Night Light

Overview

During this lesson, students will gain understanding of how a product has a purpose when it is designed and built. Students will integrate and exhibit learning by designing a night light that changes color and creates a moving pattern.

Key Information

Level 2: (Ages 8-10) US Grades 3 or 4 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	➔ Recognize criteria for an effectively designed night light.
Worked Example	7 mins	➔ Identify types of manmade light and the purpose for which they are used.
Challenge 1	7 mins	➔ Create a SAM night light that changes color and creates a moving pattern.
Challenge 1 - Debug	5 mins	➔ Modify the night light to automatically start when it is dark.
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Art and Design
- ➔ Use a range of materials creatively to design and make purposeful products

Physical Science
- ➔ Shadows are formed when the light from a source is blocked by an object.

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

Scientific Thinking
- ➔ Trial and error combined with calibration and adjustment

English Language Arts
- ➔ Participate in collaborative conversations.
- ➔ Use information gained from illustrations and text to demonstrate understanding.
- ➔ Determine the meaning of key vocabulary relevant to the learning objectives.

Math
- ➔ Duration of events and measurement of time

Materials required

- ➔ SAM Labs Kit
- ➔ SAM Labs Student Workbook
- ➔ Colander
- ➔ Blu tack

Warm Up — 5 minutes

Which of these is the best night light?

Objective: Recognize criteria for an effectively designed night light.

Procedures: *"Today we are going to learn about creating a night light and creating it to a set of specific criteria for success."*

- Look at how types of lighting have a purpose other than just illumination, for example; street lights should be bright and reliable, lights in a bathroom should be bright and moisture resistant.
- Look at a night light and determine what makes it 'good' and 'fit for purpose' and look at three images and label them with the correct set of criteria.

Sample photo ideas: A candle, an elegant night light, an ordinary table lamp

Link forward: Link to designing a night light that fulfils design criteria

Mini-lesson — 10 minutes

Look at various types of manmade light and their purpose

Objective: Identify types of manmade light and the purpose for which they are used

Procedures:

- Introduce the concept that light bounces off all objects and that light enters our eyes which is how we see. (These concepts are explored in "Light and Shadows" and "The Lighthouse" lessons)
- Look at different types of manmade light and how they have a specific purpose.
- Explain that the purpose of a night light is not just to illuminate but also to provide a comfortable ambience conducive to sleep.
- Consider what is important to night light design and the concept of direct or indirect light.
- Consider different types of light, eg: lights in a classroom, street lighting, overhead lights, shaded lights. (8 minutes)

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

Keywords

- Purpose
- Reflection
- Feature
- Design

Let's Discuss: *What does the word "reflection" mean? In your workbooks or with a partner, record, discuss, or share one example of manmade light and its purpose.*

Link forward: Link to students designing a system that can be used as a night light

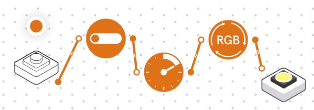
Lesson 2.1

Night Light

Worked Example

7 minutes

Create a system that forms shadows

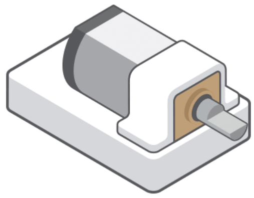
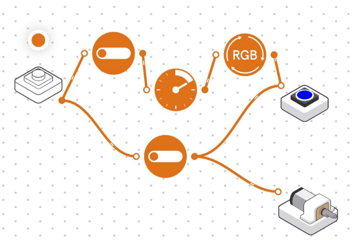
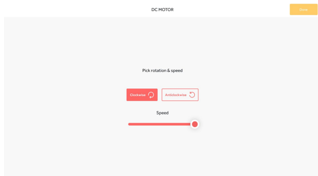
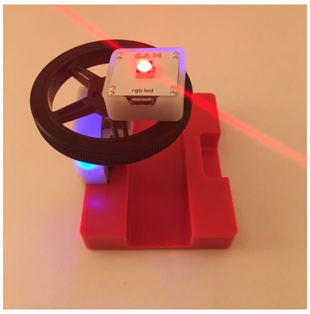
Instructions	Workspace	Notes for Teachers
Step 1. Drag on and pair: • Button/Virtual block • RGB LED block Drag the following blocks onto the workspace: • Toggle block • Interval block • Cycle Colors block		*The Button block will be the input to start the system..*
Step 2. Connect the blocks together in this order; Button block, Toggle block, Interval block, Cycle Colors block, RGB LED block.		*The Toggle block is the switch in our system to turn it on/off. The Interval block will activate the change of color when the time is reached, the default is 1 second.*
Step 3. Drag on a second Toggle block. Connect it between the Button and RGB LED.		*The second Toggle block allows the light to be switched off as well as the Color Cycle when the Key Press is pressed a second time*
Step 4. Place a colander over the top of the RGB LED. Press the Button to activate the system.		*The colander is important as it reduces the amount of light and makes the night light dim. The holes in the colander allow the light to make a pattern on the walls.*

Lesson 2.1

Night Light

Challenge 1 — 7 minutes

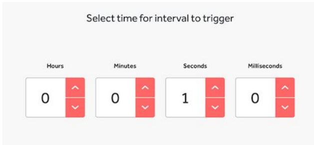
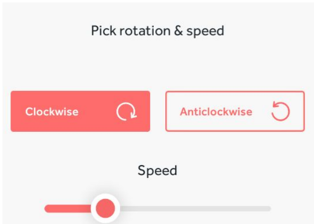
Make a working night light that changes color and creates a moving pattern

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • DC Motor block		*The motor is going to help our light move and create a moving night light effect*
Step 2. Connect the DC motor block to the Toggle block.		*Using the system in the worked example adding the DC Motor to the Toggle block will allow the Button to activate the DC Motor too*
Step 3. Set the motor to clockwise or anti-clockwise. *What are the effects of each direction?*		*The default setting of the DC Motor is clockwise - does going anti-clockwise affect how relaxing the night light seems?*
Step 4. Place the wheel on the DC Motor. Turn the RGB LED on and secure between two spokes of the wheel with blu tack.		*Place the motor in the red SAM Car Controller for steadiness and position the RGB LED. Use blu tack on the wheel, slightly to one side, to allow movement to be seen.*
Step 5. Place a colander over the top of the blocks and activate the system again.		*This time, as the light emits different colors, it will produce a moving pattern on the wall and ceiling.*

Checks for understanding: *Why is it important to make the light stay on without having to constantly press down the input? What does RGB stand for?*

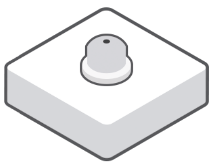
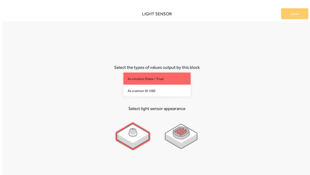
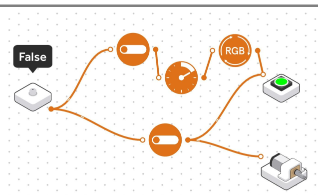
Challenge 1 - Debug it 5 minutes

How can we slow down the motor and the colors changing?

