STEM SHOWDOWN

Teacher Resource Guide

Adelaide University

Education Futures ACADEMY

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Contents

Introduction

STEM Showdown is a weekly 1-hour (approximately) challenge run over a term.

Every worksheet must be signed/stamped by the teacher for each part completed.

Each signature/stamp is worth 1 point.

Speed bonuses are awarded for tasks that can be completed at different rates:

- 1st to finish: 3 points
- 2nd: 2 points
- 3rd onwards: 1 point

Student scores for each activity can be recorded in the spreadsheet provided.

Additional awards are given for:

- Creativity
- Persistence
- Encouragement

To record this, add comments to worksheets that reflect the value that was shown, such as “Great persistence!”, then simply count up these comments to track each student’s progress towards these additional awards.

STEM boxes are highlighted to show which STEM components are the focus of each activity.

The CDFS boxes highlight which cognitive skills are employed. These four skills are:

- **C - Computational thinking** is a problem-solving approach that teaches students to break down complex problems, recognise patterns, create step-by-step solutions (algorithms), and use logical reasoning.
- **D - Design thinking** is a student-centred, creative problem-solving approach that encourages learners to empathise, define problems, generate ideas, prototype solutions, and test them through reflection and iteration.
- **F - Futures thinking** is an approach that helps learners explore possible, probable, and preferred futures, develop long-term thinking skills, and make informed decisions in the present by anticipating change and uncertainty.
- **S - Systems thinking** is an approach that helps learners understand how parts of a system are interconnected, recognise patterns and relationships, and analyse how actions in one area can influence the whole.

The levels indicate workshop complexity, as shown in table below:

Level	Pack Up Rating	Teacher Involvement	Resources
1	Return equipment to the front	Student driven once task is initially explained	Worksheets and minimal equipment
2	Clean up the area, such as, paper, tape, etc.	May need help sheets and answer questions	Some pre-session set-up needed
3	Multiple items to pack up. Wipe down of work areas may be required	Technical support and ongoing instructions throughout the session	Additional supplies and pre-session preparation required

Enter If You Dare

S T E M
C D F S

Individual   Team – recommended group size: 2

Pack up - Level 1
Teacher involvement - Level 1
Resources needed - Level 1

Required Resources:
- Soma cubes
- Worksheets
- Pencil/pen

Set Up:
- Set of Soma cubes for each student (or one set per group of two)

Recharge With:
- Fresh set of worksheets

Task
The scenario is based around the students needing to get back to class after the bell has gone, but they have been locked in the playground. Using the Soma Cube pieces they need to build a set of stairs to climb over the fence and get back as fast as they can. Once they have made the stairs, they get the worksheet signed and try the to build the other shapes in the extension actvity.
If students are struggling to work out the answer, you can give them a help sheet.

Extension task
How many additional shapes can they make using the 7 SOMA cube pieces?
Each shape made receives 1 point.
The last 2 shapes are difficult and could be worth double points.

If students solve all of the shapes in the time allocated, there are plenty of other possible shapes they can try and build on the SOMA Cube Shapes Chart.

Teacher Notes

Preparation
(minimal on the day)
If 3D printing your own Soma cubes, be aware this is a time-consuming process and will need to be done well in advance to ensure you have enough sets for the class.

Package each SOMA cube (7 pieces) in its own zip lock bag or container.
On the day, hand out the SOMA cubes to the students at the start of the session. Ensure that the same-coloured cubes do not end up at the same tables to reduce the chance of pieces getting mixed up.

Additional Information
Schools can hire or buy 3D printed SOMA Cube sets from Adelaide University.
We can also provide the .stl file so schools can print their own sets if they have a 3D printer.

If printing your own, we recommend making each cube set (7 pieces) a different size or colour and keeping them in separate zip lock bags or containers. This allows pieces to be counted back easily at the end of the activity and reduces the chance of pieces being mixed up between sets.

Answers
See help sheets

Theory
Spatial reasoning skills are the cognitive ability to mentally represent and manipulate shapes (2D and 3D). It requires visualisation, orientation and rational awareness.

Strong spatial skills directly correlate with higher performance in STEM. These skills are applied in navigation, CAD (computer architectural design/aided design) programs, medical imaging analysis, and more.

