating patterns in the code blocks

A

```
program start
do forever
    set sparkle 0 to
    set sparkle 1 to
    wait 100 milliseconds
    turn all sparkles off
    wait 100 milliseconds
    set sparkle 0 to
    set sparkle 1 to
    wait 100 milliseconds
    turn all sparkles off
    wait 100 milliseconds
    set sparkle 0 to
    set sparkle 1 to
    wait 100 milliseconds
    turn all sparkles off
    wait 100 milliseconds
    set sparkle 0 to
    set sparkle 1 to
    wait 100 milliseconds
    turn all sparkles off
    wait 100 milliseconds
loop
```

B

```
program start
do forever
    set sparkle 0 to
    wait 100 milliseconds
    turn sparkle 0 off
    wait 100 milliseconds
    set sparkle 0 to
    wait 100 milliseconds
    turn sparkle 0 off
    wait 100 milliseconds
    set sparkle 0 to
    wait 100 milliseconds
    turn sparkle 0 off
    wait 100 milliseconds
loop
```

C

```
program start
do forever
    servo A -90 degrees
    wait 1 seconds
    servo A -60 degrees
    wait 1 seconds
    servo A -30 degrees
    wait 1 seconds
    servo A 0 degrees
    wait 1 seconds
    servo A 30 degrees
    wait 1 seconds
    servo A 60 degrees
    wait 1 seconds
    servo A 90 degrees
    wait 1 seconds
    servo A 60 degrees
    wait 1 seconds
    servo A 30 degrees
    wait 1 seconds
    servo A 0 degrees
    wait 1 seconds
    servo A -30 degrees
    wait 1 seconds
    servo A -60 degrees
    wait 1 seconds
loop
```

HOW MUCH POWER?

Electrical engineers and computer scientists designing battery-powered lighting systems for safety equipment work hard to maximise the amount of time a battery will last.

A battery powering an LED on full brightness lasts for one hour. **How long will the battery last for the following programs shown on the right?**

Handy hint!
What proportion of the total loop time is sparkle on?

Stretch and challenge

A battery has a capacity of **1000mAh**. Crumble uses **4mA** for the entire runtime of the program and the white LED uses **150mA**.

Work out how long an **LED** would flash before the battery is drained if running the program below.

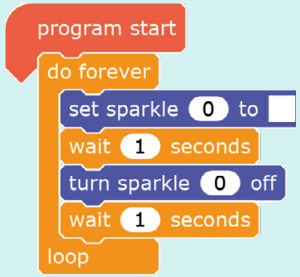
mAh – milliampere hour

Unit of electrical charge commonly used to measure battery capacity. It is a measure of the amount of current a fully charged battery can deliver in one hour.

This is how battery life is calculated for your mobile phones!

Handy hint!
Work out the average mA used across the whole loop time.

A



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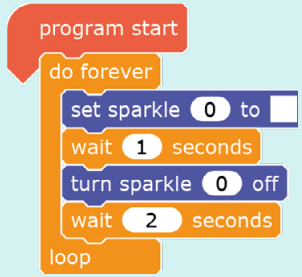

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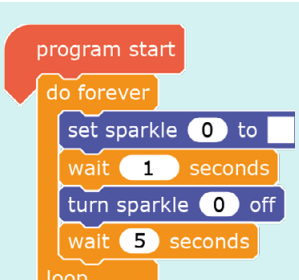


D

E

LED LIFEJACKET

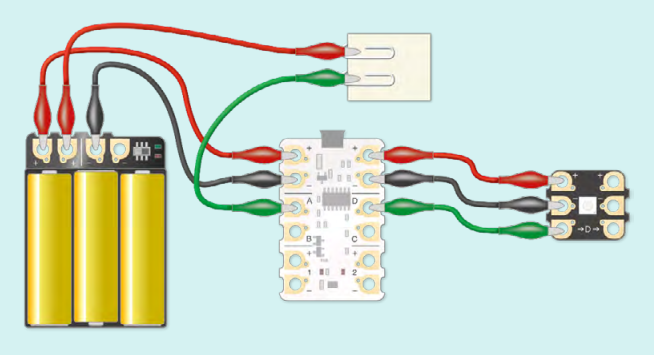
Some lifejackets are fitted with moisture sensors so that an LED light turns on once the lifejacket has come into contact with water.

Using the 'moisture sensor' (paperclips), set off a flashing sequence using the Sparkles.