Instructions	Workspace	Notes for Teachers
Step 1. Edit the settings of the Interval block so that the light changes color at a slower rate.		*To slow the speed of the changing colors down, access the settings. Reduce the time and test. Is it better at 1, 2 or 3 seconds? More?*
Step 2. Edit the settings of the DC Motor so that it runs at a slower speed.		*Access the settings, reduce the speed, and test*

Challenge 2 7 minutes

Make a night light that turns on automatically when it goes dark

Instructions	Workspace	Notes for Teachers
Step 1. Remove the Button block. Turn on and pair: ● Light Sensor block		*The Light Sensor can make events happen depending on the brightness. If you do not have a Light Sensor, you can use a Button or a Key Press.*
Step 2. Change the the Light Sensor into a Button.		*The Light Sensor as a button will react specifically to the difference of light and dark*
Step 3. When the block is covered (making it dark) the system will be activated. *Are there other ways you can improve your night light?*		*The system is now automatic and will start the night light when the sensor detects that it is dark*
Step 4. Present your night light to the class.		*This is an opportunity for oral presentations.*

Extension Ideas:

- **Computing/Design Technology**
    - Add a timer to switch night light on at your bedtime and off in the morning.
    - Add a Compare block so that the Sensor will switch on, not only when it is dark, but also when the light goes below a certain level.
    - Experiment with different Interval settings in order to set a rotate rate for the motor which is most relaxing.
    - Experiment with different brightnesses of the RGB LED to see which is the most relaxing.
    - Experiment with different covers instead of the colander.
- **Science**
    - How do we see in the dark? Look at how minimal light can still enter our eyes to help us see
    - Eyesight and disabilities - how has technology helped people see?
- **Geography**
    - Countries of the world and the difference in light - Look at Alaska town Barrow where they don't see the sun for 67 days in winter but have constant sun for 80 days in summer.
- **English**
    - Peer evaluation reports on one other night lights.

Checks for understanding: *Which block, in our final system, detects light and activates the night light? Which block sets the time for changing the color?*

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.

Music Box

Overview

During this lesson, students will gain understanding of how systems and devices for storing and streaming music have evolved. This technology enables people to listen to music. Students will integrate and exhibit learning by designing a 21st century SAM Music Box that stores and streams a melody.

Key Information

Level 2: (Ages 8-10) US Grades 3 or 4

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	➔ Explore how storage mediums have transformed how we experience music
Worked Example	7 mins	➔ Identify technology which allows music to be stored and streamed
Challenge 1	7 mins	➔ Design a physical music box, creating a system to store and stream a melody
Challenge 1 - Debug	5 mins	➔ Automate the system to turn on automatically when specific criteria is met
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Art and Design
- ➔ Use a range of materials creatively to design and make purposeful products

Music
- ➔ Compose music for a product
- ➔ The history of music storage devices
- ➔ Musical notation and performance

Computing
- ➔ Inputs, outputs, debugging

Engineering Design
- ➔ Designs can be conveyed through models
- ➔ A situation that people want to change can be approached through technology
- ➔ There is always more than one possible solution to a problem

History
- ➔ How change occurs, change-making technology such as musical storage

English Language Arts
- ➔ Participate in collaborative conversations.
- ➔ Use information gained from illustrations and text to demonstrate understanding.
- ➔ Determine the meaning of key vocabulary relevant to the learning objectives.

Materials required

- ➔ SAM Labs Kit
- ➔ Student Workbook
- ➔ Blu tack
- ➔ A box or a template to design a box
- ➔ Figurine or object to rotate
- ➔ Optional: materials to decorate the music box such as glitter, puff paint, markers etc.

Warm Up 5 minutes

What is the history of music storage?

Objective: Explore how storage mediums evolved?

Procedures: *"Today we are going to compose a song and explore how it can be stored and streamed using technology. Then, we are going to design a music box to house our song."*

- Discuss how storage mediums have changed over time which has expanded the experience of music e.g. allowing music to travel with the listener.
- Label technology utilized as storage mediums, oldest to newest

Sample photo ideas: A music box, vinyl, cassette tape, a disc, a usb stick

Link forward: Link to exploring how music is streamed.

Mini-lesson 10 minutes

What is similar and different about today's streaming technology?

Objective: Identify technology which allows music to be stored and streamed.

Procedures:

- Explore how the development of the internet has enabled more people to access different types of music through online streaming like YouTube or Spotify, allowing music to be 'on demand', further investigation can be linked to the development of electricity and impact on devices developed.
- What is similar and different about today's streaming technology?
- Pivot to how music boxes are an early, rudimentary example of music storage and streaming.
- *"We're going to bring music boxes into the 21st century today"* (8 minutes)

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

Key Words

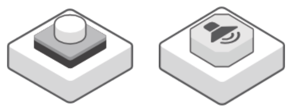
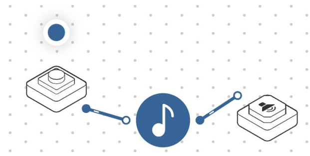
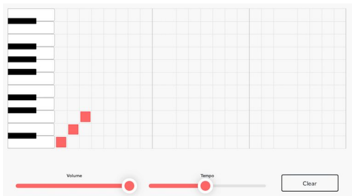
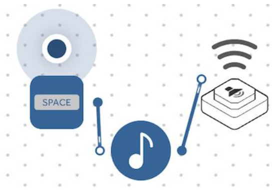
- On-demand
- Streaming
- Storage
- Compose
- Internet

Let's Discuss: *What is meant by "streaming" music? In your workbooks or with a partner, record, discuss, or share what music you like best and how you stream it.*

Link forward: Link to creating students creating own music box whereby music can be stored and streamed on-demand.