Get Ready to Ride

S T **E** **M**
C **D** F S

Individual **Team - recommended group size: 3**
Pack up - Level 2
Teacher involvement - Level 2
Resources needed - Level 2

Required Resources:
per group:

- 2 x Paper plates, 1 with 'school' written on it
- Tape
- Blu-tac
- 1 ping pong ball
- 2 sheets A4 paper
- Ruler
- Scissors
- Pencil
- Worksheets

Set Up:

- Equipment for each group
- Stopwatch for timing the teams

Recharge With:

- Replacement tape, plates and paper, fresh set of worksheets

Task
The students need to design rollercoaster ride that transports the ping pong ball safely to the school zone. They can only use the materials supplied to make their rollercoaster. It must adhere to the school zone speed limit so the slower it travels the better.
The rollercoaster must begin 25cm from the ground and span (travel) 60 cm.
The ping pong ball must travel safely without stopping or falling off the track and then stop on the "school" paper plate supplied. The "school" plate cannot be modified in any way.

Extension
Students can brainstorm design variations for extra points, such as, a tennis ball instead of a ping pong ball, a longer or steeper track, or the ability to stop halfway down.

Teacher Notes

Preparation
Rollercoaster designs can be attached to table legs, chairs or the side of a cupboard, etc. Preset the landing plate 60cm from the attachment point. The landing plate cannot be modified in any way, and nothing can be stuck to it. The rollercoaster must be a continuous track.
As this is about safety, the slowest time wins - Slowest receives 3 additional points, 2nd slowest receives 2 additional points, and 3rd slowest receives 1 additional point.

Context/story alternatives
- Transit from the Adelaide Hills down to the city; using gravity for public transport
- An emergency slide for evacuating a plane onto an inflatable raft
- A drone delivery capture system or spacecraft landing system

Design Thinking and Computational Thinking
The lack of materials for multiple build attempts makes the design thinking loop very important. Students have to better predict what would happen and build more robust structures on their first attempt. Their design process must be attempted imaginatively rather than just practically. This also means they will be engaging in internal modelling and the simulation component of computational thinking processes.

Theory
Civil engineers design structures, including bridges, buildings and the supports, structures and foundations for rollercoasters. Once lifted in height, the rollercoaster carts transform gravitational potential energy to kinetic energy and move along the track. Friction and air resistance gradually reduce the energy of the cart, requiring the peaks to get smaller as the rollercoaster progresses.

Tangram Zoo

S T E M
C D F S

Individual **Team**
Pack up - Level 1
Teacher involvement - Level 2
Resources needed - Level 1

Required Resources:
- Scissors
- Pencils
- Worksheets

Set Up:
- The tangram sheet and scissors for students to make their own sets
- Wooden or plastic tangram sets if available

Recharge With:
- Fresh set of worksheets

Task
Students need to make animal shapes using the tangram pieces. The scenario is to update the signage at the “Tangram Zoo”, making it easier for young children or people with limited English to access information about the enclosures.
Once students have made the first animal shape they can continue by making the next animal shapes. These can be done in any order.
If students are struggling, you can provide the help sheets.

Extension
If students solve all of the tangram animal shapes, they can design their own animal tangram and then ask another student to solve it.

Teacher Notes

Additional Information
Computational Thinking and Design Thinking
The problem-solving element of this activity gives students the chance to engage in computational thinking, breaking down the silhouette of the image into the tangram pieces, and evaluate their attempts to recreate the shape as they fail and try again. They will also engage in small scale design thinking as they repeat their attempts to improve and get closer to the intended shape.

Theory
Tangrams are based on dissection geometry, where a large square is cut into seven specific pieces called “Tans”. These pieces can be arranged without overlapping to make complex 2D figures.
This activity fosters visualising geometric relationships through manipulation and rotation of the pieces; linking to mathematical concepts including perimeter, congruence, symmetry and fractions.

Play Dough Power Failure

S T E M
C D F S

Individual **Team - Recommended groups size: 2-3**
Pack up - Level 1
Teacher involvement - Level 2
Resources needed - Level 1

Required Resources:
per group:
LEDs (red, yellow and green)
Playdough
D cell battery
Pencils
Worksheets

Set Up:

- Equipment for each group

Recharge With:
Fresh set of worksheets

Task
The students will make the circuit on the worksheet and connect the playdough to test that the LEDs light up. *They may need to flip the LED around if it isn't working as LEDs are polarised, they only work one way. Once the circuit is working the students will need to find objects to test between A and B on the circuit diagram and make a list of conductors and insulators.

