Properties of Matter

Overview

During this lesson, students will gain understanding of how an object is described by its properties as well as how properties can change. Students will integrate and exhibit learning by creating a SAM system to capture physical changes to an ice cube.

Key Information

Level 3: (Ages 9-11) US Grades 4-5 Time: 45/90 minutes

Lesson consists of...	
Warm-Up	5 mins
Mini-lesson	10 mins
Worked Example	7 mins
Challenge 1	7 mins
Challenge 1 - Debug	5 mins
Challenge 2	7 mins
Tidy Up / Exit Ticket	4 mins

Learning Objectives

As a result of this lesson, students will be able to

- ➔ Identify and describe different properties of an object.
- ➔ Identify the difference between materials in particular; solid, liquid and gas and if they are reversible or irreversible.
- ➔ Create a SAM system to capture the change in a material's properties.
- ➔ Modify the system to be more efficient.

Lesson Topics

Physical Science
- ➔ Objects have material properties
- ➔ Material properties can transform

Scientific Thinking
- ➔ Asking relevant questions and using different types of scientific enquiries to answer them setting up simple practical enquiries

Art and Design
- ➔ Explore and use mechanisms, devices and materials for imaginative activity that leads to original and creative outcomes

Design and Technology
- ➔ Generate, develop, model and communicate ideas through talking, drawing and mock-ups

Computing
- ➔ Inputs, outputs, abstraction, debugging

English Language Arts
- ➔ Participate in collaborative conversations.
- ➔ Use information gained from illustrations and text to demonstrate understanding.
- ➔ Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 4-5 topic or subject area.

Materials required

- ➔ SAM Labs Kit
- ➔ Bag
- ➔ Chocolate
- ➔ Student Workbook
- ➔ Marshmallows
- ➔ Saucepan
- ➔ Stick
- ➔ Spoon
- ➔ Plate
- ➔ Paper
- ➔ Hob/Refrigerator
- ➔ Ice cubes

Properties of Matter

Warm Up — 5 minutes

Can we identify an what an object is by touching it?

Objective: Identify and describe physical properties of an object.

Procedures: *"Today we are going to learn that some objects' material state can change. Some of those changes are reversible, some are irreversible."*

- Students are instructed to close their eyes, reach inside a bag and pull out an object e.g. Marshmallows, a stick, paper.
- Students then describe the object by how it feels; *is it smooth, rough, solid, soft, rigid, porous?*
- Students guess what the object is; the class verifies their guess or not.
- The aim is for students to understand that objects are made up of physical characteristics.
- Write the opposite words (antonyms) to the words given like hot and cold in the student workbook.

Link forward: Link to looking at 3 material states: solid, liquid and gas.

Mini-lesson — 10 minutes

What material states do we use to identify an object?

Objective: Recognize the difference between solid, liquid and gas as material states. Determine if these states are reversible or irreversible.

Procedure:

- Introduce that all object's matter is made up of tiny particles called 'atoms'.
- An object can be described by the 'matter' within it; hard or soft, hot or cold.
- There are 5 possible states of matter, today we will explore three main states: solid, liquid and gas.
- Students should identify objects which can move between states, considering what causes objects to change their material state (e.g. temperature)
- Determine if these material states are reversible or irreversible. (8 minutes)

At the end of the mini-lesson, students match the keywords to the correct definition. (2 minutes)

Keywords

- Solid
- Liquid
- Gas
- Matter
- State of Matter

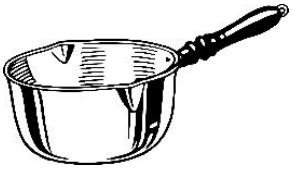
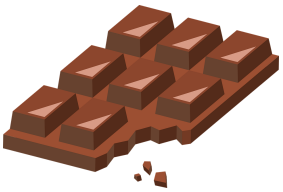
Let's Discuss: *What are three possible states of matter? In your workbooks or with a partner, record, discuss, or share one example of an object that can change its state of matter. Define whether the change is reversible or irreversible.*

Link forward: Link to programming a SAM system that can record changes in an object's state.

Worked Example

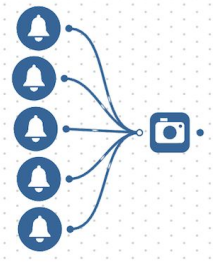
7 minutes

Look at the chocolate and observe the change to its state of matter

Instructions	Workspace	Notes for Teachers
Step 1. Gather the equipment • Saucepan • Chocolate		*This experiment can be conducted as a whole class. It's less about everyone getting to melt chocolate and more about students observing how material properties change.*
Step 2. Observe the chocolate - *what are its material properties*?		*Look at the chocolate before and discuss the properties – ask students to describe it: hard, cold, thick, thin.*
Step 3. Place the chocolate in the saucepan.		*This is an opportunity to predict the outcome and discuss what students think will happen to the properties.*
Step 4. Heat the chocolate.		*Watch the chocolate melt and discuss what happened. How would you now describe the chocolate? What caused the material properties of the chocolate to change?*
Step 5. Predict what will happen if cold temperatures are applied to the chocolate liquid.		*What do they think will happen if the chocolate is put in the fridge? How will the temperature affect the substance?*

Challenge 1 — 7 minutes

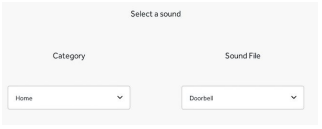
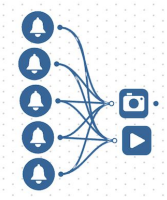
Program a SAM system to capture changes

Instructions	Workspace	Notes for Teachers
Step 1. Drag the blocks to the workspace: • Camera block • Time Trigger block x 5		*The color of the blocks are different and that is because they are not yet linked together in a system.*
Step 2. Set the Time Trigger blocks.		*Set the timer to start a few minutes ahead when you are ready to start. Each Time Trigger block needs to be changed to be a minute apart (depending on temperature of room), so you can observe the change.*
Step 3. Connect all Time Trigger blocks to the Camera block.		*All Time Trigger blocks are the inputs and need to be connected to the camera block as the output.*
Step 4. Put an ice cube on a plate.		*Placing the ice cube on a plate means the change can be seen easily and the camera can see too.* *The ice cube can be weighed and compared with the weight of the water after melting.*
Step 5. Point the camera at the ice cube.		*Ensure the device is set so the camera is pointed at the area of the plate where the ice cube is. This can be tested by accessing the camera and looking at the position of the plate on the screen. Opportunity to discuss that this demonstrates matter is made of particles that are too small to be seen.*

Checks for understanding: *What is applied to the ice cube to make it melt? What will happen to the ice cube if it is put into the fridge as a liquid?*

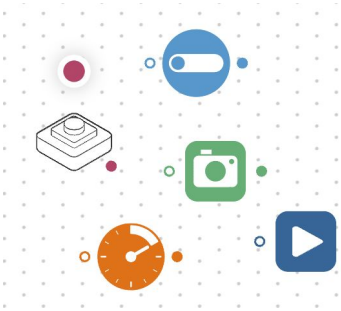
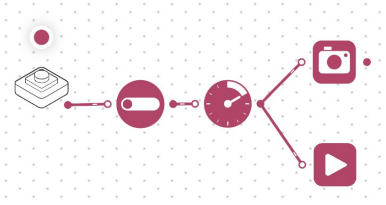
Challenge 1 - Debug it — 5 minutes

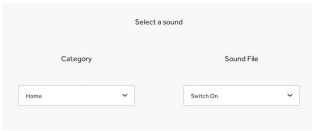
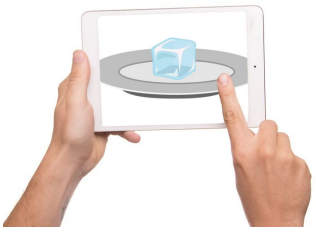
How can we tell if the camera is taking a picture?

Instructions	Workspace	Notes for Teachers
Step 1. Drag a Sound Player block onto the workspace.		*It would be useful to know when the camera is taking a picture to help determine if the timing is correct and amend if necessary.*
Step 2. Set the sound.		*Edit the settings of the Sound Player block so that you have the 'switch on' sound, this will tell you when the camera takes a picture with a click.*
Step 3. Connect all Time Trigger blocks to the Sound Player block.		*Ensuring all outputs of the Time Trigger blocks are connected to the Sound Player block, means the sound will go off every time the camera takes a photo.*

Challenge 2 — 7 minutes

Modify the system to be an efficient one.

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • Button/Virtual Button block Drag the following blocks to the workspace: • Toggle block • Interval block • Camera block • Sound block		*We are going to replace the Time Trigger blocks with a more efficient system that will take pictures every minute until the system is switched off.* *If you have a Button block, this can be used in place of the Key Press.*
Step 2. Connect the blocks in this order; Button block to Toggle block to Interval block and into both Camera and Sound Player blocks.		*The output of the Interval needs to be connected to both the Camera and the Sound Player block.*
Step 3. Set the Interval block to 1 minute.		*Edit the settings of the Interval block to 1 minute, discuss whether this is suitable or requires adjustment depending on the temperature of room/location.*

Step 4. Set the Sound Player block to Category - Home and SoundFile - Switch On.		*Edit the settings of the sound block to be Home - Switch On. This will allow the click to happen every time the camera takes a picture.*
Step 5. Place an ice cube on a plate. Note the changes as they occur.		*Add another ice cube to the plate and set up the device to see this and activate the system. Students may also wish to utilize a timer to track the amount of time the change occurs and ends.*

Extension Ideas:

- **Science**
  - Why does the temperature of the room affect the speed of the ice cube melting?
  - Position pupils in different locations and observe the difference of change in properties
- **Maths**
  - Set up a timer and compare outcomes in the classroom and other locations
- **English/Science**
  - Use the images to create a report describing how the properties changed and why
- Geography
  - Look at global warming and how this has affected the ice in Antarctica

Checks for understanding: *What is the purpose of the Toggle block? Why is this system more efficient?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

Overview

During this lesson, students will learn how Morse Code enabled efficient, fast communication before voice transmission was possible. Students will integrate and exhibit learning by programming a functioning Morse Code transmission system to send messages.

Key Information

Level 3: (Ages 9-11) US Grades 4 or 5 Time: 45/90 minutes

Lesson consists of...	
Warm-Up	5 mins
Mini-lesson	10 mins
Worked Example	7 mins
Challenge 1	7 mins
Challenge 1 - Debug	5 mins
Challenge 2	7 mins
Tidy Up / Exit Ticket	4 mins

Learning Objectives

As a result of this lesson, students will be able to

- ➔ Identify developments in communication and recognize innovation
- ➔ Demonstrate the use of Morse Code to send a message.
- ➔ Program a system to transmit a message utilizing the Morse Code block.
- ➔ Modify the system to transmit the Morse Code automatically using a button, sound and light.

Lesson Topics

History
- ➔ The revolution in communication brought about by Morse Code

Computing
- ➔ Inputs, outputs, decomposition, debugging

Design and Technology
- ➔ Investigate and analyse how well products have been designed
- ➔ Explore inventors, designers, engineers, chefs and manufacturers who have developed ground-breaking products

Engineering Design
- ➔ Designs can be conveyed through models
- ➔ A situation that people want to change can be approached through technology

English Language Arts
- ➔ Participate in collaborative conversations.
- ➔ Use information gained from illustrations and text to demonstrate understanding.
- ➔ Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 4-5 topic or subject area.

Materials required

- ➔ SAM Labs Kit
- ➔ Student Workbook

Warm Up — 5 minutes

How has communication developed?

Objective: Identify developments in communication of messages

Procedures: "*Today we are going to learn about a system for communication called Morse Code*"

- Discuss how the development of technology has helped communication throughout the world, especially during wartime.
- Identify earliest to most recent forms of communication (via student workbook).

Sample photo ideas: Stamp, telephone pylon, mobile phone, Morse code machine, old style telephone, landline telephone

Link forward: Link to learning more about the history of Morse Code

Mini-lesson — 10 minutes

How was Morse Code innovative?

Objective: Recognize that Morse Code innovated communication.

Procedures:

- *How were messages sent without technology as we know it?*
- In the 19th Century, wires were used to transmit buzzes.
- Samuel Morse developed a system in 1837 to represent letters with a combination of buzzes.
- This system came to be known as Morse Code.
- Morse Code is a series of buzzes where letters are defined by the length of the buzz.
- Unlike other methods for coded transmission (e.g. Enigma), this form of transmission was designed for efficiency instead of cryptography.

Key Words

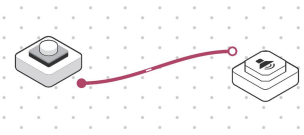
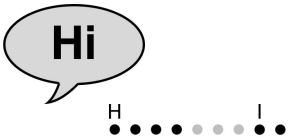
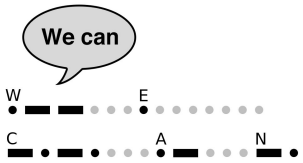
- Morse
- Dot
- Dash
- Telegraph
- Communication

Let's Discuss: *How did Morse represent letters with buzzes? In your workbooks or with a partner, record, discuss, or share one reason Morse Code was innovative.*

Link forward: Link to students creating a message to transmit using Morse Code.

Worked Example — 7 minutes

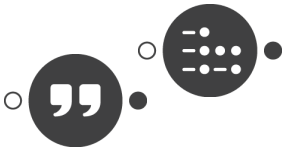
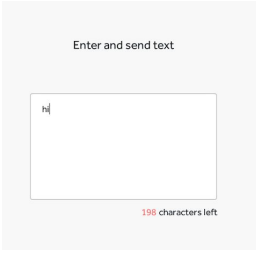
Program a SAM system to send Morse Code

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • 1 Buzzer/Virtual Buzzer block • 1 Button/Virtual block		*You can use a Morse table: link https://upload.wikimedia.org/wikipedia/commons/1/1f/International_Morse_Code.PNG* *...or this Morse Translator: link https://morsecode.scphillips.com/translator.html*
Step 2. Using Morse, send the message 'Hi'.		*All send the message 'Hi', ensuring students understand how to create and decode a message correctly.*
Step 3. Now send a short phrase of 2 - 3 words like 'We can'.		*Selecting a simple couple of words will allow a message to be sent and decoded.*

Checks for understanding: *What is Morse Code for "Hi"?? What is Morse Code for the letter "A"?*

Challenge 1 — 7 minutes

Program a system to transmit a message utilizing the Morse Code block.

Instructions	Workspace	Notes for Teachers
Step 1. Drag the following blocks on the workspace: • Text block • Morse Code block Connect them in this order: button to Text block, Text to Morse Code block, Morse to Buzzer block.		*The Button block will be the input to activate the system and the Buzzer block will be the output.*
Step 2. Access the settings of the Text block and enter the word 'HI'		*Use the same as words as the worked example at this time to show the difference clearly from completing themselves compared to using the Morse Code block*

Step 3. Test your system		*Press the Key Press block and listen to the Morse Code message*

Checks for understanding: *What is the purpose of the Text block? What is the purpose of the Morse Code block?*

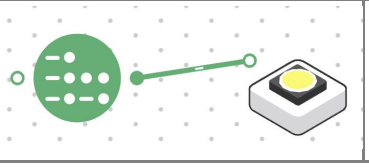
Challenge 1 - Debug it — 5 minutes

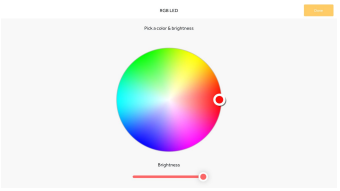
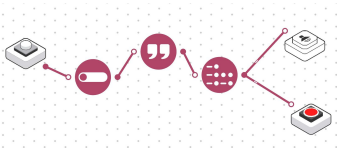
The message does not fully play when the Button is pressed

Instructions	Workspace	Notes for Teachers
Step 1. Add a Toggle block to the workspace.		*The Toggle block acts a switch with only two options ON and OFF*
Step 2. Connect the Toggle block between the Button block and the Text block.		*When the Button block is pressed it will turn on the system and play the full message.*
Step 3. Test your system.		*Press the Key Press block and test the message is sent through.* *Try adding SOS to the Text block and see what the message sounds like now*

Challenge 2 — 7 minutes

Modify the system to transmit the Morse Code automatically using a button, sound and light

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair • RGB LED Drag it onto the workspace.		*The RGB LED is going to supplement the Buzzer block to help make it easier to activate if it was on a ship*
Step 2. Add the RGB LED to the output of the Morse Code block.		*The RGB LED will act as another form of output to the system to allow the Morse Code message to be transmitted by light and sound.*

Step 3. Change the color of the RGB LED.		*In this instance, having the message SOS is an urgent message and the color can be used to help convey the message. By accessing the settings of the RGB LED you can edit the color and here we have used red to convey urgency.*
Step 4. Test your system and code another message.		*Test the system to ensure the message is conveyed through light and sound. Encourage students to develop their own messages.*

Extension Activities:

- **History**
  - Early settlers in the US
  - Inventors and inventions
- **Science**:
  - Other ways Information transmitted over long distances
- **English Language Arts**:
  - Write an informative/explanatory text to examine the topic of communication since the invention of the telegraph
  - Write an opinion piece explaining how Morse's artistic background combined with this interest in science helped him to become such a successful inventor and agent of change
- **Art and Design**:
  - Make a real Morse Code key: https://int.samlabs.com/blogs/projects/morse-code

Checks for understanding: *Which block is the input to the system? Which block is the output to the system?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

Overview

During this lesson, students will gain understanding of how stringed instruments are designed to produce different kinds of music. Students will integrate and exhibit learning by programming and playing a SAM guitar.