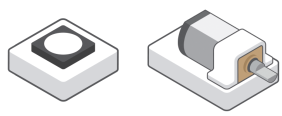
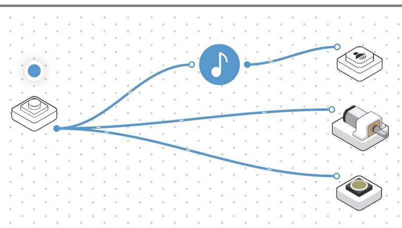
Worked Example — 7 minutes

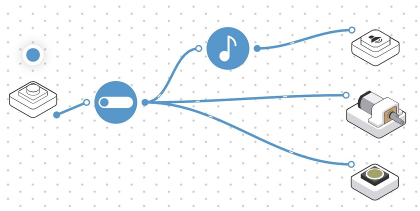
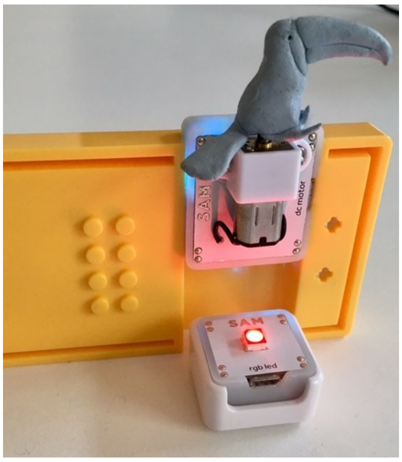
Compose a song that plays a sequence of notes

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • Button/Virtual Button • Buzzer/Virtual Buzzer block		*The Button block will act as our input and the Buzzer block will act as our output*
Step 2. Drag on the Sequencer block. Connect it between the Button and Buzzer blocks.		*The Sequencer allows a 'sequence' of notes and holds the instruction to send to the output the Buzzer block*
Step 3. Open the Settings of the Sequencer block. Choose 3 notes. Test your system.		*The Sequencer allows us to choose from A – D, or if you prefer from La – Re +1 octave. Enabling students to play a C Major scale C – C+1.* *Students need to select the notes directly by choosing the squares.*
Step 4. Add more notes. *Press and hold the Button to play the sequence.*		*Allow students to choose any notes or let them chose notes that make a melody*

Challenge 1 — 7 minutes

Design your music box

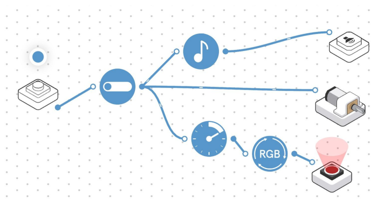
Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • DC Motor block • RGB LED		*The RGB LED will add a lighting feature and the Motor will rotate the figurine.*
Step 2. Connect the DC Motor block and RGB LED to the Button.		*Now the Button controls three outputs. Ask students if they can identify the inputs and outputs of this system.*

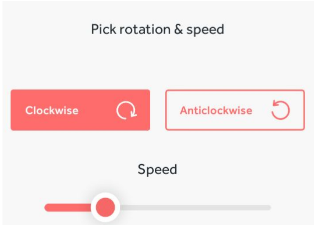
Step 3. Add a Toggle block to the workspace. Add it between the Button, Buzzer, DC Motor, RGB LED. Test your system.		*The Toggle block will allow the system to turn on and off at the press of a Button instead of students having to hold the button down.*
Step 4. Orient the DC Motor and RGB LED in your music box.		*Support students to place this in a way that makes the light visible and motor workable.*
Step 5. Place the figurine onto your motor with blu tack.		*This toucan figurine has been created out of blu tack.*
Step 6. Test your system. Activate your system when the music box is opened.		*Elicit ideas here about how students could improve the system, ahead of the debug.*

Checks for understanding: *What does each square represent in the Sequencer? Where are the Sequencer instructions "sent" to play the music?*

Challenge 1 - Debug it 5 minutes

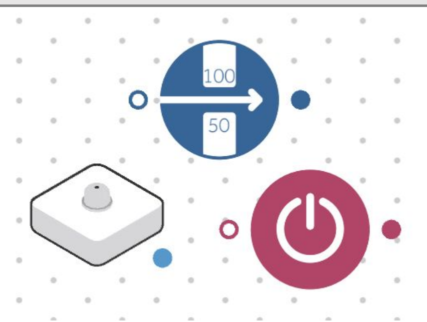
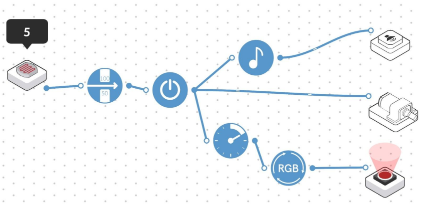
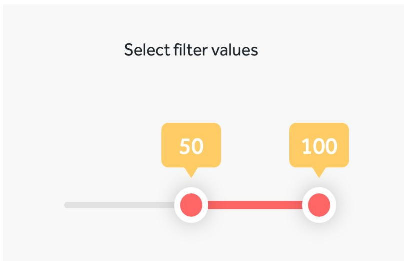
How do we slow down the motor and change the color of the RGB LED?

Instructions	Workspace	Notes for Teachers
Step 1. Add a Interval block and Cycle Colors block to the workspace.		*The combination of the Interval and Cycle Colors block will change the color at a specific interval.*
Step 2. Connect them between the Toggle and RGB LED.		*To slow the speed of the changing colours down, access the settings and reduce the time and test.*

Step 3. Edit the Settings of the DC Motor block so that it rotates at a slower speed. Test your system.		*To slow the speed of the DC Motor, access the settings and reduce the speed and test*

Challenge 2 — 7 minutes

Program the system to turn on automatically when the music box is opened

Instructions	Workspace	Notes for Teachers
Step 1. Remove the Button block. Turn on and pair: • Light Sensor block Drag a Filter and On/Off block onto the workspace.		*The Light Sensor can make events happen depending on the brightness. If you do not have a Light Sensor, you can tinker with other inputs such as the Key Press.*
Step 2. Connect the Filter to the Light Sensor and the On/Off Block to the Filter and Interval, Sequencer and DC Motor blocks.		*The Light Sensor will react specifically to the amount of light and dark. If there is enough light, the system will turn on. If the light drops below a certain level then the system will turn off.* *The addition of the On/Off block allows the value from the light to be turned into a true/false signal.*
Step 3. Set the Filter value to '50-100'. Test your system.		*This means the system will be activated when the light range is between these values (when the box is opened). The filter is now acting as a conditional.* *Encourage students to set a value that reflects the amount of light in the classroom space. They may need to tinker a bit.*
Step 4. When light is detected at a certain value, the system will be activated. *Are there other ways you can improve your music box?*		*The system is now automatic and will start the music box when the light sensor detects that it is light. In this example, the motor is secured onto the yellow Car Chassis with the blu-tack figurine attached. Encourage students to use any of the accessories to optimize their music box.*

Step 5. Present your music box to the class.		*This is a nice opportunity for oral presentations.*

Extension Ideas:

- **Music**
  - Ask students to program a specific song.
  - Change the tempo and volume settings of the music box to optimize the sound of the song.
- **Computing/Science**
  - Can you add build the music box/its features in a different way?
- **Mathematics**
  - How do the tempo and volume settings relate numerically?
- **ELA**
  - Write a persuasive essay that compares and contrasts online musical storage apps. *Which is best and why?*
  - Peer assessment reports on each other music boxes
  - Research and present a strategy for how you could sell your music box to a toy store.