Extension
Rearrange the playdough and LEDs to make new circuits listed in the table in the worksheet. For extra points they can try drawing one of the circuits they made using symbols.

Teacher Notes

Additional Information

Playdough contains salt, this will cause some corrosion on the battery terminals that may need light sanding to allow the circuit to connect after prolonged use. Students need to ensure the playdough connections are in place to reduce false non conducting readings in their investigation. Metals with coatings such as anodized aluminium (oxide layer on the aluminium) or shellac resin coatings can also limit conduction and may need a bit of a scratch at the connection to point to accurately test the object.

If you have access to Clip Circuit Kits, students can build the circuits in the kit, or they can create their own. It is advisable to replace the globes supplied with E10 LED globes as the supplied globes can be easily overloaded and burn out. When building the helicopter circuit, if the blade does not lift it is spinning backwards, simply turn the motor around.

Design and Systems Thinking

Testing for materials that conduct and insulate embraces principles of experimental design thinking and systems thinking. It transforms an abstract concept (electron flow) into a tangible, observable, and systematic investigation. Students design a system using the equipment and create a circuit. They have to troubleshoot if the initial LED doesn't light up and then test objects in the gap with the material being tested as the independent variable and the LED turning on as the dependent variable. Understnading the interactions and visual feedback loop of the LED is part of the systems thinking, with a real-world context for circuit functionality with conductors and safety with insulators.

Theory

Electric circuits are composed of electrical components that form a continuous path connected to the terminals of a power source. In this simple circuit, the power source is the dry cell battery. A break anywhere in the circuit creates a “switch” and filling that gap with an object that can conduct completes the circuit and allows the electrons to flow again lighting up the LED.
Metals and graphite (the inside of a “lead” pencil) are great examples of conductors as they readily allow electrons to move from atom to atom within them.

Bag-Tag-Arama

S T E M

C D F S

Individual Team

Pack up - Level 1

Teacher involvement - Level 3

Resources needed - Level 2

Required Resources:

- Worksheet with instructions to make their bag tags.
- Computer with Internet access
- 3D printer (schools without access can arrange printing through the university)

Set Up:

- Create an educator account on Tinkercad (www.tinkercad.com)
- Using the educator account, you can create a Tinkercad class online (Adelaide University STEMpire team can create a list for you or help you set up your own.)
- Make sure computers can access the Internet site www.tinkercad.com

Recharge With:

- Fresh set of worksheets
- New Tinkercad class list

Task

The scenario relates to a sale on backpacks that resulted in all students having the same design. To easily identify the bags apart the students need to create their own unique 3D printed bag tag design. They will use Tinkercad (free online computer aided design software) to make their tag.

Extension

Utilise your skills to create a new design incorporating some of the tools including; the align tool, copy and paste to duplicate parts, etc. Extension tasks on the worksheet accrue additional points, but do not need to get printed.

Teacher Notes

Preparation
Prior to the lesson, create an educator's Tinkercad account. Go to www.tinkercad.com and follow the prompts. This will allow you to create a classroom your students can join to create their bag tags. The account will allow you to monitor student progress and make minor design adjustments as needed.
If you do not have a 3D printer and would like us to print the tags for you, contact the outreach STEMpire team and we will set up an online classroom for you. We will then provide you with student log in details and share the teacher access with you so you can see the student's progress. Tags will be delivered to your school on completion. Printing may incur a fee, which we can discuss in advance.

Additional Information
If you are unfamiliar with CAD software, we recommend creating your own bag tag prior to the lesson to familiarise yourself with the software. There are built in tutorials on the Tinkercad platform.

Context/story alternatives
- Designing tokens to swap for a meal at school as part of a 'free lunch' program
- Designing stakes to drive into the soil to identify where seeds have been planted
- Creating a bookmark with their name on it

Design Thinking
Design thinking is a process that goes through the following steps:
- Empathise - Consider how the design process will impact on others
- Define - Get a clear understanding of the criteria for the design
- Ideate - Brainstorm ideas
- Prototype - Make a model of the task
- Test - Does the design meet the criteria?
- Repeat - If it needs improving repeat the process until the design is suitable

The 'empathise' step is the most often neglected stage of the design thinking process. To engage students here, they should consider making the tag for someone else, this could include catering for a disability such as incorporating Braille to the design. They could also consider how to recycle or reduce waste when making such items.