Key Information

Level 3: (Ages 9-11) US Grades 4 or 5 Time: 45/90 minutes

Lesson consists of...		Learning Objectives
Warm-Up	5 mins	**As a result of this lesson, students will be able to**
Mini-lesson	10 mins	➔ Compare and contrast how stringed instruments produce music
Worked Example	7 mins	➔ Discuss how stringed instruments are designed to produce different kinds of music/pitches
Challenge 1	7 mins	➔ Program a SAM guitar to simulate a stringed instrument
Challenge 1 - Debug	5 mins	➔ Modify the system to generate sound and light
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Music
- ➔ Use technology to make music
- ➔ Understand pitch

Computing
- ➔ Inputs, outputs and modifiers

Physical Science
- ➔ Waves, amplitude, frequency and pitch

English Language Arts
- ➔ Participate in collaborative conversations.
- ➔ Use information gained from illustrations and text to demonstrate understanding.
- ➔ Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 4-5 topic or subject area.

Materials required

- ➔ SAM Labs Kit
- ➔ Student Workbook
- ➔ Rubber band
- ➔ Markers
- ➔ Blu tack
- ➔ Small box
- ➔ Cardboard / cardstock

Warm Up — 5 minutes

What do these instruments have in common?

Objective: Compare and contrast how stringed instruments play music

Procedures: "*Today we are going to learn about stringed instruments and how they create music*"

- Look at images of different stringed instruments
- Compare and contrast how 2 stringed instruments produce music, e.g. fingers for a guitar, bow for violin or cello and both for double bass.

Link forward: Link to exploring how string instruments produce music

Mini-lesson — 10 minutes

How are stringed instruments designed to produce music?

Objective: Discuss how stringed instruments are designed to produce different kinds of music

Procedures:

- Discuss that the sound produced by a stringed instrument is made by plucking or strumming the strings with the fingers or with a bow.
- If the strings are made shorter on the fretboard then the sound is higher, if the strings are longer, than the sound is lower.
- The difference in design can be demonstrated by making a quick guitar using a cardboard box and a rubber band. If we make the string shorter with a piece of card under the string the sound or pitch will get higher as the strings get shorter the string vibrates at a higher frequency.

Key Words

- Pitch
- Strings
- Frequency
- Plucking

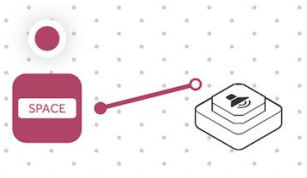
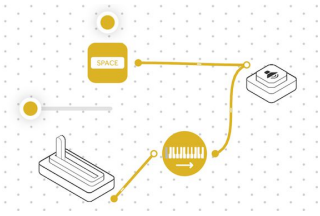
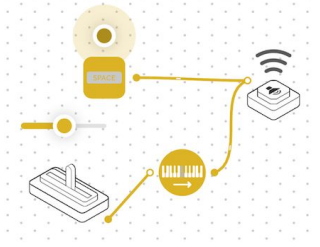
Let's Discuss: *Will the sound be lower or higher with a longer string? In your workbooks or with a partner, record, discuss, or share one example of how a stringed instrument is designed to produce a certain kind of music.*

Link forward: Link to designing a system that simulates a stringed instrument, in this case a guitar.

Worked Example

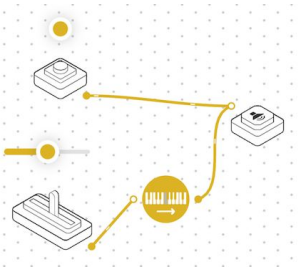
7 minutes

Make a system to play a sound and to modify its pitch or frequency

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • Buzzer/Virtual Buzzer block. • Slider/Virtual Slider block Drag a Key Press block onto to the workspace and connect it to the Buzzer.		*The Key Press is the input and the Buzzer sound is the output. It is like a one-string guitar being played with only the strumming or plucking hand, it only makes one note.*
Step 2. Drag a Note block onto the workspace. Connect the Slider to the Note block and the Note to the Buzzer block.		*The Slider block will modify the note in the Note block*
Step 3. Test your system.		*As the slider is moved to higher values the Buzzer will play a higher note and vice-versa*

Challenge 1 — 7 minutes

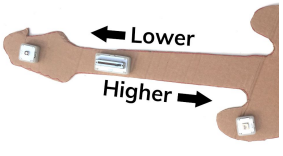
Create a system and guitar to simulate a stringed instrument

Instructions	Workspace	Notes for Teachers
Step 1. Trace and cut out a guitar shape from cardboard or cardstock.		*This can be a separate Arts lesson if you prefer, with students hunting for guitar shapes online, downloading them and cutting them from card which they then decorate*
Step 2. Turn on and pair: • Button/Virtual Button block Replace the Key Press with the Button.		*The button can be mounted onto the guitar and 'play' it in a more realistic fashion. If your students do not have a button they can use a Light Sensor block and edit the settings to a button.*
Step 3. Consider where to place the: • Button • Slider • Buzzer Blocks should be placed to emulate a real guitar.		*The Button simulates plucking the string so is best placed in the centre of the body of the guitar* *The slider modifies the pitch of the string and therefore should go on the neck of the guitar* *The buzzer should also go on the body of the guitar (as that is where the sound comes from in a guitar)*

Checks for understanding: *How does the Slider emulate how a guitar is played? How does the Key Press emulate how a guitar is played?*

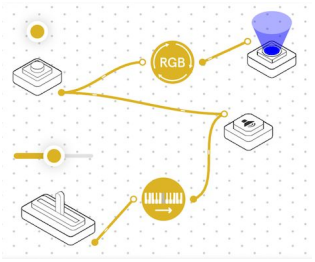
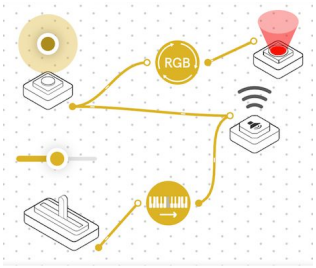
Challenge 1 - Debug it — 5 minutes

Is everything oriented the correct way? Which way should the Slider slide?

Instructions	Workspace	Notes for Teachers
Step 1. Ensure the Slider block is oriented the correct way.		*The position of the Slider block is important. As the slider moves nearer to you, the sound should get higher.*

Challenge 2 — 7 minutes

Modify the system to generate sound and light

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • RGB LED block Add a Cycle Color block to the workspace. Connect the Cycle Colors block to the Button and RGB LED.		*The RGB LED needs to connect the Button to the RGB LED and will allow colour to be added to the music.*
Step 2. Secure the RGB LED on the neck of the guitar.		*Another position can be chosen but this is quite visible. You can use blu tack to secure it.*
Step 3. Test your system.		*The RGB LED will change colour each time the button is pressed and cycle through the 3 colours Red, Green and Blue*

Extension Ideas:
- **Music**
  - Do you know any famous guitarists?
  - Can you play a melody with your guitar?
- **Physical Science**
  - Explore frequency and pitch using:
    - Rubber bands
    - Glasses with different amounts of water
    - Longer and shorter bottles
  - Make a thumb piano (kalimba) using straightened metal bobby pins fastened to a piece of wood: https://www.youtube.com/watch?v=w8tGUMre61g

Checks for understanding: *What does RGB stand for? What are the outputs now for the system?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

Lesson 3.4

Earthquake Simulator

Overview

During this lesson, students will gain understanding of what an earthquake is and how they are caused. Students explore how buildings are constructed to be earthquake-proof. Students will integrate and exhibit learning by programming a SAM Earthquake Simulator to test the fidelity of their straw structures.

Key Information

Level 3: (Ages 9-11) US Grades 4 and 5 Time: 45/90 minutes

Lesson consists of...		Learning Objectives
Warm-Up	5 mins	**As a result of this lesson, students will be able to**
Mini-lesson	10 mins	➔ Compare/contrast how different materials and objects can shake when they come into contact with a force like an earthquake ➔ Describe what an earthquake is how to design earthquake-proof structures ➔ Create a system to simulate the effects of an earthquake ➔ Design a structure to represent a strong building and program a SAM Earthquake Simulator to test the strength of the structure
Worked Example	7 mins	
Challenge 1	7 mins	
Challenge 1 - Debug	5 mins	
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Earth Science
- ➔ Earthquakes and tectonic plates
- ➔ Reducing the impact of natural hazards

Scientific Thinking
- ➔ Asking relevant questions and using different types of scientific enquiries to answer them

Engineering
- ➔ Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved

Computing
- ➔ Inputs, outputs, abstraction, debugging

English Language Arts
- ➔ Participate in collaborative conversations.
- ➔ Use information gained from illustrations and text to demonstrate understanding.
- ➔ Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 4-5 topic or subject area
- ➔

Design and Technology
- ➔ Generate, develop, model and communicate ideas through talking, drawing and mock-ups

Materials required

- ➔ SAM Labs Kit
- ➔ Pre-made Jello
- ➔ Student Workbook
- ➔ Coffee / sugar
- ➔ Blu-Tack
- ➔ Straws
- ➔ Cardboard
- ➔ Lego

Warm Up — 5 minutes

If an earthquake occurs, will these structures shake?

Objective: Compare and contrast if different materials shake when they come into contact with a force like an earthquake

Procedures: "*Today we are going to learn about earthquakes, how they occur and how to build structures to withstand a tremor*"

- Look at images of different structures and determine if they will shake
- Discuss the relationship between how objects, their materials, are constructed and whether they will wobble more or less when shaken

Sample photo ideas: Jello, eiffel tower, jellyfish, golden gate bridge, tower

Link forward: Link to exploring how objects move when an earthquake occurs

Mini-lesson — 10 minutes

What is an earthquake and how can we make a sound structure?

Objective: Describe what an earthquake is and how to design earthquake-proof structures

Procedures:

- Explain that the Earth's surface is covered with a layer called ‘crust’. The crust is split into various pieces called ‘tectonic plates’.
- When the tectonic plates move, they can collide. This causes an earthquake. Discuss if this is a change that is reversible.
- Look at how an earthquake is measured on the Richter Scale. *How is this data/information used when constructing new buildings?*
- Explore how base isolation has been developed to construct buildings to withstand the effects of an earthquake. Clip (https://www.youtube.com/watch?v=ll1M8o0BHPc&feature=youtu.be) (8 minutes)

At the end of the mini-lesson, students match the keywords to the correct definition. (2 minutes)

Key Words

- Tectonic Plates
- Structure
- Earthquake
- Base Isolation
- Crust
- Richter (Scale)

Let’s Discuss: *What is base isolation? In your workbook or with a partner, record, discuss, or share how an earthquake’s strength is measured and recorded.*

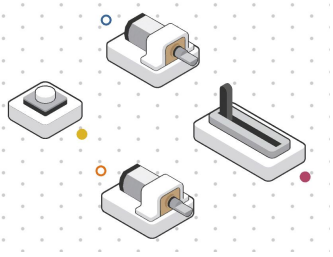
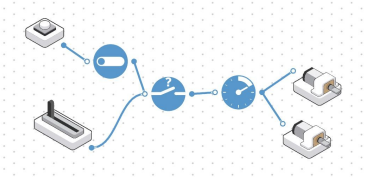
Link forward: Link to designing and making a structure to withstand a simulation earthquake.

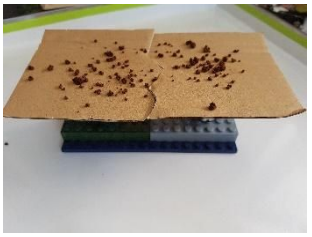
Earthquake Simulator

Worked Example

7 minutes

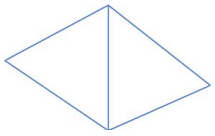
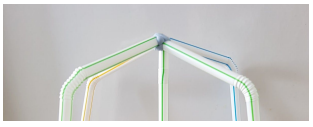
Create a system to observe the effects of an earthquake

Instructions	Workspace	Notes for Teachers
Step 1. Use a sheet of cardboard and cut a zig zag line down the middle.		*The idea is to create two tectonic plates out of cardboard, other materials could be used but needs to be sturdy enough to stand alone and not too heavy that the motors can't support the weight.*
Step 2. Attach the wheels to your DC Motor blocks and secure to a Lego base. Fix the cardboard to the top of the wheels.		*Lego and blu-tack have been used to hold the motor blocks in place but any other option could be used. The main aim is for the motors to stay stationary with just the wheels moving.*
Step 3. Turn on and pair: • 2 x Motor Blocks • 1 x Slider/Virtual Slider Block • 1 Button/Virtual Button block Add them to the workspace.		*Check the color change on the blocks to ensure they are paired with the system and if you do not have the Slider block you can use the virtual alternative on the workspace. If you don't have a Button, you can use a Key Press.*
Step 4. Drag the following blocks onto the workspace: • 1 x Toggle block • 1 x Switch block • 1 x Interval block		*The colors are all different at this point and that is because they are not connected in a system.*
Step 5. Connect the blocks together in this order; • Button block to Toggle block to Switch block. • Slider block to Switch block • Switch block to Interval block to both DC Motor blocks		*At this time, note the switch has a question mark on it, this is because it has not yet been defined.*
Step 6. Open the Switch block settings and choose 'Slider' from the drop down menu.		*The Switch block can be set to any of the inputs and in this case we want it to be the Slider block. If the Slider block is pressed, the Switch will close and complete the system allowing the Motors to start. If the*

		Switch is not closed, the system is not complete.
Step 7: Place a substance on top of your cardboard 'tectonic plates'.		*Coffee has been used in this example here so it can be seen clearly on the cardboard. Any substance that allows it to be seen when it moves is fine like; sugar, soil, glitter etc.* *This substance may scatter so ensure this task is done in an enclosed area, such as on a tray.*
Step 8: Test your system.		*Make sure the Slider block is on 0 before you press the Button block to activate the system. The DC Motors can move quickly so the speed will need to be increased slowly on the Slider block. The Tectonic Plates will collide and as in an earthquake the effects can be quick and devastating.*

Challenge 1 — 7 minutes

Design a structure to represent a strong building

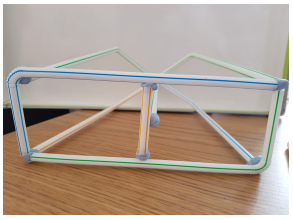
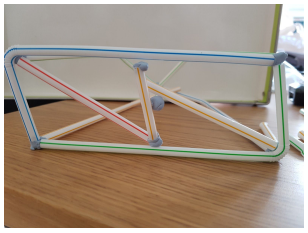
Instructions	Workspace	Notes for Teachers
Step 1. Plan your structure out on paper first.		*Think about the structure and look at the angles. Using triangles and squares and using the student workbook draw out your idea for design.*
Step 2. Gather materials for your structure. You may want to use straws and blu tack.		*Think about what you are going to use, this could be straws and blu-tac or could be cocktail sticks for more complex structures*
Step 3. Construct a good base to hold your structure in place.		*A base is essential to hold the structure and allow it to stand alone*
Step 4. Using the straws build your structure up and use blu tack at the joints.		*The blu-tac will hold the straws together but ensure not too much is used as it will add weight to the structure*

Step 5. Have a look at other people's structures. *How do they compare to yours?*		*By comparing structures with others it will allow the students to see the different concepts and how they impact on design.*

Checks for understanding: *Why should we avoid using too much blue tack to hold the structure together? Why do we add joints to a structure?*

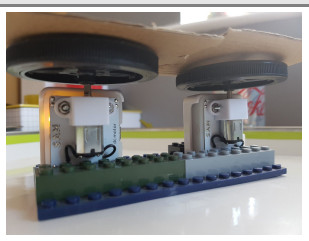
Challenge 1 - Debug it — 5 minutes

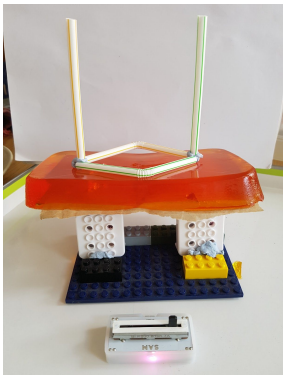
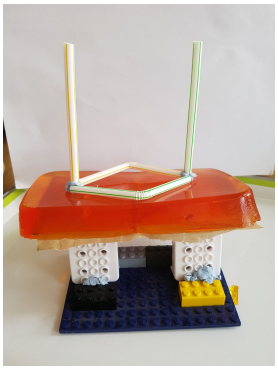
Some of the bases are not strong enough to hold the weight above, can we make it stronger?