Checks for understanding: *What block is the input on the system? Which part of the system stores the melody*

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

This lesson requires two instructional sessions, with 1 week (7 days) between sessions. During this lesson, students will gain understanding of how change occurs in plant life over time. Students will integrate and exhibit learning by identifying and recording perceptible changes in plant growth.

Key Information

Level 2: (Ages 8-10) US Grades 3 or 4 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 that change takes place at different rates in different settings
Worked Example	7 mins	➔ Compare timescales for how change occurs in objects or plants.
Challenge 1	7 mins	➔ Create a system to capture quick change over time
Challenge 1 - Debug	5 mins	➔ Modify a system to capture slow change over time
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Life Science
- ➔ Some events happen quickly whilst others slowly
- ➔ Plants acquire their material for growth chiefly from air and water

Math
- ➔ Duration of events and measurement of time (months, days hours, minutes, seconds)

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

Scientific Thinking
- ➔ Asking relevant questions and using different types of scientific inquiries
- ➔ Trial and error combined with calibration and adjustment

Computing
- ➔ Inputs, outputs, modifiers, debugging
- ➔ Create, edit, manipulate and present digital content

English Language Arts
- ➔ Use information gained from illustrations and text to demonstrate understanding.
- ➔ Determine the meaning of key vocabulary relevant to the learning objectives.

Materials required

Per group
- ➔ 1 glass water
- ➔ Cellophane
- ➔ SAM Labs Kit
- ➔ ½ tsp sugar
- ➔ 2 sheets kitchen roll
- ➔ Student Workbook
- ➔ 1 yogurt pot
- ➔ peppergrass / cress seeds

Warm Up – Scientific Discussion 5 minutes

Can we observe change as it takes place?

Objective: Identify that change takes place at different rates in different settings.

Procedures: *"Today we are going to learn about how change occurs in plants over time"*

- Discuss how objects can change physically over time and depending on environmental factors.
- Look at pictures and compare the perceptible and imperceptible changes over time.
- Estimate the time it would take for the change to occur and how students know or are able to estimate that.

Sample photo ideas: ice cream, rocks, jeans

Link Forward: Link to designing and building a system that records change

Mini-lesson 10 minutes

Exploring the speed of change

Objective: Compare and contrast timescales for how change occurs in objects or plants.

Procedures:

- Some change we can see (perceptible); like an ice cream melting or a sandcastle disappearing in the ocean waves on the beach, and some we cannot (imperceptible).
- We cannot, for example, see the change in a rock being eroded.
- We can observe the change in plant life and some plants take a shorter amount of time to grow and change – clip (https://www.youtube.com/watch?v=d26AhcKeEbE) (8 minutes).

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

Key Words

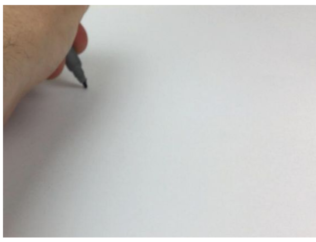
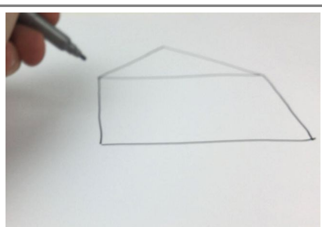
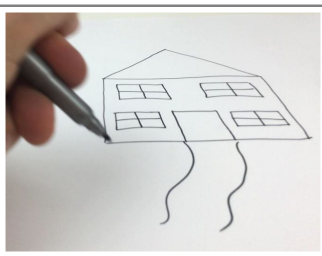
- Imperceptible
- Perceptible
- Observe
- Change
- Grow

Let's discuss: *What does "perceptible change" mean? In your workbooks or with a partner, record, discuss, or share one example of perceptible and imperceptible change.*

Link forward: Link to designing a system that tracks the growth of a plant.

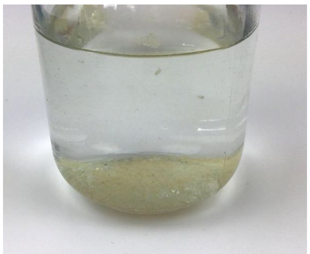
Worked Example 7 minutes

Make a working system that tracks change over a short time.

Instructions	Workspace	Notes for Teachers
Step 1. Drag the Time Trigger block, Interval Block and Camera block onto the Workspace.		*Time Trigger blocks are the input to the system and will make the output occur at a certain time*
Step 2. Set the Time Trigger block to a few minutes from now and the Interval block at 10 second intervals.		*The Interval block settings are in milliseconds, seconds, minutes and hours. We are setting this to 10 seconds to allow the camera to take a picture every 10 seconds*
Step 3. Connect the blocks in this order; Time Trigger block to Interval block to Camera block		*The camera block is a SAM feature allowing you to take photos using your device's built-in camera* ● *On iOS or Android the photos are found in the Photo app* ● *On Windows the photos are found in Windows -> Pictures folder* ● *On Chromebook the camera are temporarily saved to photos in your Files/Images/Pictures. Select these images and chose 'Save' to save them to your Google Drive account to keep a permanent copy or Chrome OS will auto delete them when it needs the space.*
Step 4. Position the camera so that it is pointing at a piece of paper.		*Ensure that the camera is stable and pointed at the desired location to capture the drawing.*
Step 5. Draw a picture.		*The students could be given a word to write or a simple drawing to sketch as the Time Trigger block has been set and the drawing will need to commence before the starting time.*
Step 6. After one minute ask them to stop and to check the photos in the device.		*In a series of photos, the paper on which you drew gradually changed and the camera captured these changes*

Challenge 1 **7 minutes**

Program a working system that records slow change.

Instructions	Workspace	Notes for Teachers
Step 1. Starting with the system created in the worked example		*The system is the same but we are going to repurpose it for a slower changing situation*
Step 2. Place a glass with some water in front of the camera.		*The glass should be transparent and the device as before will need to be in a stable position.*
Step 3. Set the Interval block to trigger every 20 seconds. Set the Time Trigger block to start a few minutes ahead		*3 minutes is approximately the time it takes for a few grains of sugar to dissolve at room temperature, but the exact time will depend on the conditions in your class*
Step 4. When the actual time is the same as the Time Trigger block, put a small amount of sugar in the water and start the system.		*The system is started by a Time Trigger block so this must happen at the right time to start the experiment and a few grains is enough to see the change.*
Step 5. After 3 minutes look at the pictures.		*The photos show how the sugar gradually dissolves in the sugar*

Checks for understanding: *Which block communicates with the Camera to take the pictures every 20 seconds? What is the purpose of the Time Trigger block?*

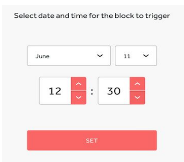
Challenge 1 - Debug it **5 minutes**

Are the intervals too long or too short to capture the sugar dissolving?