Theory
3D printing or additive manufacturing is the process of creating three-dimensional objects by building them up layer by layer and only adding material where it is needed. This process reduces waste but also allows for rapid prototyping and custom builds. The material is deposited according to G-code, a programming language that instructs the machine to place the product required in a location using an x, y and z (height) coordinate.

Chemistry Chaos

S T E M

C D F S

Individual **Team – Recommended group size: 2**

Pack up - Level 1

Teacher involvement - Level 2

Resources needed - Level 1

Required Resources:

- Worksheets
- Chemistry model kits
- Container to hold the pieces in (can use the lid of the box)
- Pencils

Set Up:

- Make sure each group has a tray/container to reduce losing pieces or mixing of the sets.

Recharge With:

- Fresh set of worksheets

Task

The scenario is based around the school running out of hand sanitizer. The students will use 2 Carbon (black), 1 Oxygen (red), and 6 Hydrogen (white) pieces, from the model kit to make the active ingredient. They will need to join the pieces up so that all the holes on the pieces are filled with a connector and no connectors are left unjoined to another piece.

There are two ways these same pieces can all be joined together, the one that has the least symmetry is used in hand sanitizer (ethanol).

Extension

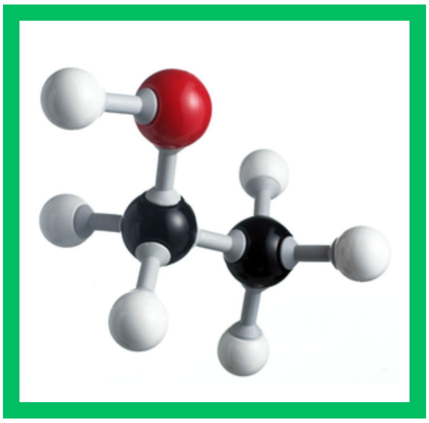
Make additional molecules pictured on the sheet.

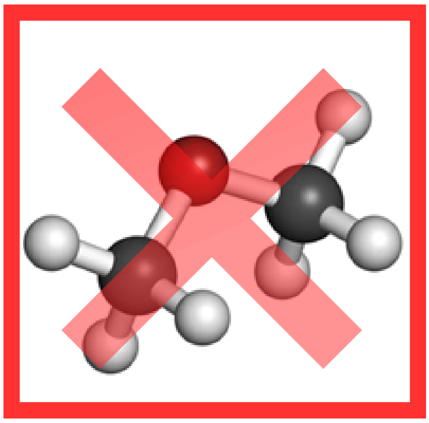
When you have made one; record the name of the molecule and describe where this substance might be found. Each molecule made receives one extra point.

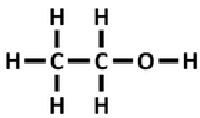
Teacher Notes

Additional Information
Schools can hire or buy 3D printed molecular model kits from Adelaide University, or we can supply the .stl files to 3D print your own.

Answers







Context/story alternatives:
Vitamin C
Students in New Zealand successfully proved the makers of Ribena were lying about the vitamin C contained in the drink, costing the company a huge fine:
https://www.theguardian.com/world/2007/mar/27/schoolsworldwide.foodanddrink
See if students can make L-ascorbic acid using the model kit and diagram on the sheet.

Photosynthesis puzzle
Glucose is a sugar made in the process of photosynthesis.
Have the students make a glucose molecule ($C_6H_{12}O_6$) How many CO_2 and O_2 models can they make using only the pieces from their glucose model?

Combustion puzzle
Burning a fuel creates carbon dioxide and water. Have the students make a simple molecule of a fuel, such as methane CH_4 adding only oxygen pieces, rearrange the pieces to make CO_2 and two H_2O molecules. This demonstrates why fire requires oxygen.

Teacher Notes

Theory
Atoms combine in set ways to make molecules. While students don't need to understand atomic theory for this activity, it is useful to still use the terms.

- Atom - The smallest fundamental unit of matter, made up of protons and neutrons in the centre, and surrounded by a cloud of electrons.
- Molecule - The smallest particle of a substance that retains its physical and chemical properties. Formed when two or more atoms chemically bond by sharing electrons. This sharing holds the atoms together and the arrangement of the atoms contributes to the physical properties of that molecule.