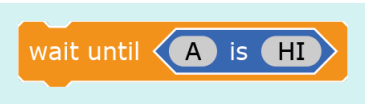
Try different Sparkle sequences. What sort of sequence would be most effective to attract attention?

Crumble set-up

Connect one end of the moisture sensor to the + end of the battery pack, and the other to the Crumble input/outputs (A, B or C – D is being used).



Handy hint!
The following snippet of code might be helpful.



Time to design

You have been tasked to invent and design the **ultimate life jacket!**

Life jackets save many lives every year, acting as a bouncy aid, helping to locate casualties at sea and even regulating body temperature.

What features will your life jacket have? Why are they important?

Things to consider:

- If you include a light, where will it be positioned and what pattern will it emit?
- What material will the life vest be made from?
- What technology could you include in your design that might help save lives at sea?

SENDING OUT AN SOS

Using lights to send messages in the dark could be very helpful if you are lost at sea or on a cliff side.

We could use multiple Sparkles to 'spell out' a word or message. We will use the Sparkle baton to do this. By flashing the lights really quickly, and waving them about, it is possible to 'write' in the air – using our own **persistence of vision**.

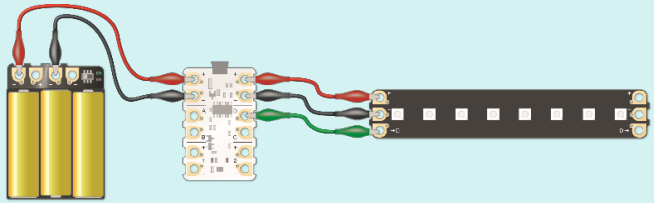
Before you write your code, plan your SOS message using the grid below.

Plan your SOS message (the letters you want to code) in the table below.

7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SOS MESSAGE USING THE SPARKLE BATON

Crumble set-up



Use the following block to set multiple Sparkles at once.

The code block corresponds to the planning grid above (red is Sparkle on and black is Sparkle off).

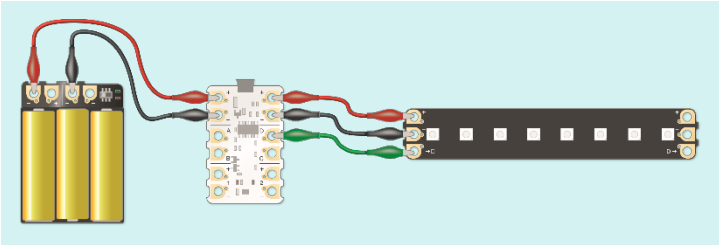
Persistence of vision works because the human eye and brain can only process 10 to 12 separate images per second, retaining an image for up to a 15th of a second. If another image replaces it in this period of time it will create the illusion of continuity.

SOUND MORSE CODE

Morse code is an alphabet or code in which letters are represented by combinations of long and short light or sound signals.

- Build a circuit that has a **'push to make'** switch to activate the buzzer but without using the Crumble board

Push to make – makes a connection only when you press the button.

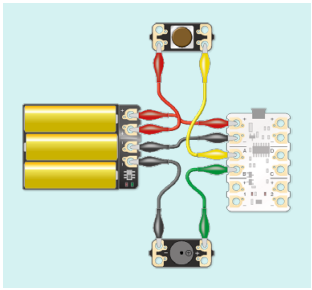


There are rules to help people distinguish dots from dashes in Morse code.

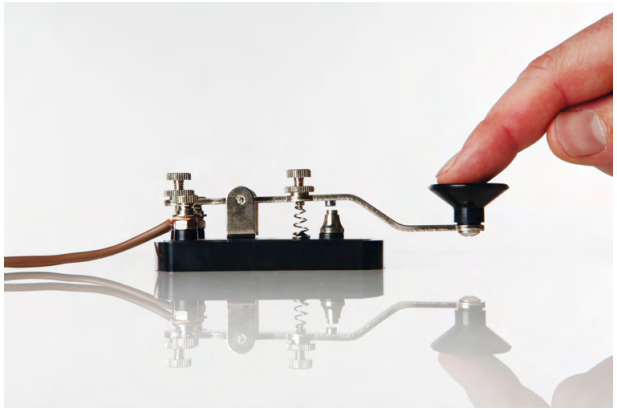
1. The length of a dot is 1 time unit.
2. A dash is 3 time units.
3. The space between symbols (dots and dashes) of the same letter is 1 time unit.
4. The space between letters is 3 time units.
5. The space between words is 7 time units

- Pre-program Morse code messages using the Crumble board

Connect the Crumble board to the circuit and write a program that has a switch as an input and buzzer as an output.