Instructions	Workspace	Notes for Teachers
Step 1. Edit the settings of the Interval block so that they capture the sugar dissolving.		*How long did the whole process take in challenge 1 and decide if the Interval block needs to be increased or decreased, depending on; the type and amount of sugar and the temperature of the water*

Challenge 2 **7 minutes**

Program a working system that records a slower change.

Instructions	Workspace	Notes for Teachers
Step 1. Put a folded sheet of wet kitchen roll in the bottom of the pot. Place cress seeds on top of the kitchen roll, evenly space apart. Cover the seeds with a few cotton balls. Place the pot near a window.		*Cress or pepper grass is chosen as it is the most rapidly-growing common seed that will allow the change to be documented over 7 days*
Step 2. Drag 7 Time Trigger blocks and a Camera block to the workspace		*We are going to record growth each day, so instead of measuring in second or minutes we are using days, as the change is slower.*
Step 3. Edit the settings of all the Time Trigger blocks to the same time for 7 consecutive days.		*Ensuring the time is the same on each day will make this a fair experiment and a consistent time lapse between photos.* *Opportunity to discuss measurements of time. Describe in hours how frequently the images are being taken?*
Step 4. Connect the outputs of the Time Trigger blocks to the input of a Camera block.		*Good practice to have the Time Trigger blocks in the order they will run so if one needs to be adjusted you know which to do.*
Step 5. Leave the system for 7 days. Present your findings.		*The SAM workspace will need to be active during this time so make sure your device is plugged in and does not go into 'sleep' mode. Either ensure the system is active just before camera due to take a picture or disable sleep mode on device.* *Opportunity to revisit analogue and digital 12 and 24 hour clocks in presenting the system.*

Extension Ideas:

- **Science**
  - How long would be needed to sufficiently record change in other plants? What about in their natural habitat versus at your home?
- **ICT**
  - Create and edit a lapse video using Movie Maker (PC) or iMovie (Mac).
- **Scientific Thinking**
  - In what ways could keeping a record of a slow change help us prepare for the future?
  - Recording pedestrian traffic or vehicle flow in cities to plan crossings and roads.
  - Recording eating patterns at lunch time. How can you improve things based on your data?

Checks for understanding: *Why did the Time Trigger blocks have the same time each day? How many inputs are there in this 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.

Resistance and Friction

SAM LABS

Overview

During this lesson, students learn about concept of friction and the difference between helpful and unhelpful friction. Students will integrate and exhibit learning by creating a car and testing it on different surfaces to investigate how friction affects movement.

Key Information

Level 2: (Ages 8-10) US Grades 2 or 3 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 hazards from a warning sign.
Worked Example	7 mins	➔ Identify what friction is and discuss the importance of friction.
Challenge 1	7 mins	➔ Create a system to move a car in a specified direction.
Challenge 1 - Debug	5 mins	➔ Compare the difference in movement on different surfaces.
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Physical Science
- ➔ Cause and effect relationships
- ➔ Patterns of change can be used to make predictions
- ➔ Helpful and unhelpful friction

Design Technology
- ➔ Design purposeful and useful products
- ➔ Choose appropriate materials.
- ➔ Evaluate products against design criteria

Scientific Thinking
- ➔ Trial and error, calibration and adjustment

English Language Arts
- ➔ Participate in collaborative conversations.
- ➔ Use information gained from illustrations and text to demonstrate understanding.
- ➔ Determine the meaning of key vocabulary relevant to the learning objectives.

Materials required

- ➔ SAM Labs kit
- ➔ Cardboard
- ➔ Student Workbook
- ➔ Lego
- ➔ Sandpaper
- ➔ Aluminum foil

Resistance and Friction

Warm Up — 5 minutes

Can you guess what these signs mean and what they have in common?

Objective: Identify hazards from a warning sign.

Procedure: *"Today we are going to learn about resistance and friction and how these are essential in getting a vehicle to move on different surfaces."*

- Look at a series of warning signs and identify what they are and what they have in common
- Discuss why it is important to have warning signs and what we have to help us on slippery surfaces e.g. shoes, tires etc,

Sample photo ideas: Slippery surfaces warning signs

Link forward: Link to looking at how we don't fall over based on friction and how this works

Mini-lesson — 10 minutes

What is friction? Why is friction important when designing vehicles?

Objective: Identify what friction is and discuss the importance of friction

Procedure:

- Introduce the Mars Rover 'Curiosity': clip (https://www.youtube.com/watch?v=nQ365jzwk5w)
- Explain how Curiosity is tested on a range of surfaces and terrain to ensure it will be able to maneuver effectively around Mars.
- Introduce the concept of helpful and unhelpful friction.
- Example of helpful friction:
    - Friction between tires and the road stops cars from skidding.
- Example of unhelpful friction:
    - Friction occurs in a bike in the chain and axles, this increases if you don't oil it regularly, making your bike difficult to pedal as well as noisy.
- Explain why it is imperative to test vehicles, particularly specialty vehicles, on different surfaces to ensure they are safe and reliable.(8 minutes)

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

Key Words

- Friction
- Force
- Rover
- Resistance

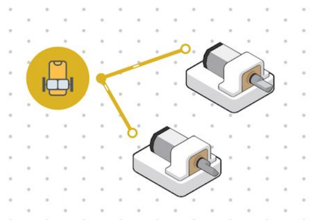
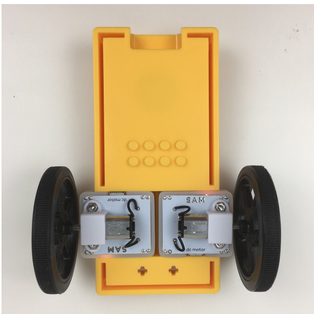
Let's Discuss: *What is friction? In your workbook or with a partner, record, discuss, or share one example of 'Helpful Friction' and 'Unhelpful Friction'.*

Link forward: Link to making a car to drive on different surfaces and observe the effects of friction.

Worked Example

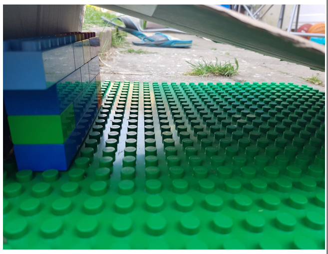
7 minutes

Create a system to move a car in a specified direction.