The model kits act as a tool to help visualise material structures. The round pieces represent atoms, with the holes representing the number of electrons they need to complete their outer shell. The grey connectors represent the bonds between the atoms. The connectors with flexible tubing are useful when double bonds are needed. By physically building molecules and rearranging the atoms, students can see how small structural differences create dramatically different materials.

For example:

- Water (H_2O is a stable molecule essential for life, but hydrogen peroxide (H_2O_2) is a reactive disinfectant/bleach and when built using the model kits the difference becomes very clear.
- Ethane (C_2H_4), a component in natural gas, can be changed to the hydrocarbon PVC (poly vinyl chloride), one of the world's most widely used plastics, by simply removing one hydrogen and replacing it with a chorine atom. This can link with the properties of solids, liquids and gases, as ethane is a gas, but PVC is a solid.

Don’t Bug Me

S T E M

C D F S

Individual Team – recommended group size: 2-3

Pack up - Level 2

Teacher involvement - Level 1 (extension task level 2)

Resources needed - Level 2 (extension task level 3)

Required Resources:

- Plastic animals (1 set for the class)
- Worksheets
- Classification charts
- Animal Scientific Names Identification Tables (3 pages per set)

Set Up:

- Spread out the plastic animals around the room for the students to find.

Recharge With:

- Fresh set of worksheets

Task

The students are going on a “field trip” (in the classroom) to identify existing species and hopefully find an unidentified species. They will select an animal and try to find it on both the classification chart and the scientific names table. These two resources will supply the common name and scientific name for their animal. If it does not appear in both of these places, a new discovery has been made. they will need to give it a scientific (2 part) name and common name, then you can draw a labelled diagram of it.

Extension

Students will have the opportunity to pin an insect to preserve and make their own specimen. If you have access to binocular microscopes, the students can use these to look at specimens. We recommend binocular microscopes with LCD display screens, these can often be connected to computers/ smart boards to highlight specific details on the specimens to the class.

Teacher Notes

Preparation

We recommend laminating copies of the classification table and scientific name tables for use with multiple classes.
The animal samples can be placed on the floor in the classroom, but beware of floor coverings that match the animals making them harder to locate at the end of the session.
For the extension activity, prepurchase large crickets (available at most pet shops/fodder stores) and freeze overnight.
On the day, remove specimens from the freezer and keep them cool until use.
To speed up the extension task, pre-pin some specimens to pieces of foam with the central pin through the abdomen.
We recommend counting out the pins to each student and getting them to check they use or return them all to reduce the chance of pins falling on the floor especially in a carpeted classroom. Long coloured “map” pins are easier to locate if they do fall on the floor.

Additional information

We do not recommend getting students to collect their own specimens in case they are bitten or stung in the process. Teachers and adults can collect their own samples by catching them safely and placing them in the freezer.
Students should only use the pins to position the sample into a lifelike pose, students should not need to place pins through the specimen. The pins can also be used to hold the wings out (on large crickets).
Note - foam can create electrostatic charge causing the antennae to move. Air conditioning can also cause movement when pinning the specimen.
Digital microscopes are an amazing addition to this task. They allow easy viewing of insects and other samples (moth wings, small bones, feathers, etc.), enabling students to get a very close and detailed look at the specimens. Microscopes that have a screen for easy viewing work best for groups. These can also be plugged in to a computer and displayed on a smart board for an entire class to see.

Context/story alternatives

Island discovery: A new island has been found. Some creatures match animals we have seen on the mainland, but some are unique to this island. Can you work out which?
Ranger training: You need to be able to identify poisonous and rare creatures before you take a tour group into the bush. Practice your identification skills and be bush ready.

Teacher Notes

Computational Thinking

This is a classification exercise, using a key, i.e. an algorithm, to identify the animals. Identifying creatures outside the key helps students understand the design of the algorithm and consider how it was designed.

To extend students, ask them to make their own classification table to sort their own set of objects.

Theory

Animals come in different colours, shapes and sizes which enable them to adapt to their environment. Scientists that study living things (biologists) go into the field in search of new species. They trap specimens and examine them closely comparing all their features. This allows them to work out if the specimen has already been discovered. If anything is new or different, they may have found a new species.

If it is determined that the creature is a new species (after lots of research), the biologist that made the discovery often gets to name it. The scientific name has two parts, just like our first name and surname. The first part identifies the genus, and the second part identifies the species within that group. Scientific names are used to ensure there is no confusion between species with similar features.