Instructions	Workspace	Notes for Teachers
Step 1. Look at your base and think about how to make it stronger.		*Triangles can be added to squares in the base to strengthen it.*
Step 2. Add straws and blu tack to your structure.		Add straws to build the base up – opportunity to discuss the importance of a good foundation on any building to hold all aspects in construction.
Step 3. *Could your structure survive an earthquake?* Test your system.		*Give the structure a little nudge and see if it is able to withstand it and not fall or demolish.*

Challenge 2 — 7 minutes

Program a SAM system to test the strength of the structure

Instructions	Workspace	Notes for Teachers
Step 1. Set up the tectonic plates.		*Set up the two tectonic plates with the zig zag part of the cardboard aligned so it is ready to simulate an earthquake on the fault line.*

Step 2. Add the jello to the top of the tectonic plates.		*Remember to do this carefully so asnot to destroy the jello or more will be needed. You could use greaseproof paper underneath it to help it from sticking to the tectonic plates. The importance of jello is that you can see the vibrations when it is shaken. This is an excellent representation of an earthquake as depending on the size of the earthquake depends on how much the earth shakes.*
Step 3. Add your structure to the top of the jello.		*The house on the jello doesn't fall because it is *cushioned* by the jello. This is called "base isolation." Engineers constructed these in skyscrapers that float on systems of ball bearings, springs and padded cylinders. Acting like shock absorbers in a car, these systems allow the building to be decoupled from the shaking of the ground.*
Step 4. Start activating your Slider block.		*As you increase the Slider to the right you will see the motors starting to increase their speed. You will see that the motors are no longer spinning fast and this is because of the weight the jello has placed on the motors. Just like a building on the ground, the weight would make it harder to shake.*
Step 5. Whose will last the longest?		*Gather the straw structures and see how long they last in an earthquake, whose can last the longest? Opportunity to document the position of the Slider and associate this with a number based on the Richter scale.*

Extension Ideas:

- **Science**
  - Compare the structure and develop a competition for the structure that stands the longest or remains standing
  - Hot and cold – what effect heating up and cooling down has on materials and the stability of a structure
  - Peer evaluations – competition and comparing looking at strengths and weaknesses of designs
- **Geography**
  - Discussion or research - Would you live on a fault line?
- **English**
  - Write a story of an earthquake from a first person's perspective
  - Write a news story about an earthquake and the effects - positive or negative
- **ICT/D&T**
  - Look at Google Sketchup or CAD software to look at structure design of buildings and how theirs could be developed further

Checks for understanding: *What was the purpose of the cardboard and the motors? Why did we use jello?*

Tidy Up / Exit Ticket

4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

Overview

During this lesson, students will identify two possible solutions for designing the steering mechanism for Mars Rover. Students will compare and contrast the capabilities of each design in order to determine which design allows the Rover to better fulfill its main objective. Students will test and improve their design through a timed task.

Key Information

Level 3: (Ages 9-11) US Grades 4 or 5 Time: 45/90 minutes

Lesson consists of...	
Warm-Up	5 mins
Mini-lesson	10 mins
Worked Example	7 mins
Challenge 1	7 mins
Challenge 1 - Debug	5 mins
Challenge 2	7 mins
Tidy Up / Exit Ticket	4 mins

Learning Objectives

As a result of this lesson, students will be able to

- ➔ Recognize that many machines are build for a specific purpose.
- ➔ Identify more than one technical solution for any given design requirement.
- ➔ Build a SAM Mars Rover which can move, forward, steer and reverse using two different mechanisms.
- ➔ Compare and contrast two possible design solutions, identifying evidence-based rationale for the chosen design.

Lesson Topics

Design and Technology
- ➔ Generate, develop, model and communicate ideas through talking, drawing and mock-ups

Computing
- ➔ Inputs, outputs, debugging, trial and error, calibration, workarounds

Engineering Design
- ➔ Working within constraints and criteria

English Language Arts
- ➔ Use information gained from illustrations and text to demonstrate understanding
- ➔ Compare and contrast
- ➔ Argumentation

Materials required

- ➔ SAM Labs Kit
- ➔ Google Mars (https://www.google.com/mars/)
- ➔ Student Workbook
- ➔ Mars Rover Video (https://www.youtube.com/watch?v=cU5MWtEs4L4)
- ➔ Athletic / Paper Cones
- ➔ Timers

Warm Up — 5 minutes

What is the purpose of the Mars Rover?

Objective: Identify the purpose of the Mars Rover

Procedures: *"Today we are going build a replica of the new Mars Rover NASA is designing for their next mission to Mars in 2020"*

- Do you know the purpose of the Mars Rover?
- Option to watch this video (https://www.youtube.com/watch?v=cU5MWtEs4L4) to support conversation.
- The purpose of the Mars Rover is to explore the surface of Mars in order to discover evidence of life.
- In order to accomplish its primary purpose the Rover needs to be able to travel far on a variety of terrain, some mountainous, dusty, rocky.
- How can the Rover be designed to fulfill its purpose? Option to elicits responses from the class.

Link forward: Students learn about steering capabilities in some specialized vehicles.

Mini-lesson — 10 minutes

What steering capabilities does the Rover need to fulfil its objective?

Objective: Explain how the purpose of the Mars Rover dictates its design.

Procedures*: "Many specialized vehicles, such as Mars Rover, use tracks, cannot turn like a bike or car because the don't have wheels as such."*

- These vehicles do not use normal wheels because they are designed with the technical capability, tracked steering, to travel over snow, rocky terrain and uneven ground.
- These vehicle are used in extreme condition where people's' lives or survival depend on them, so their steering mechanism must be robust.
- How do they turn? These vehicles have two tracks, one on each side. There are motors attached to each track. If we make one track go faster than the other, then the vehicle will turn
- Tracked wheels allows for rocker-bogie suspension which allows the Mars Rover to climb up hilly or mountainous terrain. Discuss the consideration of friction in the design of the Mars Rover.
- There are three possible landing sites for the Mars Rover 2020. They are Northeast Syrtis, Jezero crater and Columbia Hills. The Mars Rover will travel to all three sites during its mission.
- We're going to test the design of two steering systems later on in the lesson to determine the best route for it to travel. (8 minutes)

At the end of the mini-lesson, students match or define keywords in their workbooks (2 minutes).

Keywords

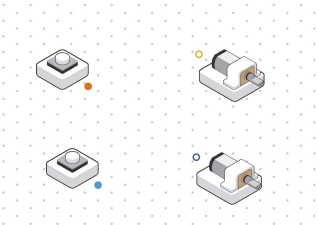
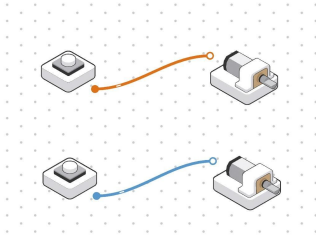
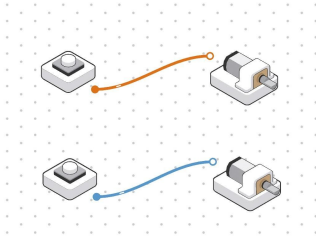
- Design technology
- Rocker-bogie
- Tracked vehicle
- Exploration

Let's Discuss: *How does the design of the Mars Rover help it to achieve its main objective? In your workbooks or with a partner, describe the steering system in a car versus that of the Mars Rover.*

Link forward: Design a SAM Rover which tests the usefulness of the tracked turning mechanism versus regular steering systems.

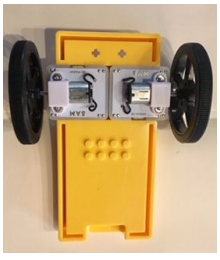
Worked Example — 7 minutes

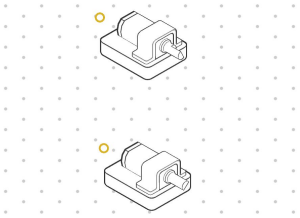
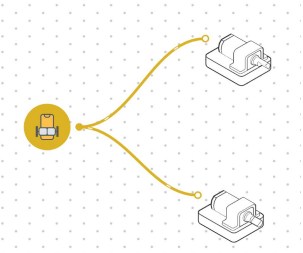
Design a tracked steering system for your SAM Mars Rover

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • 2 DC Motors • 2 Button/Virtual Button blocks		*The Buttons will act as inputs and the Motors outputs. We are modeling the track steering system first.*
Step 2. Drag them onto the workspace. Connect each Button to one Motor.		*If you do not have a Button and do not want to use virtual Buttons, you can use Key Presses.*
Step 3. Test your system.		*Pressing one button will turn one motor on, pressing both buttons will turn both motors on*

Challenge 1 — 7 minutes

Build your SAM Rover and consider another steering design

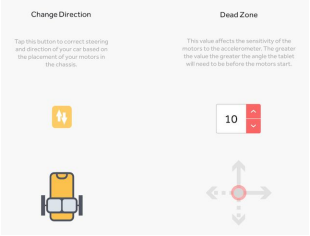
Instructions	Workspace	Notes for Teachers
Step 1. Connect the wheels to the Motors.		*Be sure to match the flat part of the wheel with the flat part of the axel.*
Step 2. Fit the DC motors into the yellow car chassis.		*Motors will need to be removed from their Lego holders for the motors to fit properly.*

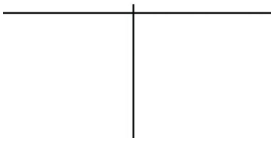
Step 3. Turn the car over and add the roller. Then, find some floorspace to test your Rover.		*You may wish to section the classroom off into areas using masking tape so each group has a designated space.*
Step 4. Hold one Button in each hand. Press down both Buttons simultaneously to drive the Rover straight. **Step 5.** To turn the Rover right or left, press down one Button and then the other.		*Encourage students to try to move the rover straight, right and left.*
Step 6. Remove everything except the two Motors.		*Now, prepare students to use a traditional steering system.*
Step 7. Add the Car Controller block to the workspace connect it to the Motors. **Step 8.** Use your device to make the Rover drive straight, right and left.		*If you have an iPad or handheld device you can tilt it forward, backward and side to side to make the Rover move. If you are using a desktop computer, use the arrow keys.*

Checks for understanding: *What is the purpose of the Button in the first Rover design? What are the outputs of both systems?*

Challenge 1 - Debug it — 5 minutes

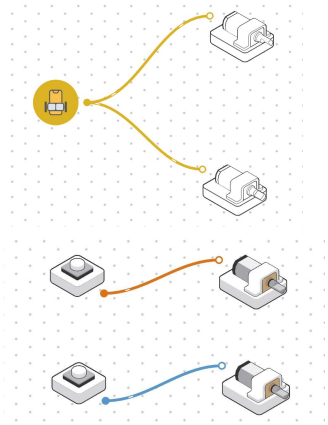
Which design is most effective? How do you know?

Instructions	Workspace	Notes for Teachers
Step 1. Using the Car Controller block to drive your rover, open the Settings and set the value to one that makes it easiest to maneuver accurately.		*Teacher says, "The higher the number the more you will have to tilt your device to operate the car."*

Step 2. Using Buttons to drive your rover, open the Motor settings and modify the speed of the Motors so that the Car doesn't move too quickly.		*Teacher says, "The Car will go very fast by default. Try and get the speed as slow as possible without the car stopping. Use trial and error."*
Step 3. Use a T-chart to compare and contrast both steering systems. *Which is design will help the Rover to accomplish its objectives?*		*This can be completed as a class or in small groups. Discuss how although both systems achieve the same result (the movement of the car) is one system more effective for this purpose?*

Challenge 2 — 7 minutes

Test your preferred design

Instructions	Workspace	Notes for Teachers
Step 1. Get into a small group. Choose the design you think is most effective and build it.		*You may wish to group students from the start of the lesson.*
Step 2. Assign group members one of the following tasks: ***Note-taker:*** *You take notes on what works and where the Rover could be improved* ***Driver****: You drive the Rover* ***Checker****: You ensure the Rover completes the task* ***Timer****: You time the mission*		*Some teachers have set up Mars-like terrain in their classrooms to support this task. This could justify another instructional session if you want students to gather more evidence and justify their chosen design.*
Step 3. Plan out the most efficient route between Columbia Hills, Jericho Crater and NE Syrtis Major. Test it with your Rover!		
Step 4. Adjust the Rover's design (or even change it altogether) and improve your time!		*Is there a more efficient route to travel? Which design will help you get there?*

Extension Ideas:

- **Engineering Design:**
  - Track the current Mars Curiosity Rover and replicate its path. Can you design a better route?
- **ELA:**
  - Write a persuasive essay presenting the available evidence for life on Mars. Is this enough of an indication that Mars could support human life? Why or why not?
  - Relate your learning to The Martian by Andy Weir.
- **Science:**
  - Research other features of the Rover. Present evidence as to why these features helpful to its purpose.

- Research other specialized vehicles. What features are integral to its design? How does these features help it fulfil its purpose?

Checks for understanding: *What is the purpose of the Mars Rover? What other input could you use to control the Rover?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

The Lighthouse

Overview

During this lesson, students will investigate how light reflects from objects and enters the eye allowing objects to be seen. Students will build and program a SAM Lighthouse to test how light is reflected.

Key Information

Level 3: (Ages 9-11) US Grades 4 or 5 Time: 45/90 minutes

Lesson consists of...	
Warm-Up	5 mins
Mini-lesson	10 mins
Worked Example	7 mins
Challenge 1	7 mins
Challenge 1 - Debug	5 mins
Challenge 2	7 mins
Tidy Up / Exit Ticket	4 mins

Learning Objectives

As a result of this lesson, students will be able to

- ➜ Understand that light travels in straight lines and that we see things because light waves are reflected into our eyes.
- ➜ Investigate which is the best material to reflect light.
- ➜ Design and build a SAM Lighthouse.
- ➜ Build a SAM lighting system to investigate if the frequency and colour of the light increases its visibility.

Lesson Topics

Physical Science

- ➜ Waves and their applications - develop a model to describe light reflecting from objects and entering the eye allows them to be seen
- ➜ Investigate the use of mirrors to change the path of light waves

Computing

- ➜ Inputs, outputs, abstraction, debugging

Design and Technology

- ➜ Generate, develop, model and communicate ideas through talking.
- ➜ Build a structure and evaluate its effectiveness

Math

- ➜ Using a protractor to calculate angles

Scientific Thinking

- ➜ Asking relevant questions and using different types of scientific enquiries to answer them

English Language Arts

- ➜ Participate in collaborative conversations.
- ➜ Plan and write a nonfiction account for a newspaper

Materials required

- ➜ SAM Labs Kit
- ➜ Lego bricks
- ➜ Small mirrors
- ➜ Blu Tack
- ➜ Student Workbook

Warm Up – 'Reflect and Absorb' 5 minutes

How do we see objects?

Objective: Students learn that light travels in straight lines and that we are able to see objects because of light reflecting off them.

Procedures:

- Watch for one minute: https://www.youtube.com/watch?v=IQktUychLS8
- What do you see first?
- Light waves travel in straight lines and are much faster than sound waves. Light travels at 299, 792 km per second.
- Some materials reflect light well. Other materials are not as good as they absorb the light.
- Predict materials which will reflect and materials which absorb.
- Students work in pairs with three materials: white card, black card and a mirror. Shine a light directly into the mirror and use a pencil to draw over the light they see reflected.
- Students can measure the angle of reflection using a protractor.
- Repeat with all three materials. Which reflects light best? How can you tell?
- Within the student workbook: Sort materials which reflect/absorb.

Link forward: Light reflects well off smooth, shiny surfaces (such as mirrors and polished metals). Light does not reflect well off dull and dark surfaces because the light waves are absorbed.

Mini-lesson 10 minutes

How can we use mirrors to 'bend' the light?

Objective: Students use mirrors to reflect light waves around corners.

Procedures: "*Today we are going to explore how waves will carry on forever unless they bounce into something. They can only travel in straight lines."*

- If I wanted to 'bend' the light from my torch around the corner of the classroom and down the corridor. How could I do this?
- Students discuss ideas with a partner.
- Each member of the class holds a mirror and stands on alternating sides of the room. One person shines the light directly into the mirror opposite. That person then tilts their mirror to reflect the light wave into the mirror opposite them. Students repeat, reflecting the light into each mirror, until they reach the edge of the classroom and are able to reflect the light around the corner and down the corridor. (8 minutes)

At the end of the mini-lesson, students match or define keywords in their workbooks (2 minutes).