This loop may be useful!



MORSE CODE ALPHABET

A	•—	J	•———	S	•••
B	—•••	K	—•—	T	—
C	—•—•	L	•—••	U	••—
D	—••	M	——	V	•••—
E	•	N	—•	W	•——
F	••—•	O	———	X	—••—
G	——•	P	•———•	Y	—•——
H	••••	Q	——•—	Z	——••
I	••	R	•—•		

Search for '[See and hear Morse Code]' on Youtube to watch a video showing the Morse code alphabet.

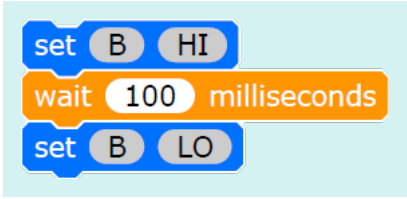
We will create a program for this using the Crumble board and Crumble software.

1. Connect your Crumble, battery pack, buzzer and switch.
2. Pre-program your Morse code device to say 'SOS' with one push.
3. Get creative! Have a go at pre-programing different messages (how about names for people in your class) for your classmates to work out.

Stretch and challenge

Write a program so that the buzzer will only be activated for one unit of time or three units time to correspond with the Morse code rules.

This code block might be helpful!



Do you think this makes it easier or harder to send Morse code?

Did you know?

As well as being used during war time, Morse code used to be the standard format for ocean communication.

'SOS' was initially designed as a universal distress signal by the German government in 1905. It is still recognised as a maritime distress signal today and continues to save many people's lives.

What do you notice about the sequence for this code? Why do you think this was the agreed upon distress signal?

Time to think

- Why do you think that both dots and dashes are used in Morse code?
- What do you notice about the sound/light sequence for different letters?

Handy hint!
What letters do you think are most commonly used in the English language?

Other options!

Have a go at using the LED Sparkles to write messages in Morse code.

Time to think

- If you need to use Morse code to send a distress signal, do you think it is best to use a sound or light sequence?


Sergey Sivkov / Shutterstock.com

WAVE DETECTION

Quickly detecting people buried under rubble after a natural disaster is essential for saving people's lives.

FINDER (Finding Individuals for Disaster and Emergency Response), a technology developed by NASA, has been assisting disaster relief workers on the ground in doing just that.

After a **7.8 magnitude earthquake** in 2015 in Nepal, by using the suitcase-sized radar instrument capable of detecting human heartbeats under the rubble, rescuers were able to save the lives of four men trapped under a building.

How it works

FINDER sends out low-powered microwave signals through rubble and looks for changes in the reflections of those signals coming back from tiny motions caused by breathing and heartbeats.

FINDER detects the small motions using algorithms similar to those used to measure changes in the Earth's surface from orbiting satellites.

A rescue worker can specify a minimum and maximum range for detecting heartbeats in the area and the program can identify whether the signal is stronger from the left or right of the device.

Microwaves are a type of electromagnetic radiation.

Ultrasonic waves are soundwaves above the frequency that can be detected by humans.

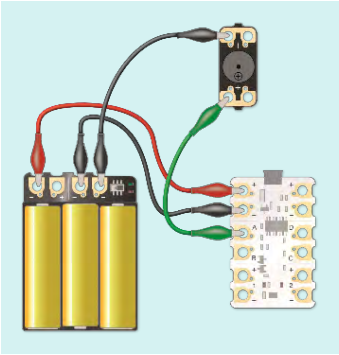
ULTRASONIC OBJECT FINDER

Instead of using microwave signals, we will use an **'ultrasonic sensor'** to detect objects. The ultrasonic sensor measures the distance from an object by emitting and receiving **ultrasonic waves**. The distance is calculated by measuring the time between release and return of waves.