Little Bit of Trouble

S T E M

C D F S

Individual Team - Recommended group size: 2

Pack Up - Level 1
Teacher involvement - Level 2
Resources needed - Level 2

Required Resources:

- Worksheets
- Computer with Internet access to utilise MakeCode online.
- https://makecode.microbit.org/

Set Up:

- Access to MakeCode online for virtual Micro:bits or add Micro:bit hardware if available.
- Micro:bits (if using the hardware)

Recharge With:

- Fresh set of worksheets

Task

Students will utilise the coding platform to create a device that has a visual tick or cross when the buttons are pressed. The scenario is that the students need to vote if the class will be involved in a National Science Week activity.
Go to **makecode.microbit.org/** and select **'Create New Project'**

Extension

Make modifications to the code to explore making pictures, sound and interactivity with the Micro:bit device.

Teacher Notes

Additional Information
We recommend using the actual hardware, not just the online platform, for this activity.
Adelaide University has class sets of micro:bits available for sale or hire.
Contact the Outreach STEMpire team for more information.
It is not necessary to create or log in to an account, unless there are plans to revisit their codes at a later date.

Context/story alternatives:
The school is making a digital display for Open Day. Design two simple logos, one for STEM and one for the school, that can be switched between.
Make a display that can show whether you are happy or sad. Extend by adding more feelings or incorporate sounds/tunes to match the feeling.
The voting system can also be repurposed for anything: civics issues, whether to dunk the science teacher in water at the school fair; get creative!
If you are interested in some of our coding courses, contact STEMpire@adelaide.edu.au for more information.

Design Thinking and Computational Thinking
Micro.bit programming is a great starting point for further activities. This activity can act as a tutorial of sorts that gets students quickly familiar with the tools but can then be easily extended with other challenges. The looser the requirements, the greater the opportunity for complex thinking during the exercise.
As a first step in a short time frame, this activity is good but extending it is what will allow the students to really push further into both computational and design thinking. Programming tasks like this are a great way to challenge learners to do both.

Theory
A micro:bit is a small programmable board with LED lights, 2 programmable buttons and a number of sensors that can be used when teaching algorithms, logical thinking and basic electronics. They use MakeCode blocks, an icon based programming language for easy visual drag-and-drop coding, but they can also be utilised with text-based coding using JavaScript and a simplified version of Python coding called MicroPython. The students create step-by-step commands that can detect inputs such as the buttons and any sensors, process those signals, and control outputs such as LED displays or sounds.
There are many resources online to help with coding with micro:bits including:
www.microbit.org - contains beginners guides, lesson plans, projects and tutorials.
www.microsoft.com/en-au/makecode/resources - Step-by-step instructions to create projects.

Mystery Message

S T E M
C D F S

Individual Team
Pack up - Level 1
Teacher involvement - Level 2
Resources needed - Level 2

Required Resources:
- Sound files available in the teacher resources.
- This activity can be run together as a class but if students have access to their own laptops and headphones this option is recommended so students can work at their own pace.
- Access to the 'Mystery Message' files.
- Worksheets

Set Up:
- A laptop and headphones for each student or a smartboard/projector.

Recharge With:
- Fresh set of worksheets

Task
the scenario involves Mission Control losing standard communication systems to reach the astronauts on the International Space Station. Together they will utilise Morse Code to communicate and the students need to translate it to help rescue them.
- Listen to the message
- Write down the dots, dashes and breaks
- Use the tables and charts on the worksheet to decode the message

Extension
Students can write their own short Morse Code messages and share with their friends. They can also create their own code system using the coloured discs to represent all the letters and numbers to send messages.
If you wish to extend this activity even further, consider semaphore. Students can consider flags waved from a boat or the bush. Create your own semaphore messages at http://www.semaphorify.info/

Teacher Notes

Additional Information
To create your own Morse Code Message MP3 files, you can use this website:
https://morsecode.world/international/trainer/generator.html
Be sure to adjust the timing to make it slow enough for everyone to be able to follow it. The setting speed of 5 or below is recommended, especially for the gaps between characters.