Keywords

- Light wave
- Reflect
- Absorb
- Smooth
- Shiny
- Dark
- Dull

Let's Discuss: *Why is it important for a Lighthouse to be a tall structure? In your workbook or with a partner, record, discuss, or share your Lighthouse design with a partner. Can they think of a way to help you improve it?*

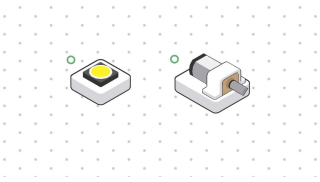
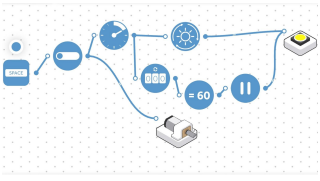
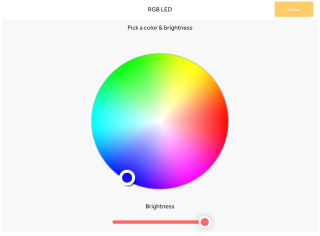
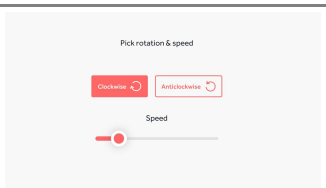
Link forward: We are going to program a lighting system for a Lighthouse. Discuss with your partner things you would need to include in your system/structure.

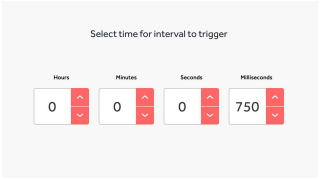
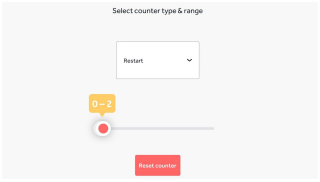
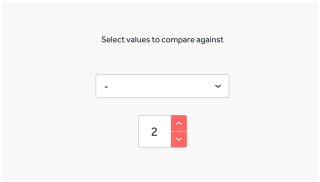
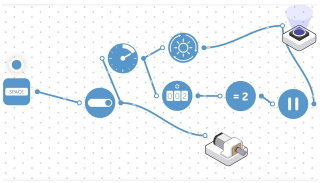
The Lighthouse

Worked Example

7 minutes

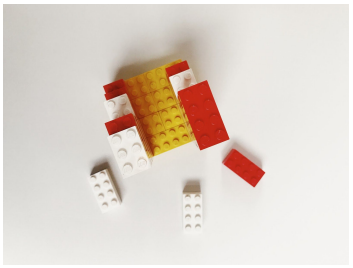
Program a light system for your SAM Lighthouse

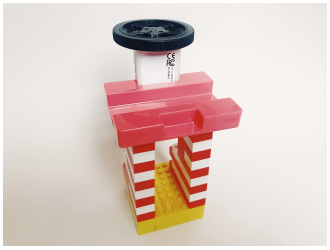
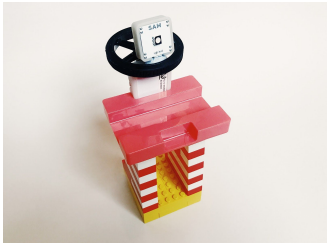
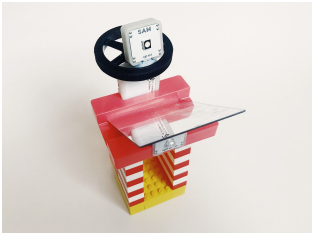
Instructions	Workspace	Notes for Teachers
Step 1. Pair and add the following blocks to the workspace: • 1x DC Motor Blocks • RGB LED block		*The color of the blocks will change when they are connected as a system.*
Step 2. Drag the following blocks onto the workspace: • Key Press block • Toggle block • Compare block • Interval block • Counter block • Cycle Brightness block • Hold block		*If you have a Button block, you can use it in lieu of the Key Press block.*
Step 3. Connect in the following order: • Key Press block to the Toggle block. • Toggle block to the DC Motor block and the Interval block. • Interval block to the Cycle Brightness block, then to the RGB LED block.		*The DC Motor block needs to be connected separately from the RGB LED block otherwise the system will not work.*
Step 4. Connect in the following order: • Interval block to the Counter block • Counter block to the Compare block • Compare block to the Hold block. • Connect the Hold block to the RGB LED block.		*The system will cycle the brightness of the light. The Hold block will ensure the light turns off before the system repeats. This should make the Lighthouse as visible as possible.*
Step 5. Access the settings of the RGB LED block and select a color. Ensure the brightness is at its highest setting.		*Students choose which color they think will make the Lighthouse most visible.*
Step 6. Edit the settings of the DC Motor block and lower the speed.		*This will ensure the lighthouse does not turn too quickly.* *Make sure the speed is not too low otherwise the motor will not turn once*

		the weight of the wheel and light is added to it.
Step 7. Edit the settings of the Interval block. Set the interval to 750 milliseconds.		*This will increase the frequency of the flashing light.*
Step 8. Edit the settings of the Counter block and slide the counter down to 2. Ensure the 'Restart' option is selected.		*The Counter block is now acting as a conditional.* ***If*** *the number on the Counter block is less than 2,* ***then*** *the system will not restart.* ***If*** *the number reaches 2,* ***then*** *the system will restart.*
Step 9. Edit the settings of the Compare block and select = 2		*The RGB LED block will turn off every three flashes. This is because the Compare block includes the value 0.*
Step 10. Test the system.		*Students may change the color and interval of the light if they feel it can be made more visible by doing so.* *Students may need to check the brightness of the RGB LED by accessing its settings.* *Which color makes the light most visible?*

Challenge 1 — 7 minutes

Build a SAM Lighthouse using Lego bricks. Include a mirror to reflect the light beam.

Instructions	Workspace	Notes for Teachers
Step 1. Build the structure of the Lighthouse using Lego bricks.		*Students could spend time designing their structure before building. They will need to consider what is an appropriate height and how to ensure the structure does not fall over.*
Step 2. Secure the Car Controller to the top of the structure.		*We will use this to attach the RGB LED and DC Motor blocks to the top of the Lighthouse.*

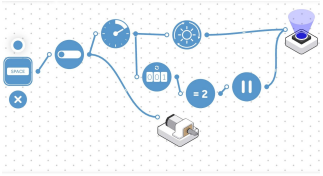
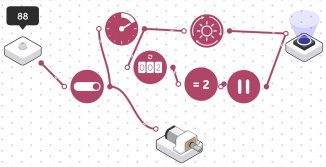
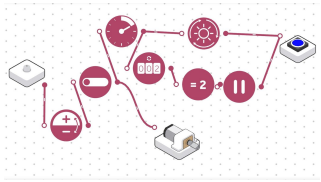
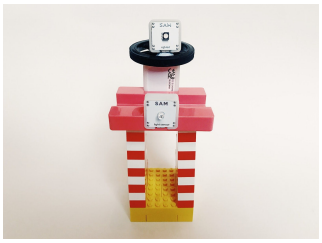
Step 3. Attach a wheel to the DC Motor and secure the block into the space on the Car Controller.		*The wheel will provide a base for the RGB LED block to sit on.* *Ensure the DC Motor does not switch off when slotted in as the fit can be quite tight.*
Step 4. Use blu tack to secure the RGB LED to the wheel.		*Students may need to use two smaller pieces of blu tack for each corner of the RGB LED block to avoid it falling off when the wheel starts to turn.*
Step 5. Secure a small mirror to the Car Controller using blu tack.		*It is important the back mirror is fairly light otherwise it will fall off.* *You could investigate whether it is better to use several small mirrors, or two longer mirrors.*
Step 6. Attach a second mirror to the back of the Lighthouse using blu tack.		*Encourage students to test the best angle and positioning of the two mirrors and adjust accordingly.*
Step 7. Test the system.		*Does the Lighthouse work?* *Is the frequency of the flashing light high enough?* *Do the mirrors increase or decrease the visibility of the light?* *Do they need to alter the positioning of the mirrors?*

Checks for understanding: *Why is it important the light flashes? Why will the mirrors increase the visibility of the light?*

Challenge 1 - Debug it — 5 minutes

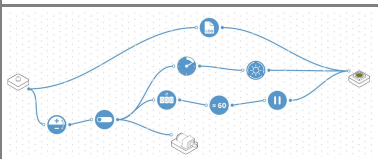
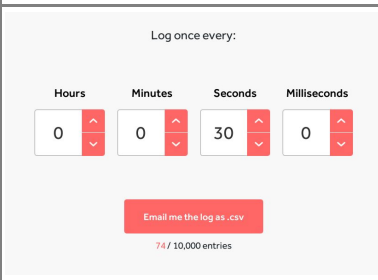
Include a Light Sensor in the system so the SAM Lighthouse only turns on when dark

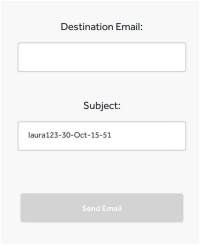
Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • Light Sensor block		*The Light Sensor block will help us make our system turn on when it is dark, and turn off when it is light. If you don't have a Light Sensor block, you can continue to use a Button/Key Press block.*

Step 2. Delete the Key Press block from the system.		*Highlight the Key Press block and click on the cross sign to delete it from the Workspace.*
Step 3. Connect the Light Sensor block to the Toggle block.		*The Light Sensor block is going to be our input.*
Step 4. Drag an Inverse block onto the workspace and connect it between the Light Sensor and the Toggle blocks.		*The Inverse block turns everything into its opposite, so the system will be activated when it is dark instead of light.*
Step 5. Place the Light Sensor block into the space at the front of the Car Controller.		*The Light Sensor block will detect when there is not enough light and the system will turn on.*

Challenge 2 — 7 minutes

Add a Log Findings block to the system to record data from the Light Sensor.

Instructions	Workspace	Notes for Teachers
Step 1. Drag a Log Findings block onto the workspace.		*You will need to be able to provide students with an email address they can enter to send the results from the Log Findings to.*
Step 2. Connect the Log Findings block to the Light Sensor and RGB LED.		*We want the Log Findings block to be able to collect and retrieve data from the Light Sensor.*
Step 3. Access the settings of the Log Findings block. Change the timer so results are logged once every 30 seconds.		*Discuss with students how frequently the data needs to be logged. Is once every 30 seconds going to be a useful time? Do they think it needs to be more/less frequent? Why?*

Step 4. Let the system run for a couple of minutes, then access the settings of the Log Findings block. Select the email function and enter a destination email address. Press 'Send Email' to send the stored data.		*The system needs to be able to run for a set period of time in order for there to be enough data to collect. Discuss what students think an appropriate amount of time would be.*
Step 5 Retrieve the data from the given email address and download the findings.	log.csv A B C 1 date module value 2 10/30/2018 14:24:24 Light Sensor 43 3 10/30/2018 14:24:24 Light Sensor 40 4 10/30/2018 14:24:24 Light Sensor 42 5 10/30/2018 14:24:24 Light Sensor 38 6 10/30/2018 14:24:25 Light Sensor 35 7 10/30/2018 14:24:25 Light Sensor 32 8 10/30/2018 14:24:25 Light Sensor 30 9 10/30/2018 14:24:25 Light Sensor 26 10 10/30/2018 14:24:25 Light Sensor 24	*What do the results show us?* *What is the average value of the Light Sensor?* *Predict how these results would alter if we conducted the same test in a room with brighter lights/outside on a cloudy day etc.* *Can students plot and create a graph from their results?*

Extension Ideas:

- **Math:**
  - Measure the distance up to which you can see the beam of the Lighthouse. Does changing the colour make it more or less visible?
- **English**:
  - Watch https://www.youtube.com/watch?v=6HfBbSUQRvo up to the part where the Lighthouse breaks. Write a newspaper report explaining how your invention will save the ships and the villagers. You could interview the Lighthouse Keeper and ask him what he thinks about your new design.
- **Science:**
  - Use the lesson as a lead into a discussion around refraction and colour dispersion. E.g. how do we see rainbows.

Checks for understanding: *Why did we replace the Key Press block with a Light Sensor? What would happen to the values of the Light Sensor if we built the system outside on a sunny day?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

SAM Spider

Overview

During this lesson, students will learn about the 5 senses and how these are received and ultimately determine how we react. Students will integrate and exhibit learning by creating a SAM Spider that reacts based on 2 senses; touch and sight.

Key Information

Level 3: (Ages 9-11) US Grades 4 or 5 Time: 45/90 minutes

Lesson consists of...		Learning Objectives
Warm-Up	5 mins	**As a result of this lesson, students will be able to**
Mini-lesson	10 mins	➜ Identify the 5 senses and how they are used to stimulate a reaction
Worked Example	7 mins	➜ Describe how the senses use the environment around us to send messages for us to react
Challenge 1	7 mins	➜ Create a spider whose legs move as a reaction to the touch sense through the Pressure Sensor
Challenge 1 - Debug	5 mins	➜ Modify the system to show a physical reaction to the sight sense
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Science
- ➜ How senses receive information from the environment around them, send it to the brain, to determine a reaction.
- ➜ How senses can be used to aid survival in new situations

Computing
- ➜ Inputs, outputs, abstraction, debugging

Scientific Thinking
- ➜ Asking relevant questions and using different types of scientific enquiries to answer them

Design and Technology
- ➜ Generate, develop, model and communicate ideas through talking, drawing and mock-ups

Math
- ➜ Identify apparent relationships between corresponding terms in a given equation or word problem

English Language Arts
- ➜ Participate in collaborative conversations.
- ➜ Use information gained from illustrations and text to demonstrate understanding
- ➜ Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 4-5 topic or subject area

Materials required

➜ SAM Labs Kit ➜ Student Workbook ➜ Blue tack ➜ Pipe Cleaners

SAM Spider

Warm Up — 5 minutes

How does your body communicate information from one part to another?

Objective: Identify the 5 senses and how they are used to stimulate a reaction

Procedures: *"Today we are going to learn how our bodies can react to the 5 senses and investigate how sight and touch can simulate a response"*

- Identify the 5 senses in the body and discuss how these senses stimulate the body to react in different ways, for example we see something we do not like we can move away, scream, jump etc.
- Using the scenario of encountering a new item of food; describe how they would use the senses to make a judgment if they liked it or not.
- Discuss how one sense can be increased to accommodate the loss of another; for example hearing can be improved to compensate for loss of sight. Could you still make a judgment on the new food item if you were without one of your senses?

Link forward: Link to how the senses are used to process the information to stimulate a reaction.

Mini-lesson — 10 minutes

Why do we have senses and how do they help us survive?

Objective: Describe how the senses use the environment around us to send messages for us to react

Procedures: *"We all have 5 sense organs that are always reading the environment around us and sending messages to the brain for us to react"*

- Your brain takes the information generated by the sense organs; eyes, ears, nose, tongue and skin and tells your body how to respond.
- Investigate how these senses enhance our 'fight' or 'flight' responses to help us survive situations; we see a rock falling towards us, the senses can see, hear and possibly feel it happening, all sending the brain the message to react by moving the body out of the way.
- Discuss how we are different and react differently, our brains are not universally programmed to react in one way. One person may run from a spider where another may observe and study.
- Investigate how a sense can be enhanced by technology; hearing aid, glasses. (8 minutes)

At the end of the mini-lesson, match the keywords to the correct definition in their workbooks. (2 minutes)

Keywords

- Senses
- Brain
- React
- Sight
- Touch
- Smell
- Taste
- Hearing

Let's Discuss: *Why do we need our senses? In your workbook or with a partner, record, discuss, or share an example of how you would sense a change in the weather and how you would react to it.*

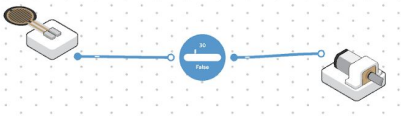
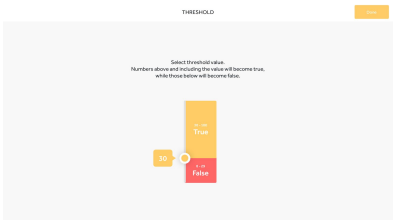
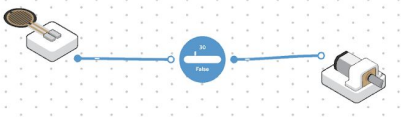
Link forward: Link to designing a system which demonstrates a physical reaction to one of the senses.