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • 2 DC Motor blocks.		*The light will be red on the block when first switched on but will change colour when the block is paired with the workspace*
Step 2. Drag 2 DC Motor blocks and a Car Controller block onto the workspace and connect them together.		*The Car Controller is a special block to control Cars on devices that can sense Tilting. We are going to see if your devices can do this'. It is essential to check all students have the right system open to control their cars and pairing blocks works*
Step 3. Connect the 2 Wheels to the DC Motors and insert into the Yellow Car Chassis. Insert the Rollerball underneath the car.		*Ensure the lights in the blocks are all the same colour and not red, which means that all are connected to the system*
Step 4. Test the car using the Car Controller to control the direction and speed of the car.		*Make sure the car goes in both directions when tilting the tablet and the speed adjusts when the tablet is tilted. How well does it move on the smooth surface of the classroom floor?*
Step 5. Test it on grass.		*How does the car move on the grass? Is it faster or slower?*

Challenge 1 — 7 minutes

Compare the difference in movement on different surfaces.

Instructions	Workspace	Notes for Teachers
Step 1. Make a ramp.		*We have used Lego to create an incline but students could use other materials to create a tower for the ramp to rest on.*
Step 2. Cover the ramp in cardboard.		*Put cardboard on the ramp and position to allow the car to drive up it*
Step 3. Test the car on cardboard.		*Place the car at the bottom of the ramp and test the car on cardboard*
Step 4. Cover the cardboard with foil.		*Cover the cardboard with foil, this is a smoother surface and there won't be as much friction between the wheels and the surface as on cardboard*
Step 5. Test the car on foil.		*Place the car at the bottom of the ramp and test the car on the foil*

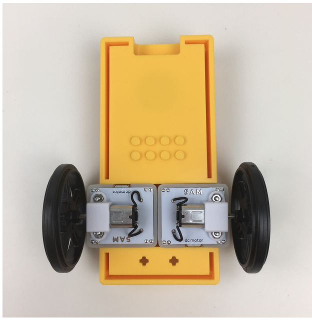
Checks for understanding: *Why do the cardboard and foil surfaces affect the speed of the car or its ability to climb? Why does the car move on both surfaces?*

Lesson 2.4

Resistance and Friction

Challenge 1 - Debug it 5 minutes

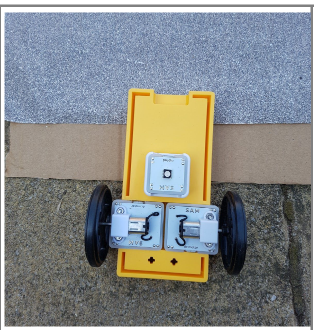
Should the car be moving on all the surfaces for this experiment?

Instructions	Workspace	Notes for Teachers
Step 1. Take the wheels out of the chassis.		*The tires are the reason the car is working on all surfaces, we have learned that the friction caused between objects is why it does not slip; the tires on the wheels cause the friction, which makes the car move.*
Step 2. Remove the tires from the wheels.		*Remove the tires and place the wheels back on the DC motors and back into the chassis.*
Step 3. Test it.		*Test the system to make sure the car still moves*

Challenge 2 7 minutes

Test the car on other surfaces

Instructions	Workspace	Notes for Teachers
Step 1. Cover the first section of the ramp with sandpaper.		*Make sure the ramp is only partially covered as this will show the difference in surfaces*

Step 2. Place the car at the bottom of the ramp.		*To ensure that this is a fair test, make sure the position of the car is the same each time. Place it in the middle in case it wanders to the side and make sure it is facing straight up the incline*
Step 3. Test it.		*As you drive the car up on the sandpaper the friction created allows the car to move, but as the car gets to the cardboard this friction is reduced and the car slips*
Step 4. Test other surfaces		*Try other surfaces; paper, scrunched up foil compared to smooth foil, plastic etc.*

Extension Ideas:

- **Science**
  - A competition between teams to find the best surfaces
  - Forces – bigger and smaller pushes and how that affects the car's progress
  - Does the car need a 'run up' to help it get over certain surfaces?
  - Does the ramp angle affect the car's progress?
- **Geography**
  - How do road surfaces and land surfaces change around the world? How do they use vehicles on ice?
- **History**
  - Roads over the years. How did we get to smooth tarmac or concrete roads?
- **ICT/Computing**
  - Can you use the SAM system to make the car turn?

Checks for understanding: *Why do the tires help the movement? Why did the car move better on the sandpaper than the foil?*

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 2.5

Smart Doorbell

Overview

During this lesson, students will look at the use of sensors within "smart" technology and how sensors can optimize everyday objects and tasks. Students will integrate and exhibit learning by designing a smart doorbell that features light, image capture and sound.

Key Information

Level 2: (Ages 8-10) US Grades 2 or 3   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 how sensors are used in technology
Worked Example	7 mins	➔ Describe what a sensor is and how they are used today in Smart technology
Challenge 1	7 mins	➔ Design a doorbell that when activated rings, takes a picture and turns on the light
Challenge 1 - Debug	5 mins	➔ Modify the system to be 'Smart Technology' by utilizing a sensor
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Computing
Inputs, outputs, abstraction, debugging.

Engineering
Describe on a basic level how sensors are integrated into objects via logic and computer programming.

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
Measure and estimate lengths in standard units.

English Language Arts
- ➔ 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 3-4 topic or subject area

Materials required

- ➔ SAM Labs Kit
- ➔ Student Workbook

Warm Up — 5 minutes

How can sensors be used in security systems?

Objective: Identify how sensors are used to optimize a security system

Procedures: *"Today we are going to learn that utilizing sensors is essential in creating smart technology"*

- Discuss that smart technology can detect, through sensors, information to activate the system/process/device.
- Students review the image in their workbook and make notes as to how they think it works as a security system.
- The red light is shone in a straight line and bounces off the many mirrors/surfaces. When the beam is disrupted or broken, the alarm sounds.

Link forward: Link to creating a system that will use a light sensor to activate our own smart technology.

Mini-lesson — 10 minutes

How can sensors be used to optimize everyday items or tasks?

Objective: Describe what a sensor is and how it can be used to make everyday items smart.

Procedures:

- Consider different ways sensors are used. For example, a security alarm system can use an infrared sensor where the beam is broken, heat sensitive sensor which can detect body temperature entering a room, temperature sensors to help monitor and control the heating in any buildings, magnetic sensors that detect metal and can be used in roads to monitor traffic
- Elicit ideas from students for optimizing everyday items and tasks, particularly those in their household or everyday routine. (8 minutes).