Context/story alternatives

- Flashing lights from a boat; SOS: “Out of fuel”
- Static on a walkie talkie in the bush; SOS: “Lost by fire”
- Friend code between neighbours: “Come over now”

Computational Thinking
Decoding a message is primarily pattern recognition, matching letters to the series of dots and dashes. In the extension task the students use computational thinking to make their own patterns.
The process:

- Decomposition - Breaking down the task into parts.
- Abstraction - Removing the unimportant bits.
- Pattern Recognition - Focussing on the important bits.
- Algorithms - Making the pattern.
- Modelling and Simulation - Trialling the pattern and rules.
- Evaluation - Report on the success or repeat the process to make it better.

Answers
The supplied sound files will reveal the following messages:
Sound file 1 - Get a rocket
If multiple classes are involved with this challenge, and have been supplied the answer by other students you can use the alternative message:
Sound file 2 - Map a rescue

Teacher Notes

Theory
Morse code can be sent by almost anything you can turn on and off, as long as someone can receive it. You don’t have to be listening: a person could see a torch being turned on and off. Morse code is not a binary code (two letters) of just dots and dashes, but a ternary (three letter) code of dot, dash, and break. It can be translated into binary of 01, 11, and 00 respectively, and humans read it by translating it into the letters and numbers it encodes.

Listening to a message at the default speed allows us to appreciate how efficient this form of communication was.

Optional Additional Task

Who Ate the Teacher's Lunch?

S T E M

C D F S

Individual **Team – recommended group size: 2-3**

Pack up - Level 3

Teacher involvement - Level 3

Resources needed - Level 3

Required resources:
1 or 2 boxes with number combination padlocks, with a picture of a mouse inside.

Per group:
- Worksheet
- 2 tsp Bicarb soda
- 10ml Water
- ¼ tsp Turmeric powder
- 5 ml Hand sanitiser
- Cotton tips for mixing and for writing
- 2 Small plastic medicine cups
- Code cards (premade)
- Puppy pad (optional)

Extension activity resources:
Selection of kitchen supplies
- cabbage indicator (or other indicator if available)
- milk
- vinegar
- lemon juice
- dishwashing liquid
- salt
- spices

Set up:
On the day distribute the per group items to the students.
Students must unlock the security footage before they can attempt the extension task and get access to the household items for testing.

Recharge with:
- Fresh set of worksheets
- Top up consumables

Task
The scenario involves solving the mystery of the stolen lunches in the staff room, especially the missing cheese sandwiches. The students need to make invisible ink to secretly record their suspects and then use turmeric and hand sanitiser to reveal the code that will unlock the security footage. When they reveal the three numbers, they will need to record all the possible combinations (six of them) on their worksheet and then systematically try them on the padlock to release the footage.
Extension Activity
Investigate other household solutions to find out which ones react with the bicarb soda paste. The solutions that are in a group called acids will reveal the ink, bases won't. Students can also use acid/base indicator to group their kitchen supplies.

Teacher Notes

Preparation
Prepare code cards before the session using a paste made with bicarb soda and water. The card will have a jumbled combination of the three numbers that unlock the padlock written using the paste. (e.g. if the padlock code is 314 you could have 431 on the card). Make sure you put a pen mark on the side as the paste, this allows students to know which side of the paper to test.

For the extension task if you have not got access to an indicator such as pH strips or universal indicator you can make your own by boiling red cabbage and collecting the coloured liquid.
Students will also need some pre-made test cards that simply contain stripes of baking soda paste to test their kitchen substances on. (template available in the resources).

Additional Information
Allergies and skin sensitivities may warrant non-latex gloves or replacing some of the testing liquids.
We recommend two locked boxes with a 3-digit number padlock to avoid a long queue waiting to try their combinations.

Theory
There are many signs that show us that a chemical reaction has occurred.

- New substances form - this can be a solid forming at the bottom of a liquid (called a precipitate), or bubbles of gas forming in a solution.
- Temperature changes - releasing heat (getting hotter/ exothermic) or absrobing heat (getting colder/ endothermic) can mean a reactions has occurred.
- Light or sound produced - this can be as dramatic as a firework, or a bioluminescent reaction when a glow worm gives off light.
- Colour change - if a substance changes colour, this can indicate a chemical reaction has taken place.

Acids and bases/alkalis are groups of chemicals with specific properties that can react with each other. In this activity the invisible ink acts as a base and changes the chemical structure of the turmeric, causing a visible colour change. This is due to the new structure having different light absorbing properties. Many household acidic substances, such as lemon juice or vinegar, will also make the invisible message change colour.