SAM Spider

Worked Example

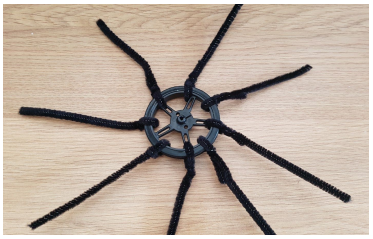
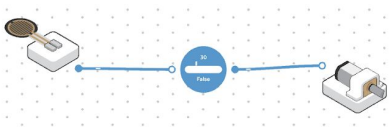
7 minutes

Design a system where movement is controlled by touch

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • Pressure Sensor block • DC Motor block		*The Pressure Sensor block will be the input and the DC Motor block will be the output.*
Step 2. Drag the Pressure Sensor and DC Motor blocks onto the workspace and connect them.		*This will generate a response straight away and the motor will turn as the setting of the pressure sensor will react from 0.*
Step 3. Drag on a Filter block to the workspace. Connect between the Pressure Sensor and DC Motor blocks.		*The default setting of the Filter block is 30-70.*
Step 4. Test your system		*Apply pressure to the Pressure Sensor block by touching it and see the number above the Pressure Sensor block increase on the workspace, the DC Motor will turn when 30 is reached.*
Step 5. Swap the Filter block for a Threshold block.		*The Threshold block will activate the DC Motor when the default number of 50 is reached or above.*
Step 6. Edit the settings of the Threshold block to 30.		*This block has the same functionality as the Filter block as it starts at the same number but has no end number.*
Step 7. Test your system.		*Which works better? Is there a preference?* *Are there any other blocks that could be used? The Compare block is another option that can be set as < > = a value.*

Challenge 1 — 7 minutes

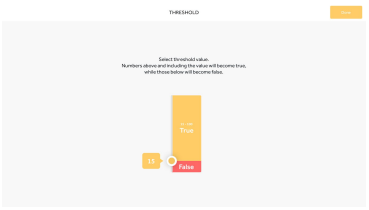
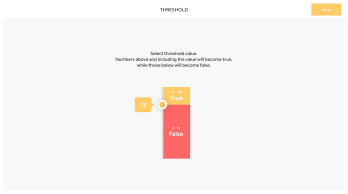
Create a spider whose legs move as a reaction to the touch sense through the Pressure Sensor

Instructions	Workspace	Notes for Teachers
Step 1. Cut 4 x pipe cleaners in half.		*The pipe cleaners will be the legs of our insect and need to be approximately the same length.*
Step 2. Attach the pipe cleaners to the Wheel.		*Try and get the pipe cleaners at regular intervals around the wheel, fold over the edge of the wheel and wind around the same pipe cleaner to secure.*
Step 3. Attach the DC Motor block to the Wheel.		*The DC Motor block needs to be pointing upwards.*
Step 4. Bend the legs towards the table like a spider.		*The pipe cleaners are not meant to lift the DC Motor from the table but to touch the table to aid stability.*
Step 5. Test your system.		*When you touch the Pressure Sensor block and it reaches a value of 30, the 'spider' will start moving across the table.*

Checks for understanding: *What sense is the Pressure Sensor block simulating? What is the purpose of the Threshold block?*

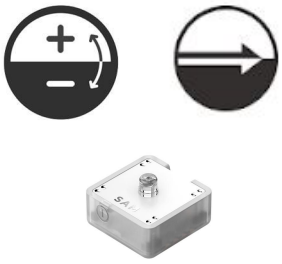
Challenge 1 - Debug it — 5 minutes

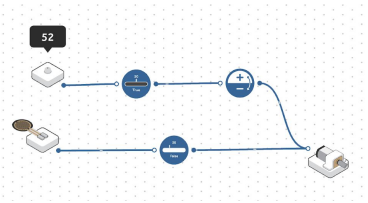
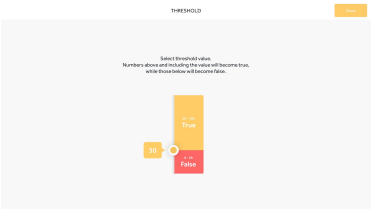
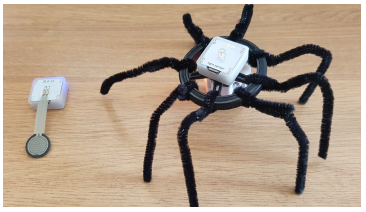
Can the spider react faster or slower?

Instructions	Workspace	Notes for Teachers
Step 6. Decrease the Threshold to 15.		*What happens if the Threshold is reduced? The spider will react with less pressure added to the Pressure Sensor block.*
Step 7. Increase the Threshold to 75.		*What happens if the Threshold is increased? The spider will not react till more pressure is added to the Pressure Sensor block.*

Challenge 2 — 7 minutes

Modify the system to show a physical reaction to the sight sense

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • Light Sensor block		*The Light Sensor block will simulate the eyes of the spider and the sight sense.*
Step 2. Secure the Light Sensor block to the top of the spider on the Wheel.		*Use blu tack to secure the Light Sensor block to the middle of the wheel.*
Step 3. Drag on the following blocks to the workspace: • Light Sensor block • Threshold block • Inverse block		*The Light Sensor block will form our second input to the system as our 2nd sense. The Inverse block will ensure the spider moves in a different direction to when the Pressure Sensor block is activated.*

Step 4. Connect the blocks in the following order: • Light Sensor block to Threshold block • Threshold block to Inverse block • Inverse block to DC Motor block		*The Light Sensor will show as detecting the changes in the light in the space surrounding the block by the number above the block on the workspace. It is worth noting the resting number; which depicts the light in the room.* *If the room light is above the default setting of the Threshold block (50) the spider may move as soon as connected. If this occurs remove the link from the Inverse block to the DC Motor block till the Threshold block settings are edited in the next step then reconnect them.*
Step 5. Edit the settings of the Threshold block to 30.		*The setting is 30 here as it is below the resting number of 50 in the environment we are in. This may need adjusting to your rooms light settings. The setting should be about 20 below to allow it to react accordingly.*
Step 6. Test your system.		*The spider will now react also to your hand as it moves over the top of the spider (obscuring the light from the sensor) to make the spider move until the hand or object is moved away.*

Extension Ideas:

- **Computing**:
  - What technologies are used to enhance the senses?
  - What does the term assistive technology mean?
- **Science:**
  - How does the body carry the messages to the brain through neurons?
  - What does a neuron cell look like?
  - What happens in the body if a neuron is damaged and cannot transmit the message?
  - What difficulties can occur when a sense is not sending a message?
- **Geography**:
  - Do different countries have different advancements in technology to aid people?
  - Do different cultures have different senses enhanced to survive in their environment?

Checks for understanding: *What sense has been simulated in challenge 2? What is the purpose of the Inverse block?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

Lesson 3.8

Lava Lamp

Overview

During this lesson, students will gain understanding of how two substances can be mixed together to create new substances. Students will integrate and exhibit learning by combining two substances, creating a SAM lava lamp.

Key Information

Level 3: (Ages 9-11) US Grades 4 or 5 Time: 45/90 minutes

Lesson consists of...	
Warm-Up	5 mins
Mini-lesson	10 mins
Worked Example	7 mins
Challenge 1	7 mins
Challenge 1 - Debug	5 mins
Challenge 2	7 mins
Tidy Up / Exit Ticket	4 mins

Learning Objectives

As a result of this lesson, students will be able to

- ➔ Identify the outcome of combining two substances; baking soda and vinegar
- ➔ Explain how substances can be combined and whether it creates a new substance or not
- ➔ Design a system to generate a mixing motion on two substances and observe the interaction
- ➔ Modify the system to design and create a Lava Lamp

Lesson Topics

Physical Science
- ➔ Measurement of a variety of properties can be used to identify materials

Computing
- ➔ Inputs, outputs, abstraction, debugging.

Scientific Thinking
- ➔ Asking relevant questions and using different types of scientific enquiries to answer them.

Design and Technology
- ➔ Generate, develop, model and communicate ideas through talking, drawing and mock-ups.

Art and Design
- ➔ Explore and use mechanisms, devices and materials for imaginative activity that leads to original and creative outcome

English Language Arts
- ➔ Participate in collaborative conversations.
- ➔ Use information gained from illustrations and text to demonstrate understanding.
- ➔ Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 4-5 topic or subject area.

Materials required

- ➔ SAM Labs Kit
- ➔ Student Workbook
- ➔ Glitter
- ➔ Black card
- ➔ Lego
- ➔ Water bottle and water
- ➔ Vegetable oil
- ➔ Food coloring
- ➔ Alka-Seltzer
- ➔ Baking powder
- ➔ Vinegar
- ➔ Plastic tub

Warm Up — 5 minutes

What happens when two substances are mixed together?

Objective: Identify the outcome of combining two substances; baking soda and vinegar

Procedures: *"Today we are going to learn how substances can be combined and that the mixing of two or more substances can result in new substances."*

- Look at two household substances; baking soda and vinegar and discuss what might happen if the two are combined.
- Clip (https://www.youtube.com/watch?v=_CYgsqji_0k) shows the interaction of the two substances or could be done for the students to see. As the two substances are combined it starts to fizz and bubble as a gas is released called Carbon Dioxide.

Sample photo ideas: Baking soda and vinegar

Link forward: Link to looking at the different properties of a substance and how combining them can create a new substance with new properties

Mini-lesson — 10 minutes

How can properties change?

Objective: Explain how substances can be combined and whether it creates a new substance or not

Procedures: Materials can have three states of matter; Solid, Liquid and Gas and experiments can be undertaken to change a materials properties from one to another, like chocolate that is reversible as the change from solid to liquid can be reversed back to solid.

- Look at mixing different materials together and whether this creates a new substance or no reaction takes place.
- The warm up showed an interaction between two substances; baking powder and vinegar to create a new substance, gas.
- Discuss other substances that can be mixed together to create a new substance like a recipe where liquid and solids are mixed together to create a new solid (8 minutes).

At the end of the mini-lesson, students can match or define keywords in their workbooks. (2 minutes)

Keywords

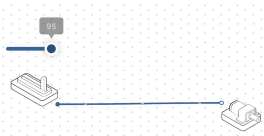
- Solid
- Liquid
- Gas
- Substance
- Interaction

Let's Discuss: *What happens when baking powder and vinegar are mixed? In your workbook or with a partner, record, discuss, or share one example of other substances that can be mixed together to create a new substance.*

Link forward: Link to combining different substances together and creating a SAM lava lamp to combine them

Worked Example — 7 minutes

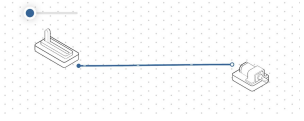
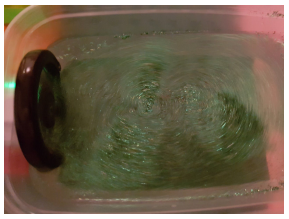
Create a system to control the DC Motor block

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • 1 Slider/Virtual Slider block • 1 DC Motor		*The Slider block will be the adjustable input, determining the speed of the output DC Motor*
Step 2. Connect the Slider block to the DC Motor block		*If you do not have the Slider block it can still be used on the workspace*
Step 3. Connect the wheel to the DC Motor		*The wheel connects to the DC Motor and will need to be secure to stay on when turning.*
Step 4. Move the Slider to increase or decrease the speed of the motor		*The Slider will increase the speed of the block and in order to see the waves it is important the speed is considered which in turn will create more waves.*

Challenge 1 — 7 minutes

Design a system to generate a mixing motion on two substances and observe the interaction

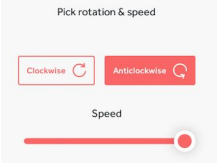
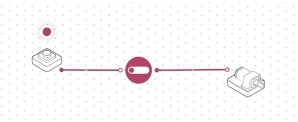
Instructions	Workspace	Notes for Teachers
Step 1. Using a plastic tub make a small hole in the end		*The hole needs to be big enough for the motor to go through but also for it to spin*
Step 2. Push the DC Motor through the hole and attach the wheel		*Depending on the size of the tub, a base may need to be built under the DC Motor block and here I have used lego.*

Step 3. Add about an inch of water		*Add water to the tub remembering not to go over the hole created, half way up is best to allow the wheel to be partly under water.*
Step 4. Use the system from the worked example		*Make sure the blocks are paired by checking the color on the blocks are not red.*
Step 5. Add a lump of glitter to the water		*There needs to be enough glitter added so that it is in one mass and this is done by dropping it in from a tub, not sprinkling it in.*
Step 6. Start the DC Motor by the Slider block		*As the DC Motor starts the glitter will start to mix with the water and change from a mass of glitter in one place to dispersing it throughout the water. Changing to 'glitter water'.*

Checks for understanding: *What happens to the glitter when the DC Motor is started? Which block is the output in the system?*

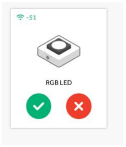
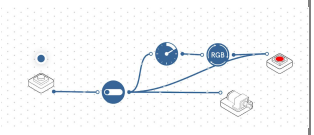
Challenge 1 - Debug it — 5 minutes

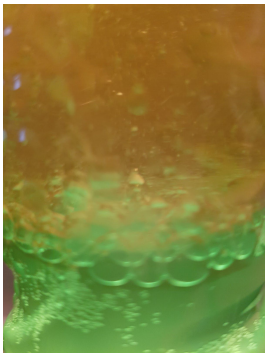
The motor is too slow, can we make the speed setting high only?

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • A Button/Virtual Button block Drag a Toggle block to the workspace		*We are going to have a switch instead of a Slider block to start the system as we can set the speed instead of increasing it.* *If you do not have the Button block you can use this virtually or if you have the physical block ensure paired with the system.*
Step 2. Open the Settings icon of the DC Motor and make sure speed at the maximum.		*The speed needs to be at maximum so that this is the setting when the system is activated*
Step 3. Remove the Slider block. Replace it with the Button block into the Toggle block.		*Test the system and see that you now have a switch to control the DC Motor but at one speed setting*

Challenge 2 — 7 minutes

Modify the system to design and create a Lava Lamp

Instructions	Workspace	Notes for Teachers
Step 1. Drag on an Interval block, Cycle Colors block.		*RGB stands for red, green and blue and will cycle through these colors only. If you want to create one color for the lava lamp this block can be omitted*
Step 2. Turn on and pair: • RGB LED Add it to the workspace.		*Press and hold the power button on the block and pair with the system, check it is not red to ensure connected with the workspace.*
Step 3. Connect the blocks from the output of the Toggle block in this order; • Interval block to Cycle Colors block to RGB LED. • Toggle block to RGB LED		*The output of the Toggle block needs to go to both the RGB LED and the DC Motor as this will enable switching off of the light as well as activating the system.*
Step 4. Create a base using the Car Chassis and Lego. Secure the DC Motor pointing up with the RGB secured to the wheel.		*We have used Lego Duplo to build round the Car Chassis to secure it in place and acts as a base for resting the plastic tub on.* *We have used black card to create a tunnel for the light to projected upwards and placed on top of the wheel. The RGB LED is secured to the wheel with blue tac.*
Step 5. Collect a clear plastic bottle, water, vegetable oil, food coloring, alka-seltzer and a small plastic tub.		*We have used a small water bottle as it needs to rest above the wheel on the DC Motor but a larger one could be used.*
Step 6. Add ⅓ water to ⅔ vegetable oil into the bottle and drops of the food coloring.		*You may need to give it a moment to settle as the water and vegetable oil seperate. The food coloring when added will sink to the bottom in with the water.*

Step 7. Place the bottle on top of the plastic tub over the wheel of the DC Motor and add half an alka seltzer.		*The tub is the stable base to hold the weight of the bottle and the wheel with light and tunnel on top will project the light up and moving.*
Step 8. Activate the system. Notice the bubbles generated and the light showcase it.		*The bubbles will rise and the color from the light and the food coloring will define the bubbles to see how the substances interact.*

Extension Ideas:

- **Computing**:
  - Choose a color that best showcases and create the right mood for the lava lamp and set within the RGB LED and remove the Cycle Colors block
  - Experiment with speed of the motor and without the motor - which produces the best lava lamp (any further experiments will require adding additional alka-seltzer to the bottle
- **Science**:
  - What other substances interact? Baking soda and vinegar experiment
- **Maths:**:
  - Time the effect of the alka-seltzer - to start reacting and how long it lasts

Checks for understanding: *What causes the bubbles to start? What does RGB stand for?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

Describing Expressions

Overview

During this lesson, students will write and physically model mathematical expressions. Using SAM Blockly to further their understanding, students will learn multiple ways to write a mathematical expression. *Please note, students should have basic familiarity with the Blockly application before this lesson.*

Key Information

Level 3 (Ages 9-11) US Grade 4 and 5 Time: 45/90 minutes

Lesson consists of...	
Warm-Up	5 mins
Mini-lesson	10 mins
Worked Example	7 mins
Challenge 1	7 mins
Challenge 1 - Debug	5 mins
Challenge 2	7 mins
Tidy Up / Exit Ticket	4 mins

Learning Objectives

As a result of this lesson, students will be able to

- ➜ Write simple expressions that record calculations with numbers, and interpret numerical expressions without evaluating them.
- ➜ Describe the associative property of multiplication and addition; apply understanding of the distributive property.
- ➜ Use SAM Blockly to compare two similar expressions and find the results.
- ➜ Discover the effect the order of operations can have on a system.