1. Buzz the buzzer

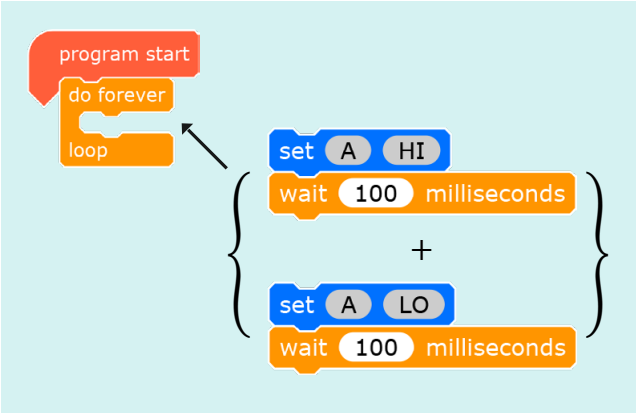
Connect the buzzer to the Crumble.

You can connect it to any of the 4 input/output pads (A, B, C or D). Let's go for **A**.



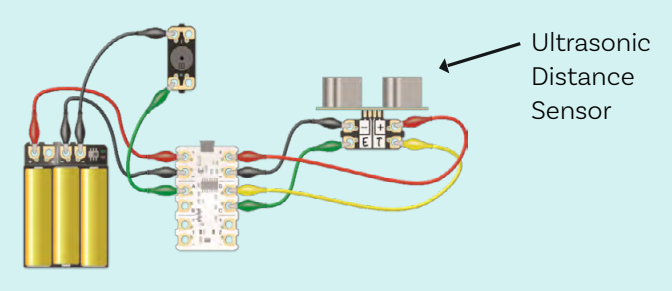
2. Write a program for the buzzer

By setting A to HI, the buzzer will be powered. Using the following blocks, can you make your buzzer pulse on and off?



3. Connect the ultrasonic distance sensor

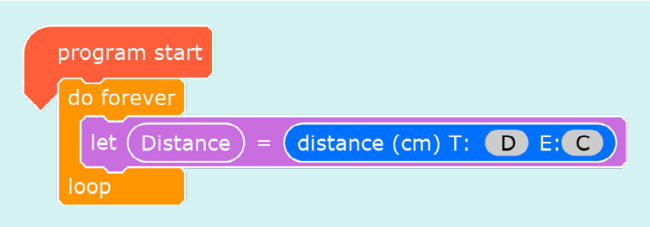
To 'see' our objects, we're going to use the Ultrasonic Distance Sensor. Connect the sensor up shown.



4. Write a program to measure distance using the ultrasonic object finder.

Now run the following program, leaving the Crumble plugged into the computer.

Looking at the variables tab (blue section), move your hand back and forth in front of the ultrasonic. What happens to the variable?

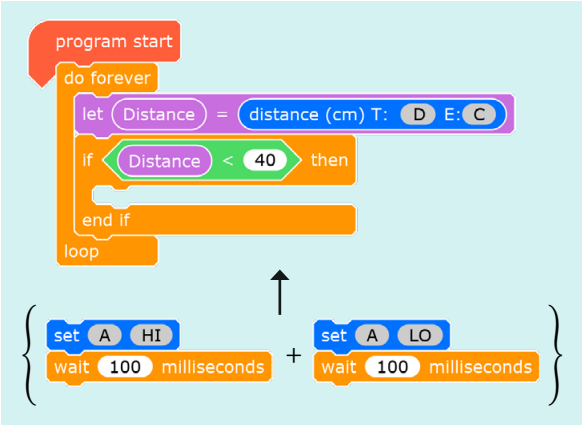


Handy hint!
Click on the grey areas to match the relevant connections.

5. Detect an object

By holding the distance sensor face down at arm's length, we are able to detect changes in height. We can use this, *while blindfolded*, to help us locate objects.

First, let's make a program that will detect the presence of a box. To set our 'trigger' value (our condition), we need to work out how high our arm will usually be off of the table top. Choose a threshold value so that you can detect when an object is underneath the distance sensor.



You can use the program above as a starting point, to help determine when an object is underneath your hand.

Stretch and challenge

Determine different objects using the ultrasonic sensor.

Choose a number of different objects that are different heights.

Write a program that pulses the buzzer at different speeds depending on how close the object is? The closer it is, the faster it beeps.

Challenge: Select a number of different objects that have different heights. Using your program, working in pairs or small groups can you identify the different objects whilst blindfolded?

Try this activity with a triangular prism. What do you notice as the ultrasonic distance sensor moves over the highest point?

WINCH RESCUE PLAN

The Coastguard are responsible for search and rescue operations at sea and on the coast.