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

Keywords

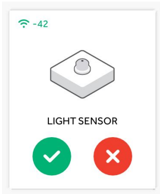
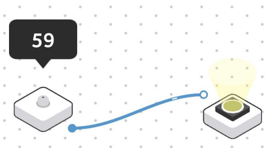
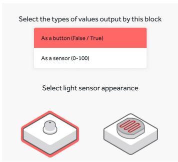
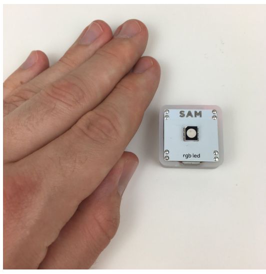
- Sensor
- Infrared sensor
- Magnetic sensor
- Temperature sensor
- Heat sensitive sensor

Let's Discuss: *What is a sensor? In your workbook or with a partner, record, discuss, or share on example of how a sensor can be useful to completing an everyday task.*

Link forward: Link to creating a smart doorbell utilizing sensors and alerts.

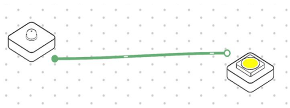
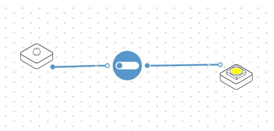
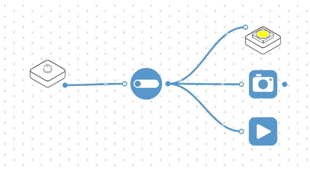
Worked Example — 7 minutes

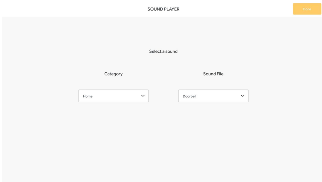
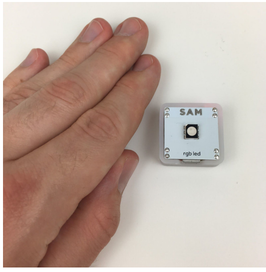
Create a system that will turn a light on and off

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • 1 Light Sensor block • 1 RGB LED block		*Scenario is that we need to create a doorbell that utilizes a sensor and is suitable for a hearing impaired individual*
Step 2. Drag the Light Sensor and RGB LED onto the workspace and connect them.		*In this system we have 1 input, the sensor and 1 output, the RGB light.*
Step 3. Select the settings icon and turn the Light Sensor into a button.		*Turning the Light Sensor into a button will make the button 'True/False' to activate but it is still detecting the change in light and dark as a sensor in the system.*
Step 4. Test your system. *Put your entire palm over the Light Sensor to turn the RGB LED on.*		*When the light sensor is covered by your hand the input is TRUE so will turn the light on as if it's dark outside. Remove your hand and the input will be FALSE and will turn the light off as if it's light outside*

Challenge 1 — 7 minutes

Design a doorbell that when activated rings, takes a picture and turns on the light

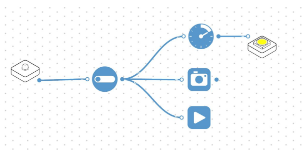
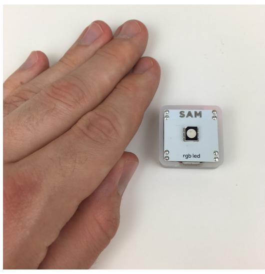
Instructions	Workspace	Notes for Teachers
Step 1. Start with the system from the worked example.		*This system utilizes a sensor but needs to remain as a button in the settings for now, recognizing only true and false.*
Step 2. Drag a Toggle block onto the workspace. Connect it between the Light Sensor and RGB LED blocks.		*The Toggle block will act as our switch in the system to turn it on and off*
Step 3. Drag on a Camera Block and a Sound Player block onto the workspace. Connect to the Toggle block.		*We now have three outputs in this system of Light, Image and Sound. The Light will allow the hearing impaired to know when the doorbell rings and see who it is by the image captured.*

Step 4. Set the Sound Player block to 'Doorbell'.		*The Sound Player block has a large number of sounds but under 'Home' there is a 'Doorbell'. This will allow the 'hearing' to hear the doorbell.*
Step 5. Test your system.		*Test your system by covering the Light Sensor block which will activate the system to take a picture, sound the doorbell and turn on the light.*

Checks for understanding: *Which part of the system is the input? How many outputs are there in this system?*

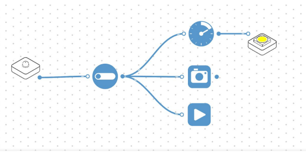
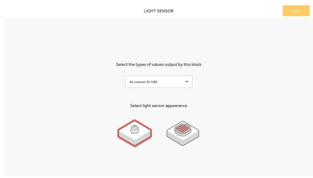
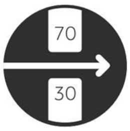
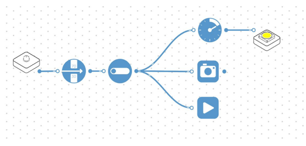
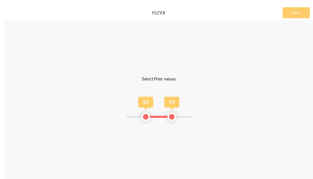
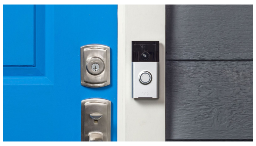
Challenge 1 - Debug it **5 minutes**

Does a light turning on catch the attention of the hearing impaired?

Instructions	Workspace	Notes for Teachers
Step 1. Drag on an Interval block to the workspace.		*An Interval block allows the input to 'pass through' to the output at the given time lapses either hours, minutes, seconds or milliseconds*
Step 2. Connect the Interval block between the Toggle block and the RGB LED.		*This will now ensure the light flashes at the default setting of every 1 second*
Step 3. Test your system.		*Test the system and decide if the time lapse defined in the Interval block is right, too fast or too slow.*

Challenge 2 — 7 minutes

Use a sensor to clearly define out system as ‘SMART Technology’

Instructions	Workspace	Notes for Teachers
Step 1. Start with the system created in Challenge 1.		*At present out Light Sensor block is a button with only 2 settings; True or False. To be a true piece of SMART technology we need to utilise sensors fully.*
Step 2. Edit the settings of the Light Sensor block to be ‘As a sensor’.		*Change the settings back to ‘Sensor’ and press ‘Done’*
Step 3. Drag on a Filter block to the workspace.		*The Filter block allows a defined range through to the outputs.*
Step 4. Add the Filter block between the Light Sensor block and the Toggle block.		*In this case the defined range the light sensor will be set to activate the doorbell*
Step 5. Set the range of the Filter block.		*This will require a mini test of the environment and what the normal setting is and when someone moves closer how the light changes to set the starting point for the range*
Step 6. How can you optimize the doorbell further? *For example, if you have the Proximity block swap with the Light Sensor block.*		*The Proximity block is ideal in Smart Technology and would allow the doorbell to be activated when someone approaches the sensor.*
Step 7. Test your system.		*Test the system to see if the light flashes, doorbell sounds and the camera takes a picture when the person approaches the sensor. Students can demonstrate it’s functionality on the classroom door or at home.*

Extension Ideas:
- **Computing**:
  - Does the Camera work with the sensor and take accurate pictures? How can this be adjusted?
  - Does the color of the light help it to be seen?
- **Geography/Science**:
  - How does smart technology differ in different countries such as Japan?
  - Link to how smart technology sensors are helping save lives in natural disasters as warnings.
- **Science**:
  - How is smart technology used elsewhere in the home to help disabled individuals?