Lesson Topics

Math

- ➜ Write descriptions as numerical expressions
- ➜ When applicable, describe the impact of parentheses on expressions as changing or not changing the result

Computing

- ➜ Inputs, outputs, modelling, debugging

Design and Technology

- ➜ Generate, develop, model and communicate ideas through talking, drawing and mock-ups

English Language Arts

- ➜ Participate in collaborative conversations.
- ➜ Use information gained from illustrations and text to demonstrate understanding
- ➜ Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 4-5 topic or subject area

Materials required

- ➜ SAM Blockly
- ➜ Student Workbook
- ➜ Lego blocks
- ➜ Elastic bands
- ➜ Paper clips
- ➜ Erasers

Describing Expressions

Warm Up — 5 minutes

Modeling written mathematical expressions

Objective: Model a mathematical expression using physical props.

Procedures: *"For today's lesson, we are going to model number expressions from written or spoken sentences and then program our expressions using SAM blocks and Blockly."*

- To start, students are given mathematical expressions and are asked to model their answers with physical prompts. They should demonstrate their answer with the props.
- Students choose a scenario to model (using blocks, counters, manipulatives, pens etc.) e.g.
  - Michelle has 6 lego blocks. You have 4 more blocks than her. Show how many blocks you have.
  - Sarah had 5 erasers in a gift bag. Dan had 4 times as many in his gift bag. Show how many erasers Dan had.
  - Steven has 7 paper clips and Sarah has 4 paper clips. Jane has 3 times as many as Steven and Sarah. Show how many paper clips Jane has.
  - Michael has 5 elastic bands. Tracy has 7 more than 2 times as much as Michael. Show how many elastic bands Tracy has.
- Discuss the reason behind their choices. Ask if they are unsure about any?

Link forward: Elicit thoughts about the best way to go from a picture to a written description, with words, of what you drew.

Mini-lesson — 10 minutes

What's the best way to express a mathematical statement?

Objective: Determine the most efficient way to express a mathematical statement.

Procedures: *"In our earlier example, we looked at physical representations of mathematical expressions. This time, we are going to use written statements to demonstrate our expressions."*

- You may wish to model one for students.
- In a small group, decide the best way to express one or some of the following statements:
  - William has 5 lego blocks and John has 6 lego blocks. Kate has 8 more than William and John. Write an expression to show how many blocks Kate has.
  - Nancy has 1 eraser and Susan has twice as many as Nancy. Trevor has twice as many as Susan. Write an expression to show how many erasers Trevor has.
  - Ben spent 15 minutes playing in his room and Tammy spent 18 minutes playing in her room. It took their dad three times as long to clean up their mess. Write an expression to show how long it took for their dad to clean their rooms.
  - John earned 12 dollars last month. You earned 6 dollars more than 2 times as much as him. Write an expression to show how much you earned.
- Have students record and label the expressions in their workbooks. (8 minutes)

At the end of the mini-lesson, students can write a synonym for each keyword in their workbooks. (2 minutes)

Keywords

- Expression
- Associative
- Distributive
- Simplified

Let's Discuss: *Why are parentheses used in mathematics? In your workbook or with a partner, record, discuss, or share one example of when parentheses are needed in mathematical expressions and when they are not.*

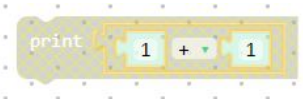
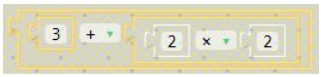
Link forward: Now we're going to use Blockly to explore where we might use parentheses to express a mathematical statement and where we might not.

Describing Expressions

Worked Example

7 minutes

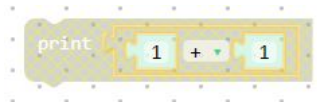
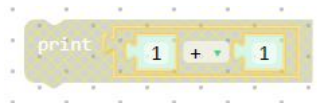
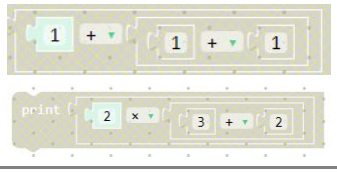
Introduce output through SAM Blockly

Instructions	Workspace	Notes for Teachers
Step 1. Drag on the 'Program Start' block from the 'General' tab.		*This is needed for every program in SAM Blockly. Everything you want to run in the main program has to be contained within this block.*
Step 2. Drag on the 'Print' block from the 'General' tab and snap it into the 'Program Start' block.		*This text block allows you print a welcome message or introduction to the workspace.*
Step 3. Click the empty space between the quotation marks to enter a text. Click "RUN" to see what will be displayed on the console.		*The text entered here can be whatever you want it to be, but challenge 1 will use, Steven has 3 pets. John has 2 pets. Joanna has 2 times as many as Steven and John. Write an expression for this."*
Step 4. Drag on the 'Print' block from the 'General' tab onto the workspace.		*This is not being put within the Program Start block: this block is being used as a discussion point.*
Step 5. From the 'Math' tab, drag on a '1+1' block and connect into the 'Print' block's empty space.		*This will be the starting point for the expressions.*
Step 6. Duplicate the '1+1' block and place it into the second space showing '1'. Place them both within the Print block.		*This is an example showing two operations in the expression. The two terms on the right are within parentheses.*
Step 7. Modify the numerals and operands to display 3 + (2 x 2).		*This will be the first expression. Have students consult with one another as to whether they think the expression matches the description from step 3. You might ask students to justify their point of view with drawings and / or examples depicting what this expression does.*

Describing Expressions

Challenge 1 — 7 minutes

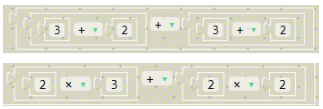
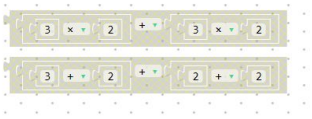
Suggest other possible expressions for the suggested statement

Instructions	Workspace	Notes for Teachers
Step 1. From the 'General' tab drag a 'Print' block onto the workspace.		*This will house the expressions, like in the worked example.*
Step 2. From the 'Math' tab, drag a '1+1' block and connect into the 'Print' block.		*This will be the starting point for the expressions.*
Step 3. Drag 2 further '1+1' blocks onto the workspace and connect as shown.		*This will be a way to display this expression in expanded form. The next two steps suggest two ways that expressions could be displayed*
Step 4. Modify the numerals to become an addition of two expressions: Stephen and John's pets.		*This expression refers to Step 3 from the Worked Example.*
Step 5. Repeat steps 1 - 4, but this time make it the sum of Joanna x Stephen and Joanna x John.		*Take time to discuss how these expressions are equivalent.*
Step 6. From the 'General' tab drag a new 'Print' block onto the workspace.		*Use the opportunity to ask students what blocks could be inserted into the print block to replace the text section.*
Step 7. From the 'Math' tab, drag a '1+1' block and connect into the new 'Print' block.		*Ask students for examples of number sentences that could be entered into this block, ensure that students are aware of the different operators as a drop down option between the numbers.*
Step 8. Insert a second '1+1' block into the second space. Modify the expression to become Joanna x (Stephen + John).		*Take time to talk about the reason why this can be expanded to become either of the above examples.*

Checks for understanding: *How do we know these expressions are correct? Why might mathematicians choose the expression from step 9, instead of the other ones?*

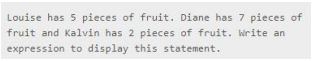
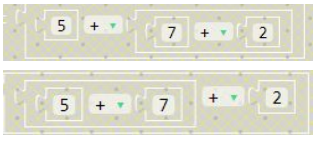
Challenge 1 - Debug it — 5 minutes

Check to ensure the expression is correct.

Instructions	Workspace	Notes for Teachers
Step 1. Inspect the expressions to ensure that the operators are correct.		*If the operators and operands have not been inserted properly, the expression becomes something else entirely.*
Step 2. Ensure that the operands are arranged properly in the expression.		
Step 3. Test to see what would happen if operands or operators were mixed up.		*The results here are neither equivalent not correct*

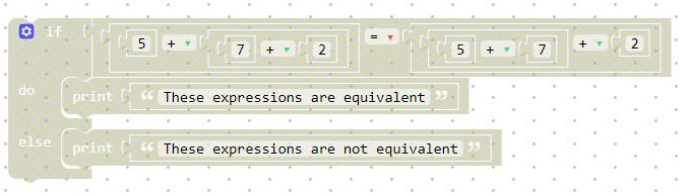
Challenge 2 — 7 minutes

Use SAM Blockly to express a mathematical statement in a variety of ways

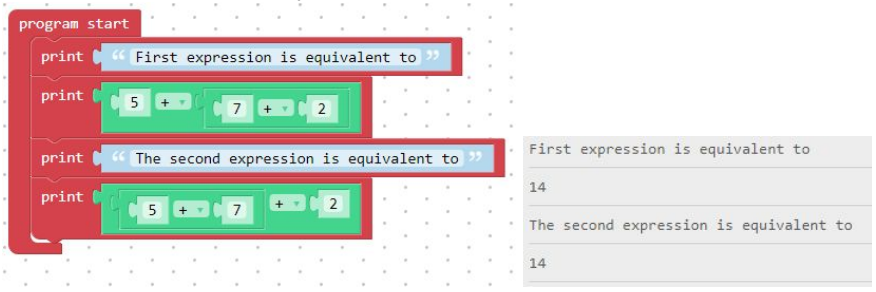
Instructions	Workspace	Notes for Teachers
Step 1. • Clear the workspace. • From the 'General' tab, drag a 'Program Start' block and a 'Print' block onto the workspace. • Connect the 'Print' block into the Program Start block.		*As mentioned, the 'Program Start' block is needed for every program in SAM Blockly. Everything you want to run in the main program has to be contained within this block.*
Step 2. Click the empty space between the quotation marks on the 'Print' block to enter text. Click "RUN" to see what will be displayed on the console.		*The text entered here can be whatever you want it to be, but challenge 2 will use, "Louise has 5 pieces of fruit. Diane has 7 pieces of fruit and Kalvin has 2 pieces of fruit. Write an expression to display this statement."*
Step 3. Duplicate step 8 and 9 from Challenge 1 to display an expression.		Explain that the way Blockly works is that whenever there is more than one operation, parentheses are used.
Step 4. Repeat step 3 but place the 2nd '1+1' block into the space for the 1st value. Enter integers from the sentence in Step 2.		*Two examples are included from the text example but the order is not important with addition. Ask students why this is possible with addition. After discussion, highlight that this is the associative property at work.*

Extension Ideas:

- **Computing**:
  - Students could investigate using loops rather than using the x operator for their expressions.
  - Logic could be explored comparing two expressions to see if the results are the same:



- **Math**:
  - Students could apply the commutative property to this expression and get many more examples.
  - Students could begin to evaluate their expressions by placing the Print blocks within the Program Start block to compare the results:



Checks for understanding: *Which block is essential for this program to run? How do you make sure statements stay together?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

Overview

During this lesson, students will explore the result of expressions that make use of numerical values and parentheses. Students will write expressions in SAM Blockly and comparing the results of expressions. *Lesson 3.9 Describing Expressions is a useful prerequisite to this lesson.*

Key Information

Level 3: (Ages 9-11) US Grade 4 or 5 Time: 45/90 minutes

Lesson consists of...	
Warm-Up	5 mins
Mini-lesson	10 mins
Worked Example	7 mins
Challenge 1	7 mins
Challenge 1 - Debug	5 mins
Challenge 2	7 mins
Tidy Up / Exit Ticket	4 mins

Learning Objectives

As a result of this lesson, students will be able to

- ➔ Evaluate mathematical expressions
- ➔ Determine the effect of parentheses on expressions by comparing it with similar expressions without them
- ➔ Write expressions in SAM Blockly and compare them manually and automatically; identify whether the expressions are equivalent or not
- ➔ Use trial and error in order to find which expressions are equivalent, determine why

Lesson Topics

Math
- ➔ Evaluating expressions
- ➔ Interpret the effect of parenthesis

Scientific Thinking
- ➔ Design a hypothesis about parentheses and how they affect expressions

Computing
- ➔ Inputs, outputs, logic, debugging

Design and Technology
- ➔ Generate, develop, model and communicate ideas through talking, drawing and mock-ups

English Language Arts
- ➔ Participate in collaborative conversations.
- ➔ Use information gained from illustrations and text to demonstrate understanding
- ➔ Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 4-5 topic or subject area

Materials required

- ➔ SAM Blockly
- ➔ Student Workbook
- ➔ Cards with printed statements

Warm Up — 5 minutes

How can I express a written sentence mathematically?

Lesson 3.10
Comparing Expressions

Objective: Identify which written sentences correspond to mathematical expressions.

Procedures: *"Today we are going to evaluate mathematical expressions, comparing what happens when numbers are recorded in different ways."*

- Students will see 4 sentences printed on cards, 4 corresponding expressions and 4 single number answers.
- The task is to discuss together, which sentence goes with which expression and provide justification.
- Sentences:
  - Louie has 3 bananas, Ralph has 4 more than 2 times as much as Louie. Write an expression for the number of bananas Louie has.
  - Sheila has 3 blue medals and 4 green medals. Betty has 2 times as many medals as this. Write an expression for how many medals Betty has.
  - David had 3 pieces of pizza, Megan had 2 pieces of pizza. Their uncle ate twice as many pieces of pizza. Write an expression to show how many pieces the uncle ate.
  - Rover had 3 bones in his dish. Spot had 2 more than twice as many bones as Rover. Write an expression for the number of bones Spot had.
- Expressions

2 x 4 + 3 or (2 x 4) + 3	2 x (4 + 3)	2 x (3 + 2)	2 x 3 + 2 or (2 x 3) + 2

- Number answers

11	14	10	8

Link forward: What did you notice about the effect of the parentheses? What did you notice about when you really needed the parentheses?

Mini-lesson — 10 minutes

Express and solve mathematical expressions

Objective: Describe and evaluate mathematical expressions.

Procedures: *"You have practiced matching up written sentences with mathematical expressions, now let's produce mathematical expressions from sentences, and vice versa. When you're done, compare the results of the expressions. Why are the results are different even when the numbers are the same."*

- Model the first one. Show the word problem, together picking out the main parts of the sentence in order to write the expression. If parentheses are suggested, ask why and what happens if they are removed. If they are not, why not.
  - James had 3 giant peaches, Charlie had 4 chocolate bars and Danny had 5 pheasants more than Charlie's and James' collections. Write an expression to show how many pheasants Danny had.
  - Draw or write the idea that the 3 and 4 need to be added. The additional 5 also has to be added to find Danny's total.
- Ask about parentheses. Where should they go. Explore the result of having the parentheses in a variety of places and not having them at all. (8 minutes)

At the end of the mini-lesson, students can write a synonym for the keywords in their workbooks. (2 minutes).

Keywords

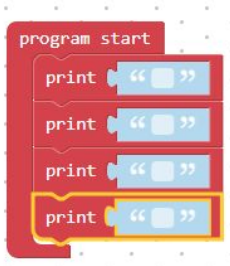
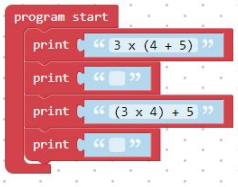
- Equivalent
- Evaluate
- Operand
- Expression
- Operator

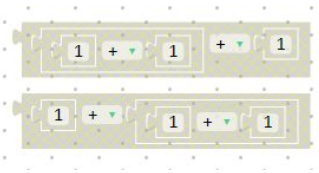
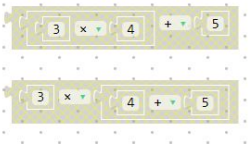
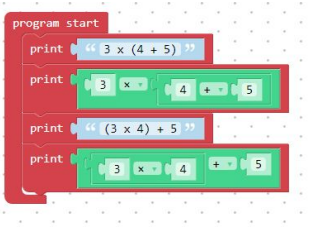
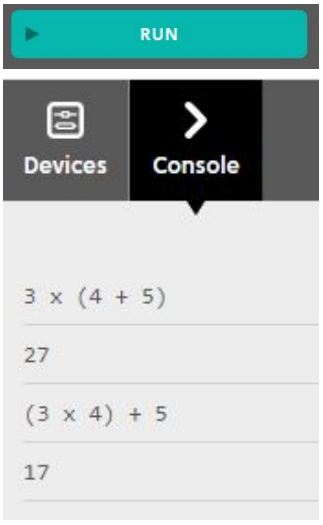
Let's Discuss: *Why are parentheses so important? In your workbook or with a partner, record, discuss, or share the effect parentheses can have on mathematical expressions.*

Link forward: How can we compare mathematical expressions automatically? How can we indicate when expressions are equivalent or different?