This often means that they need to rescue people from places that are difficult to access. It is the only emergency service vehicle that operates a winch system so that they can reach people who are stranded out at sea, on cliff edges, on remote beaches or anywhere a helicopter can't land.

Search for '**The HM Coastguard – The UK's modern search and rescue service**' on YouTube to watch them on a search and rescue operation.

Winch rescue plan

Two groups of hikers are stuck on the Cairngorm mountain range in Scotland after the weather became increasingly turbulent for them while they were out in the snow. Both groups had personal GPS tracking devices that you have used to find out their location on the mountain.

There are five people in the first group, including one young person and a dog. They have reported that they are all safe. The winch will need to be lowered 45m to reach this group.

There are four people in the second group. One person in this group needs immediate medical assistance. The winch will need to be lowered 65m to reach this group.

The groups are 5 miles apart.

One member of your crew is a paramedic.

Put together a mission plan to show how you will safely rescue all members of both groups from the mountain.

Some things to consider:

- How long will it take to rescue each person in the different groups?
- Which group will you go to first? Why?
- Could more than one person be rescued by the winch in a trip?
- Will both groups fit in the helicopter?
- Will the helicopter need refuelling in this time?

HELICOPTER SPECIFICATION

- **Crew:** 4
- **Air speed:** 145 knots (260 kmh)
- **Fuel capacity:** 3200 litres
- **Fuel consumption (endurance):** 600 litres per hour
- **Survivor capacity:** 21 persons
- **Endurance:** 4 hours
- **Twin hoist** (winch)

WINCH SPECIFICATION

- **Speed:** 30m every minute
- **Full length:** 90m
- **Max hoist weight:** 230kg

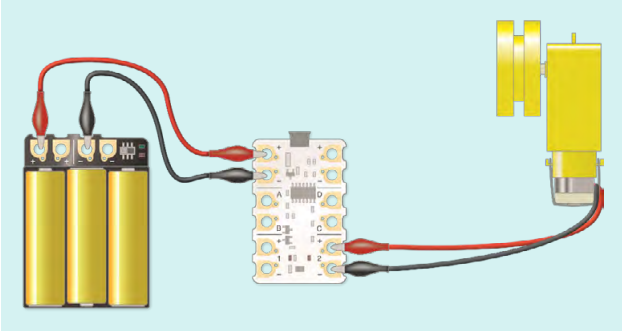
WINCH TO SAFETY

Design and program a winch system.

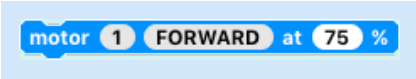
Handy hint!
Use the edge of a table or shelves to fix your winch mechanism to. Attach the long cliff face to the side of the table so you can measure the distance travelled.

1. Move the motor

Firstly, wire up your motor.



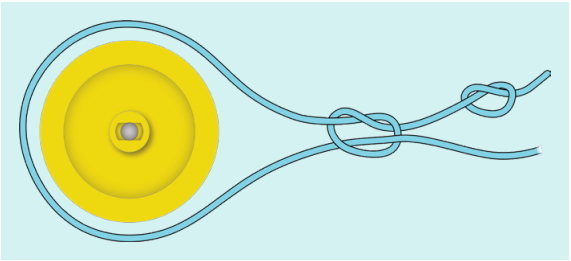
Experiment with the motor block to see how to get the motor moving forwards and backwards, and how to adjust the speed. Click on the grey areas to change the values, or on the white to edit the number.



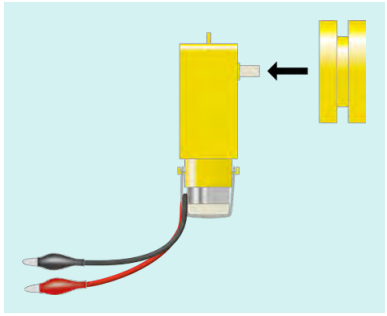
2. Build the platform

Using card, tape and twine, design and make a suitable stretcher and platform for your winch.

Attach your stretcher to the longer piece of twine and attach it to the yellow pulley using an Arbor knot (see image).