Worked Example — 7 minutes

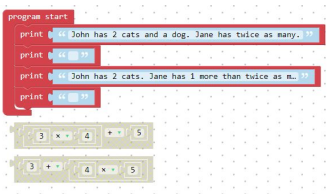
Program a SAM Blockly system that can evaluate and compare mathematical expressions

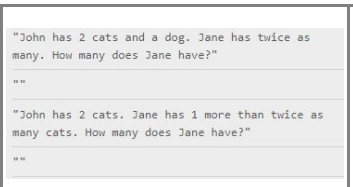
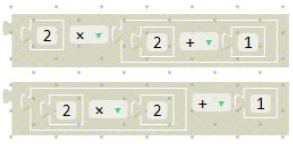
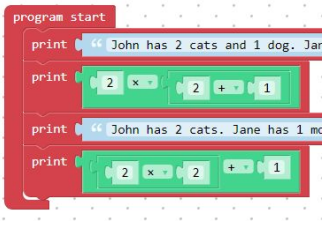
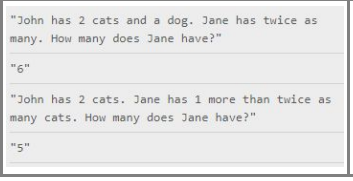
Instructions	Workspace	Notes for Teachers
Step 1. • From the 'General' tab; drag on the 'Program Start' block and 'Print' block; • From the 'Math' tab, drag on the '1+1' block		*These are the 3 blocks that are essential for this example. They will be used to evaluate expressions upon pressing RUN. To have more of these made, left click to select a block and then right click and choose 'Duplicate'.*
Step 2. Duplicate the 'Print' block 3 times, by 'Right-clicking' the 'Print' block and choosing 'Duplicate', so you will have 4 'Print' blocks in total. Snap them all into the 'Program Start' block.		*These 4 blocks are used for 2 different purposes. 2 of the blocks will return the text of the expression and 2 of the blocks will evaluate the expression.* *Highlight the block, right click and select the 'duplicate' option.*
Step 3. Type the expressions you want to compare into the first and third print blocks. These are just examples.		*This system uses 3 x (4 + 5) and (3 x 4) + 5.The parentheses in the second expression are redundant but are included because of how the expressions will look in the later blocks.*
Step 4. From the 'Math' tab, drag on 1 '1+1' block and duplicate 3 times.		*This prepares the blocks for expressions that will follow.*

Step 5. • Snap 1 of the '1+1' blocks into 1st space of another of the '1+1' blocks. • Repeat this for the 2nd set of '1+1' blocks but into the 2nd space.		*This is just to set up the expressions, the next step will change the numerals.*
Step 6. Modify the numerals and the operator in the '1+1' block to match the expressions that have been entered into the 'Print' blocks.		*The operator is changed by selecting the dropdown menu on the '1+1' blocks.* This system uses the expressions from step 2: 3 x (4 + 5) and (3 x 4) + 5.
Step 7. Snap them in to the correct, empty, 'Print' block.		*The blocks are ordered so that the text is printed first and the value for the expression follows.*
Step 8. Click "RUN" to see the results in the console.		*You now have a system where text is printed and an answer will appear on a new line on the console. This will happen for both expressions. Ask students why they think it is important to have expression values printed after the text statements.*

Challenge 1 — 7 minutes

Use knowledge of expressions and parentheses to write statements and convert them to mathematical expressions

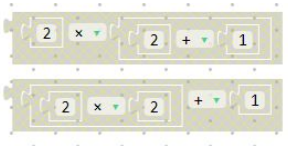
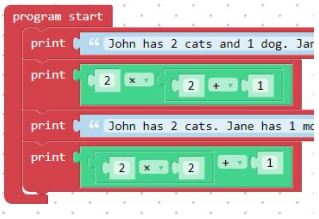
Instructions	Workspace	Notes for Teachers
Step 1. Enter text into the 1st and 3rd of 4 'Print' blocks. Use the same numerals for different sentences.		*Clear the text from each of the 4 'Print' blocks, but keep the '1 + 1' blocks on the workspace; drag the text from the 1st and 3rd 'Print' block to the trash can in the bottom right.* *The new text is, "John has 2 cats and a dog. Jane has twice as many.* *John has 2 cats. Jane has 1 more than twice as many cats."*

Step 2. Click “RUN” to see results of the text entry in the console.		*The results will show in the left-most section of the screen: the console. The text here is, “John has 2 cats and a dog. Jane has twice as many. How many does Jane have?* *John has 2 cats. Jane has 1 more than twice as many cats. How many does Jane have?”*
Step 3. Change the expressions (numerals) from step 5 of the worked example to reflect the new statements (text).		*The new expressions are 2 x (2 + 1) and (2 x 2) + 1.* *This is a point where you can discuss, at your table, the effect that parentheses will have on the expression.*
Step 4. Snap in the expressions to the appropriate ‘Print’ block.		*This now has the text statement followed by the result of the expression for each statement.*
Step 5. Press “Run” to see the results of the expressions.		*The results will show in the left-most section of the screen: the console.*

Checks for understanding: *In this case, did the use of parentheses increase or decrease the result? What did the parentheses do this expression?*

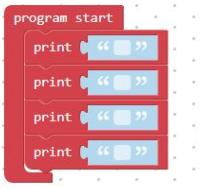
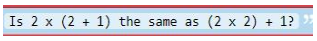
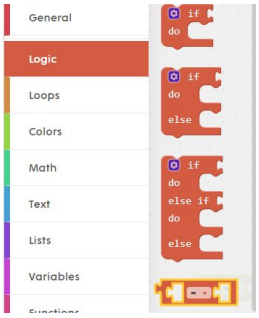
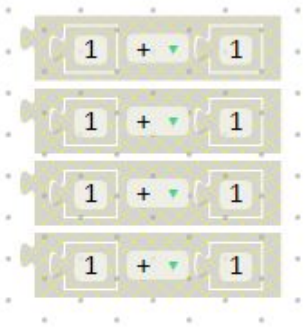
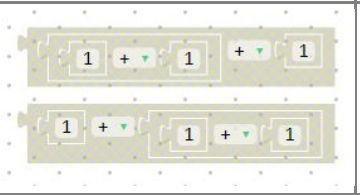
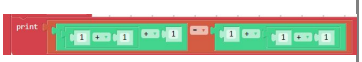
Challenge 1 - Debug it — 5 minutes

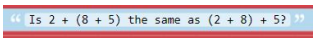
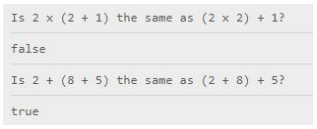
Why might expressions return unexpected results?

Instructions	Workspace	Notes for Teachers
Step 1. Check the order of, and numbers and symbols used for, the expression.		*Check if the x or + are in the wrong place. Check if the parentheses are used properly. They results will be for what was entered but sometimes there are errors when the text was entered: the wrong operator - + or x - or the ‘1 + 1’ block was put in the wrong place. Encourage students to swap around the numbers and symbols to see the results on the answer.*
Step 2. Check that each statement links to the proper expression.		*Have students written the correct expression but attached it to the wrong statement? Have students describe what the numerical expression means.*

Challenge 2 — 7 minutes

To use SAM Blockly to compare the results of two expressions - True or False

Instructions	Workspace	Notes for Teachers
Step 1. Move all of the content from the 'Print' blocks to the trash can.		*You should now see 4 empty 'Print' blocks within the 'Program Start' block.*
Step 2. Enter a comparison statement into the first 'Print' block. For this system, we have used: "Is 2 x (2 + 1) the same as (2 x 2) + 1?"		*Encourage the use of two different operators. x and + are used here.* *Any two expressions could be used at this point, but ensure that both use the same numbers and symbols with parentheses in a different place.*
Step 3. From the 'Logic' tab, drag a 'Comparison' block onto the workspace.		*The Comparison block allows for two expressions to be compared by choosing the symbol: =, <, >, etc.*
Step 4. From the 'Math' tab, drag on 1 '1+1' block and duplicate 3 times.		*These 4 blocks will be used as the basis for the upcoming comparison.*
Step 5. Follow the steps from the Worked Example, step 5.		*Snap 1 of the '1+1' blocks into 1st space of another of the '1+1' blocks.* *Repeat this for the 2nd set of '1+1' blocks but into the 2nd space.*
Step 6. • Snap both '1+1' blocks into the empty spaces of the 'Comparison' block. • Snap the 'Comparison' block into the 2nd Print block.		*You now have the 2 expressions from before but rather than returning values you will now be told if this is 'True' or 'False'.*

Step 7. Modify the numbers and symbols to be the same as the statement used in step 2.		*Example statement from step 2: "Is 2 x (2 + 1) the same as (2 x 2) + 1?"*
Step 8. Enter a second comparison statement into the 3rd Print block. Our example is, "Is 2 + (8 + 5) the same as (2 + 8) + 5?"		*Encourage the use of two of the same operators.* *Ensure that students see that when all operators are addition or all operators are multiplication, the order of the calculation is not important.*
Step 9. • Duplicate the 'Comparison' block from step 7. • Modify the numbers to be from the statement you used in step 8. Our example was, "2 + (8 + 5) = (2 + 8) + 5".		*You now have 2 comparisons of 2 expressions: do you think they will both return 'True', 'False' or is it a mixture? Why do you think this?*
Step 10. Click "Run" to see the results in the Console.		*Talk about what made these two expressions different in terms of their parts and the resulting comparison.* *Why does only one expression return 'true'? Do you see anything that each set of expressions shares and anything that they do not share?* *One set of expressions has two different operators, one set of expressions uses the same operators throughout.* *Encourage students to try out their own comparative expressions.*

Extension Ideas:

- **Computing**:
  - Depending on hardware used for this system, students could add SAM blocks to add output in the form off light or sound when certain results are achieved.
  - Students could add If / Then blocks to the system to give different output depending on the result of the comparison.
- **Math**:
  - Ask students if there are example values that would result in equivalent expressions even when using parentheses sometimes results in different values: 1 x (3 + 5) = (1 x 3) + 5
  - Ask students to experiment with inequalities as a comparator between their expressions in an attempt to make the comparison true; do they notice any patterns?
- **Science**:
  - Are there any other hypotheses you can create with regard to expressions or their resulting values?

Checks for understanding: *Which function was used to tell if two expressions were the same? Which expressions always resulted in equivalent values when parentheses were used in different places?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

Apostrophe

Overview

During this lesson, students will learn how an apostrophe is used. Students will integrate and exhibit learning by building a game to investigate apostrophes for possession and contraction.

Key Information

Level 3: (Ages 9-11) US Grades 4 or 5 Time: 45/90 minutes

Lesson consists of...	
Warm-Up	5 mins
Mini-lesson	10 mins
Worked Example	7 mins
Challenge 1	7 mins
Challenge 1 - Debug	5 mins
Challenge 2	7 mins
Tidy Up / Exit Ticket	4 mins

Learning Objectives

As a result of this lesson, students will be able to

- ➔ Differentiate between the two uses of apostrophes
- ➔ Use apostrophes to form contractions
- ➔ Use apostrophes to show possessives
- ➔ Build a light and sound game using a SAM system

Lesson Topics

English Language Arts
- ➔ Use an apostrophe to form a contraction and possessive.
- ➔ Collaborative discussion and group work.
- ➔ Using a range of techniques (adjective, adverb etc.) to form sentences.
- ➔ Recognise and use a range of simple punctuation

Computing
- ➔ Inputs, outputs, abstraction, debugging

Design and Technology
- ➔ Generate, develop, model and communicate ideas through talking

Scientific Thinking
- ➔ Asking relevant questions and using different types of scientific enquiries to answer them

Materials required

- ➔ SAM Labs Kit
- ➔ Student Workbook
- ➔ Scissors
- ➔ Felt tips
- ➔ Blu tack
- ➔ Words to sort/cut out

Warm Up — 5 minutes

Using apostrophes

Objective: Students learn that apostrophes can be used to form contractions and possessives.

Procedures:

- "Kung Fu Punctuation" warm up. Recap function and use of of simple punctuation - Capital Letter, comma, full stop, exclamation mark, question mark (see clip for background to "Kung Fu Punctuation" .
- Students come up with a new Kung Fu move for an apostrophe.
- Look at two uses of apostrophe. What is the difference between how they have been used?
- *An apostrophe can be used in two ways. A possessive apostrophe is used to show something belongs to someone. You can also use an apostrophe to show you have omitted some letters when joining words together. This is called contraction.*
- Students have a selection of words (printed and cut out from the slides) and work with a partner to sort them into two groups: possessive apostrophes and contractions.
- Discuss how students sorted their words. Were they correct? Were any of the words trickier than others to sort?

Link forward: Apostrophes can be used for possession or contraction.

Mini-lesson — 10 minutes

How do we form contractions?

Objective: Students use apostrophes to form contractions.

Procedures: *When we join words together we use an apostrophe to take the place of the missing letter. Sometimes we need to rearrange the letters a bit, and the apostrophe will take the place of more than one letter. When we use apostrophes for contraction it can make our writing a bit friendlier.*

- Students discuss ideas for when they would need to use 'friendly' writing e.g. postcard, character conversation, comic strip.
- *We are going to form our own contractions.*
- Display the words 'did not' on a piece of paper. Which letter, or letters, do we need to pop out to shorten this?
- Cut out the 'o' and gap between the two words. Push them together and secure using a small piece of Blu Tack. Use a bright pen to draw the apostrophe in place of the 'o'.
- Students work with a partner to cut up and shorten the words they sorted into the contraction group in the Warm-up activity. (8 minutes)

At the end of the mini-lesson, students can match or define keywords in their workbooks. (2 minutes)

Keywords

- Apostrophe
- Possessive
- Contraction

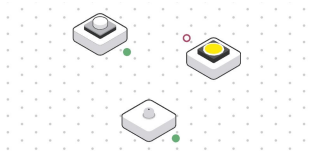
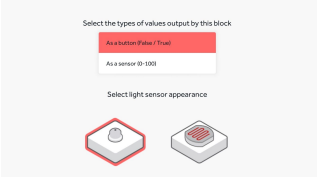
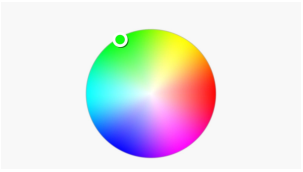
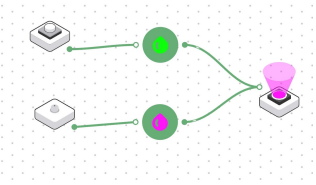
Let's Discuss: *Which is the correct contraction of 'we will'? In your workbook or with a partner, record, discuss, or share how we use apostrophes for possession*?

Link forward: We are going to build a game to use when identifying different uses of the apostrophe.

Apostrophe

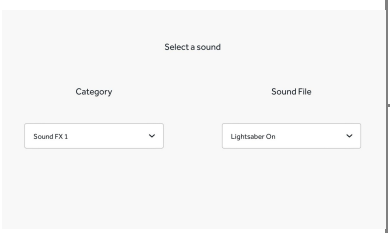
Worked Example — 7 minutes

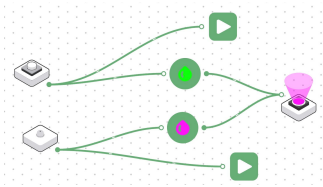
Build a light system with two different colors for the Apostrophe game

Instructions	Workspace	Notes for Teachers
Step 1. Pair and add the following blocks to the Workspace: • Button/Virtual Button block • RGB LED block • Light Sensor block		*If you do not have a Light Sensor block, you can use a Key Press block instead.*
Step 2. Edit the settings of the Light Sensor block to act as a button.		*The Light Sensor can now be used as a Button.*
Step 3. Drag 2 Color blocks onto the Workspace.		*These will allow students to change the color of the Light.*
Step 4. Edit and select a color within the settings of one color block. Repeat for the second color block.		*Students must choose a different color for each block.*
Step 5. Connect the blocks in the following order: • Button block to Color block then to RGB LED block • Light Sensor block to second color block then to RGB LED block.		*Pressing the Button block or covering the Light Sensor block should now change the color of the RGB LED accordingly.*

Challenge 1 — 7 minutes

Add sound to the light system for the Apostrophe game

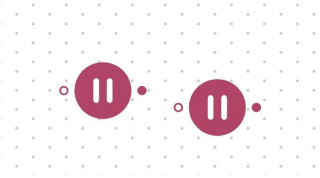
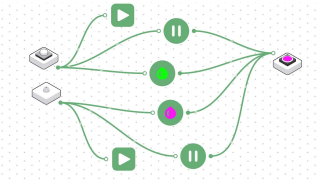
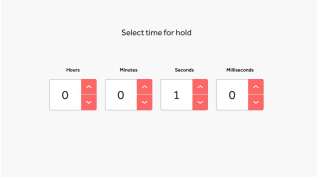
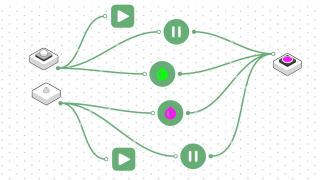
Instructions	Workspace	Notes for Teachers
Step 1. Drag 2 Sound Player blocks onto the Workspace.		*Depending on which input is activated will depend on the sound activated.*
Step 2. Edit the settings of one Sound Player block and select a sound.		*Sound FX 1 and Sound FX 2 contain the best sounds for this activity.*
Step 3. Repeat Step 2 with the second Sound Player block.		*It is important that the two chosen sounds are easily distinguishable.*

Step 4. Connect each input to one of the Sound Player blocks.		*Each Sound Player needs to be connected to a different input.*
Step 5. Test the system.		*Does a different sound play as each button is pressed?* *Does this correspond to the change in light color?*

Checks for understanding: *Why do we need to use the Light Sensor as a button? Can you identify the output in the system?*

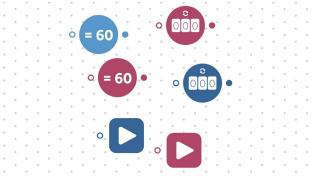
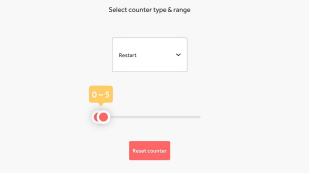
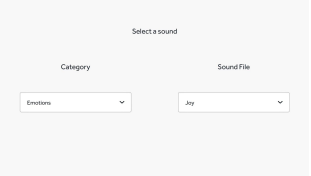
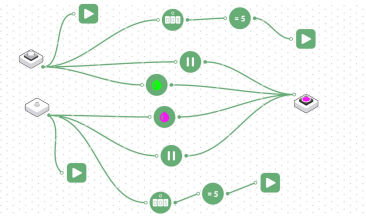
Challenge 1 - Debug it — 5 minutes

How can we prevent the RGB LED from staying on?