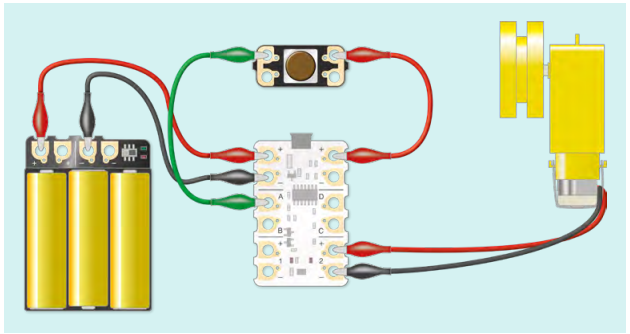


3. Place the pulley onto the motor spindle as shown in the diagram.

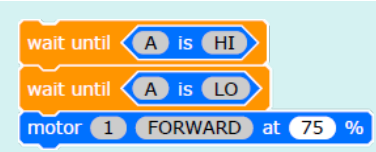


4. Connect the switch to the Crumble board and the motor and pulley.

Write a program that will lower and raise the winch and platform using the push switch



These code blocks might help you write your program.



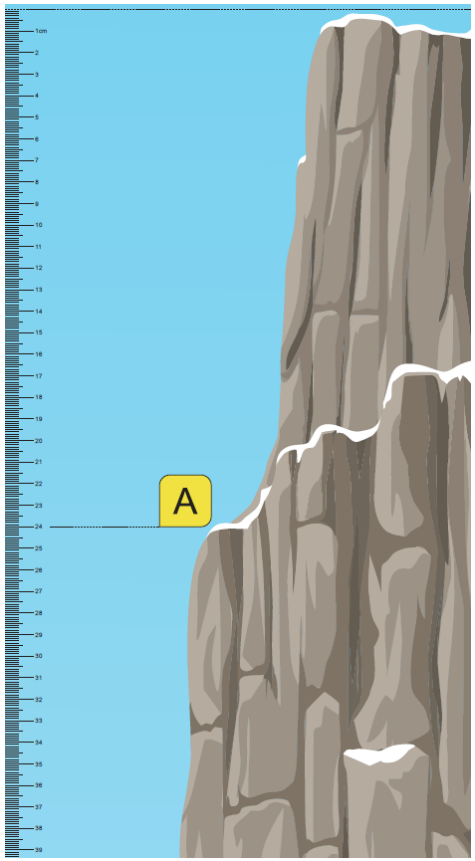
5. Pre-programming your winch

Pre-program your winch mechanism so that it travels to and from different levels of the cliff face with one push of the switch.

To do this we need find out the **speed** of your winch.

My winch travels ____ in 10s.

Speed = Distance ÷ Time

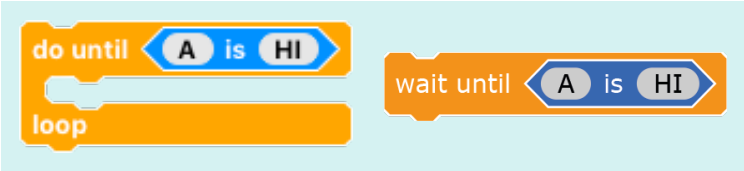


6. Challenge: Stopping the winch going too high

For an additional safety measure for your casualties and crew, we are going to add a safety cut-off using a switch that is attached to the platform.

Design a switch (you could use metal paper clips or aluminium foil) that can be attached to your platform.

You might find either of these coding blocks helpful when writing your program.



7. Challenge: stop the winch in time to rescue our casualty

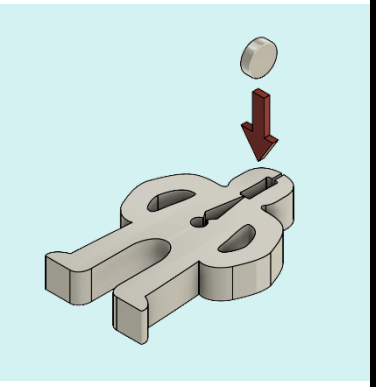
You need to rescue a casualty who has been trapped by the tide at the bottom of a cliff.

You will need to lower the winch to collect them.

But the winch must lower at a steady speed, stop to collect the casualty, and return back to the top without the casualty falling off or falling over.

Write a program that will rescue and retrieve the casualty without knocking them into the sea.

Once you think your program is ready to save the casualty, you cannot interfere with the program once it has started running.



Stretch and challenge

Design and build a winch mechanism that includes more components.

- Could you include the buzzer? Where might this be used?
- Could you include sparkles? Where might these be used?
- Could you include the ultrasonic distance sensor? Where could this be used?

Experiment with different design ideas and tinker with the coding blocks to see what you can come up with!

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Together we're working to tackle the greatest challenges of our age.

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