Instructions	Workspace	Notes for Teachers
Step 1. Drag 2 Hold blocks onto the Workspace.		*They will be a different color until connected to the rest of the system.*
Step 2. Connect the blocks: • Button block to the input of the first Hold block and the output to the RGB LED. • Light Sensor block to the input of the second Hold block and the output to the RGB LED.		*Students need to attach the Hold blocks between the Light Sensor/Button and RGB LED.*
Step 3. Edit the settings of both Hold blocks and set to 1 second.		*Setting the hold for 1 second is enough time for students to see the light without delaying the pace of the lesson.*
Step 4. Test the system.		*Does the light turn off after 1 second?*

Challenge 2 — 7 minutes

Turn the system into the Apostrophe game

Instructions	Workspace	Notes for Teachers
Step 1. Drag the following blocks onto the Workspace: • 2x Counter blocks • 2x Compare blocks • 2x Sound Player blocks		*Students will use these blocks to create a game.*
Step 2. Edit the settings of the Counter block and set the range to 0-5. Select the Reset option.		*Repeat this step for both Counter blocks.*
Step 3. Edit the settings of the Compare block and set the value to = 5.		*Repeat this step for both Compare blocks.*
Step 4. Edit the settings of the Sound Player block and select the category 'Emotions' and the sound file 'Joy'.		*This will create a cheering sound when one team wins.*
Step 5. Connect the blocks to the system in this order: • Button block to Counter block to Compare block to Sound Player block. • Light Sensor block to 2nd Counter block to 2nd Compare block to 2nd Sound Player block.		*The system is now ready to use as a game.*
Step 6. Play the Apostrophe Game!	*How to play the Apostrophe Game:* 1. *Split class into 2 teams.* 2. *Team 1 will be 'Possessives' and Team 2 will be ' Contractions'.* 3. *Use the slides to flash up a selection of different sentences containing words with apostrophes. If the apostrophe is used in a possessive format then Team 1 press their button. If the apostrophe in the word is used as a contraction then Team 2 press their button.* 4. *The team who gets to a count of 5 and sets off the cheering have won.* 5. *Repeat for another round.* *Extension: Repeat the game but with a page from a shared book instead of individual words.*	

Extension Ideas:

- **Math:**
  - Use the system from Challenge 2 to play any number of times tables or division games.
- **English**:
  - Plan and draft an extended piece of writing using apostrophes.
  - Write a set of instructions explaining how to create the game using the SAM system.

Checks for understanding: *Which of these sentences is correct? x2*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

Lesson 3.12

Rocks and Wind

Overview

During this lesson, students will learn about the four spheres that make up the Earth and how they can interact with each other; focusing on the interaction of the atmosphere on the geosphere. Students will integrate and exhibit learning by creating a system to simulate the speed and sound of the wind and the impact of the wind on a model rock formation.

Key Information

Level 3: (Ages 9-11) US Grades 4 and 5 Time: 45/90 minutes

Lesson consists of...	
Warm-Up	5 mins
Mini-lesson	10 mins
Worked Example	7 mins
Challenge 1	7 mins
Challenge 1 - Debug	5 mins
Challenge 2	7 mins
Tidy Up / Exit Ticket	4 mins

Learning Objectives

As a result of this lesson, students will be able to

- ➜ Identify from the fossil the period it would have been within and the rock layer location
- ➜ Discuss the impact of weather on a rock formation
- ➜ Demonstrate the sound and speed of the wind with a SAM system
- ➜ Create a rock formation and simulate the impact of wind

Lesson Topics

Earth and Space Science
Model the effect of weather and the impact of erosion

Computing
Inputs, outputs, abstraction, debugging.

English Language Arts
Participate in collaborative conversations.

Math
Measure and estimate in standard units.

Materials required

- ➜ SAM Labs Kit
- ➜ Student Workbook
- ➜ Cheetos
- ➜ Cardboard
- ➜ Glue
- ➜ Sandpaper block
- ➜ Elastic bands
- ➜ Stopwatch

Rocks and Wind

Warm Up — 5 minutes

Which era would the fossil be from?

Objective: Identify from the fossil the period it would have been within and the rock layer location

Procedures: *"Today we are going to learn about rock formation and how this can be affected/changed"*

- Students look at the image showing the 3 x periods of time; Paleozoic, Mesozoic and Cenozoic and the description of each;
  - Paleozoic era = fish, amphibian, and reptile fossils in that order
  - Mesozoic era = dinosaurs, first flowering plants, birds, and mammals
  - Cenozoic era = modern mammal fossils like cats, dogs, monkeys and humans.

Link forward: Link to looking at the 4 x spheres that make up Earth and how interaction can help us find these fossils.

Mini-lesson — 10 minutes

How are rock formations made and changed?

Objective: Discuss the impact of weather on a rock formation

Procedures: *"A rock formation is formed by the world around us"*

- Discuss that the Earth is made up of 4 x Spheres and those spheres encompass:
  - Hydrosphere, comes from the greek word for water and covers all water forms on Earth
  - Geosphere, comes from the greek word for ground and covers all land/rock on Earth.
  - Biosphere, comes from the greek word for life and covers all living things on Earth
  - Atmosphere, comes from the greek word for air and covers all gases on Earth.
- Students could watch these informative videos on the spheres - Geosphere and Biosphere - https://www.youtube.com/watch?v=VMxjzWHbyFM and Hydrosphere and Atmosphere - https://www.youtube.com/watch?v=UXh_7wbnS3A
- A rock from the Geosphere can be affected by the wind in the atmosphere; this is called chemical weathering and can cause erosion. Changes to the rock formation and landscape can happen as a result of erosion.
- Simulation on https://www.nhc.noaa.gov/aboutsshws.php shows the effect and damage of increasing wind with a scale of the hurricane's intensity. Point out the terms e.g. Category 1 etc.
- Can these interactions be stopped or slowed down by technology? Reducing wind speed at ground level and improving soil cohesion so smaller and lighter soil or sand is not lifted and moved with the wind are two methods for slowing down hurricane damage.

Keywords

- Hydrosphere
- Geosphere
- Biosphere
- Atmosphere
- Chemical Weathering
- Formation

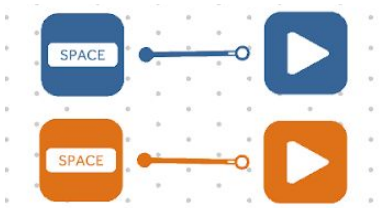
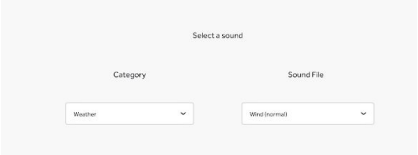
Let's Discuss: *What is the name of the sphere related to rocks? In your workbook or with a partner, record, discuss, or share a way each of the four spheres can be remembered.*

Link forward: Link to creating a model to show the impact of the atmosphere on the geosphere.

Rocks and Wind

Worked Example — 7 minutes

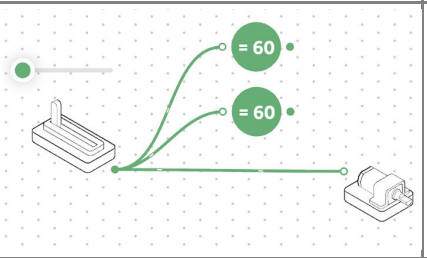
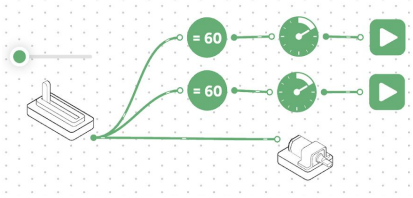
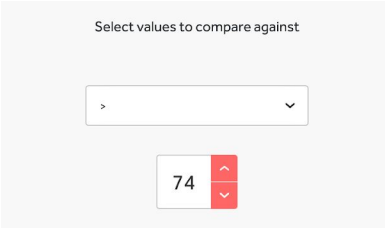
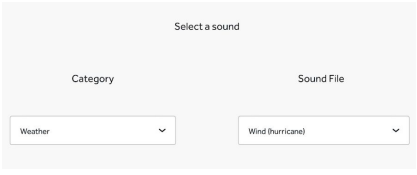
Can we simulate the sound of the wind in the atmosphere

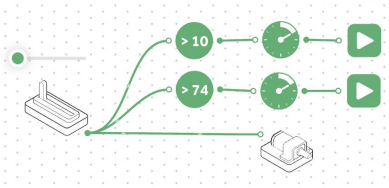
Instructions	Workspace	Notes for Teachers
Step 1. Drag the following blocks onto the workspace: • 2 x Key Press block • 2 x Sound Player block		*The Key Press block will be the input and the Sound Player block will be the output to this system.*
Step 2. Connect the Key Press block to the Sound Player block. Repeat x 2.		*We now have two systems next to each other that will trigger the Sound Player blocks when the Key Press block is pressed.* *Discuss why having the same Key press block setting is not advisable?*
Step 3. Access the settings of the Key Press blocks and set them to two different options e.g. A and B		*This will allow the sounds to be activated with two different inputs.*
Step 4. Access the settings of the Sound Player blocks and set to: • Category = Weather and Sound file = Wind (normal) • Category = Weather and Sound file = Wind (hurricane)		*There are two sound files within the settings that allow the simulation of wind at a normal level and a second at an increased speed to hurricane level.* *Both these sounds will simulate the sound of the wind in the atmosphere.*
Step 6. Test your system.		*Press the two inputs individually and then at the same time to hear the wind blow.*

Rocks and Wind

Challenge 1 — 7 minutes

Demonstrate the sound and speed of the wind with a SAM system

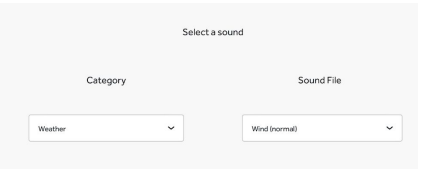
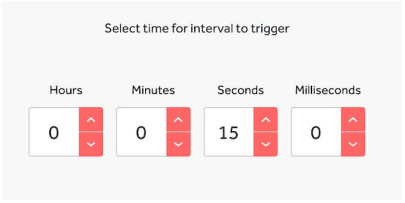
Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • Slider block • DC Motor block Drag onto workspace.		*If you do not have the Slider block you can still use the virtual block on the workspace.*
Step 2. Drag onto the workspace: • 2 x Compare blocks • 2 x Interval blocks • 2 x Sound Player blocks.		*The Sound Player blocks with the DC Motor block will form 3 x outputs to our system.*
Step 3. Connect the blocks in the following order: • Slider blocks to DC Motor block • Slider block to both Compare blocks		*The Slider block will now control the DC Motor block speed. The Compare blocks will take the value from the Slider block.*
Step 4. Connect: • The Compare block to the Interval Block • The Interval block to the Sound Player block. Repeat for both Compare blocks.		*At the moment if the number on the Slider block equals 60 both Sound Player blocks will be activated.* *The purpose of the Interval blocks is to let the sound repeat as a loop.*
Step 5. Access the Compare block settings and set them to: • Top Compare block to '>10' • Bottom Compare block to '>74'		*The 'greater than 10' setting will mean the Sound Player block (the wind) will not start until it reaches a speed of 10 or greater.* *Greater than 74 will simulate a hurricane scale wind; category 1 is 74 mph - 95 mph.*
Step 6. Access the Sound Player settings and set them to: • Top Sound Player block to 'Weather' and 'Wind(normal)' • Bottom Sound Player block to 'Weather' and 'Wind(hurricane)'		*When the Slider block reaches over 10 the normal wind sound will start.* *When the Slider reaches over 75 the hurricane wind sound will start.* *This will simulate that as the speed increases the intensity of the wind will increase too.*

Step 7. Test your system.		*Increase the speed on the Slider block and see the DC Motor turn and the corresponding wind sounds when the respective Compare blocks are triggered.* *When the Slider is returned to 0 the cycle of the sound will need to finish before the sound stops.*

Checks for understanding: *How many outputs are there to this system? What will happen if the Slider block setting is at 80?*

Challenge 1 - Debug it — 5 minutes

Why is the sound not fully playing before repeating?

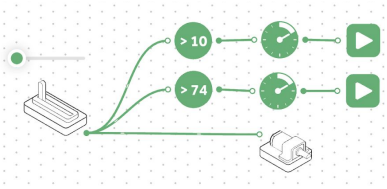
Instructions	Workspace	Notes for Teachers
Step 1. Drag on a Key Press block and a Sound Player block. Connect them together.		*This is a new mini system for the purpose of testing the duration of the individual wind noises.*
Step 2. Access the Sound Player settings and set it to 'Weather' and 'Wind(normal)'		*It doesn't matter which wind noise is completed first.*
Step 3. • Using a stopwatch or similar, time how long the sound stays on. • Access the settings of the Sound Player block and time the second sound.		*It is important to start the stopwatch and press the Key Press block at the same time to generate a true result.*
Step 4. Set the Interval block to the rounded up number of seconds the sound plays for.		*This system has the interval set at the following times which were the results of timing both sounds:* • *Normal wind = 14 seconds* • *Hurricane wind = 15 seconds* *Once timings have been gathered, delete the blocks.*

Rocks and Wind

Challenge 2

7 minutes

Create a rock formation and simulate the impact of wind

Instructions	Workspace	Notes for Teachers
Step 1. Glue Cheetos to a piece of card.		*Glue the Cheetos in a line and close together on the card.* *The Cheetos need to be fresh as if left out for long they will go soft and not work in the experiment.* *Need to use a faster drying glue to ensure the Cheetos stay fresh for the experiment.*
Step 2. Connect the wheel to the DC Motor.		*The wheel will allow stability within the next step.*
Step 3. Secure a sandpaper block to the wheel with elastic bands.		*The elastic bands are crossed over behind the wheel to hold the sandpaper block in place.* *If you do not have a sandpaper block you could use a regular sheet of sandpaper folded up.* *The purpose of the sandpaper block is to simulate the result of the wind's force interacting with the rocks and also carrying smaller substances like 'sand' that would increase the impact.*
Step 4. Hold the wall up or secure to an upright surface.		*This is to ensure that it withstands the pressure applied by the sandpaper block*
Step 5. • Hold the DC motor block and turn on the system. • Move the block closer to the Cheetos wall so that it touches.		*It is important that the two objects interact but not too much pressure is applied to show the true impact from one to another.*
Step 6. Test your system at different settings.		*What happens when the wind is normal as opposed to the hurricane wind.* *The stronger the wind the greater the impact and small and large rocks (Cheetos) will fall from the rock face.*

Extension Ideas:

- **Computing**:
  - What other sound effects or timing blocks could be added to the system to simulate a storm?
  - How has technology helped people living in hurricane prone areas?
- **Geography**:
  - Where in the world are hurricanes more prominent?
  - What are some of the ways different countries have innovated to protect the environment against natural forces such as hurricanes and floods?
- **Science**:
  - What fossils have been located due to erosion?
  - What types of rocks deteriorate quicker in erosion and which withstand it for longer?
  - Investigate further how hurricanes are measured in strength?
  - What years built up the Paleozoic era, Mesozoic era and the Cenozoic era

Checks for understanding: *What does the Slider block simulate? What was the purpose of editing the interval block to 14 seconds?*

Tidy Up / Exit Ticket — 4 minutes

Reinforcing the learning objectives of the lesson, students can reflect on key takeaways by completing and submitting an exit ticket.