Checks for understanding: *Why is a Filter block used in the system? What is the role of the Interval block in 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.

Magnetic Forces

SAM LABS

Overview

During this lesson, students will work collaboratively to investigate cause and effect of magnetic interactions. They will build a SAM Magnetic Car in order to measure the effect magnets have on the car's movement.

Key Information

Level 2: (Ages 8-10) US Grades 3 or 4 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 that materials attracted to magnets are made from metal
Worked Example	7 mins	➔ Build a SAM car to investigate magnetic force
Challenge 1	7 mins	➔ Demonstrate that poles will attract or repel depending on the orientation of the magnets
Challenge 1 - Debug	5 mins	➔ Relate the functionality of the car's design to the validity of the experiment
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Physical Science
- ➔ Investigating the effect of magnetic forces

Computing
- ➔ Inputs, outputs, debugging

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

Design Technology
- ➔ Design, build and improve upon a variety of structures

Math
- ➔ Measure and estimate lengths in standard units
- ➔ Comparing and ordering measurements

English Language Arts
- ➔ Determine the meaning of key vocabulary relevant to the learning objectives

Materials required

- ➔ SAM Labs Kit
- ➔ Lego bricks
- ➔ Student Workbook
- ➔ Ruler
- ➔ Strong Magnet

Warm Up – 'Magnetic Materials' — 5 minutes

Are all objects attracted to magnets?

Objective: Students can explain why metal objects are attracted to magnets.

Procedures: "*We are going to investigate if all objects are attracted to magnets.*"

- Students look at a variety of materials; cotton wool, paper clips, paper, plastic rulers, metal rulers, nails etc.
- *Which objects do you think will be attracted to the magnet and why?*
- Students work together to sort the objects into two groups: objects they think will be attracted to the magnets and objects they do not think will be attracted.
- *Are you undecided about any of the objects you have?*
- Students investigate whether their prediction was correct by holding a magnet above each of the materials.
- *Do you need to move any of your objects into a different group?*
- The teacher briefly explains that objects made from metals are attracted to magnets, but that not all metals are magnetic.
- Dependent on time, they could perform a 'classroom treasure hunt' where they collect and group objects themselves.

Link forward: Link to the idea that not all metals are attracted to magnets.

Mini-lesson - 'Attract or repel?' — 10 minutes

How do magnets react when placed in contact with each other?

Objective: Students investigate the attract and repel force of the magnets. They will recognise that these are dependent on their orientation and proximity.

Procedures: "*A magnet has a north pole and a south pole. Magnets create magnetic fields which fill the space around the magnet. It is this invisible field which creates the attract and repel force. The magnetic field is strongest at the poles. Opposite poles are attracted to each other, like poles repel each other. We are going to investigate which side does which."*

- Watch: https://www.youtube.com/watch?v=snNG481SYJw. This provides a visual aid of a magnetic field using iron filings. If the teacher has access to iron filings they may wish to provide this example themselves.
- Students work in small groups using two magnets to investigate which poles attract and which repel.
- What do they discover?
- How close can they hold similar poles before the magnets repel?
- How far away can they stand with opposing poles without the magnets attracting? (8 minutes)

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

Keywords:

- Attract
- Repel
- Poles
- North Pole
- South Pole
- Magnetic field

Let's Discuss: *Which materials are attracted to magnets? In your workbook or with a partner, record, discuss, or share why this is the case.*

Link forward: The effect of the attract/repel force is dependent on the proximity and orientation of the magnets.

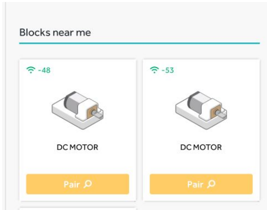
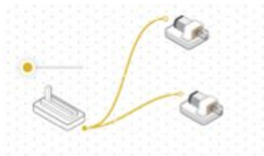
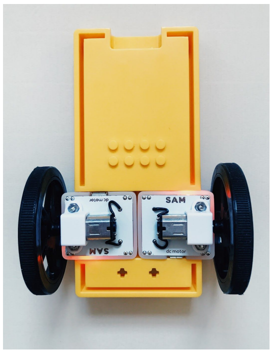
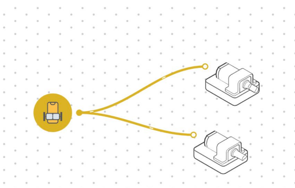
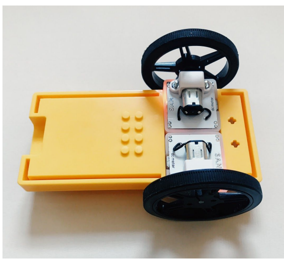
Lesson 2.6

Magnetic Forces

Worked Example

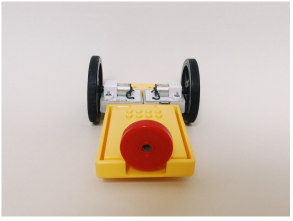
7 minutes

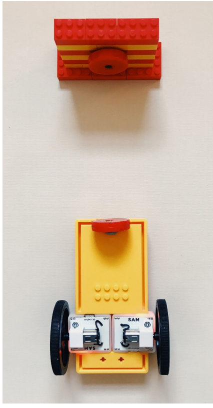
Demonstrate two ways in which to build a SAM system to control a car. Students build the system they think will give them greater control of the car.

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • 2 DC motors • Slider/Virtual Slider block Drag the DC Motors and the Slider onto the workspace.		*If you do not have a Slider block in your kit, you can use the Virtual Slider and control the car from your device.*
Step 2. Connect the Slider to both DC Motors.		*The Slider is going to act as our controller and we will use it to adjust the speed.*
Step 3. Click the setting icon of one of the DC motors. Set it to 'counterclockwise'.		*This is important, so the car does not spin in a circle once tested. Make sure one of the motors remains clockwise.*
Step 4. Add the two motors with wheels to the Car Chassis. Add the roller underneath the car. Test your system.		*Encourage students to experiment with the speed of the car via the Slider. What are the limits in this design? E.g. Can they go backwards and forwards with the Slider?*
Step 5. Now, let's try another build. Delete the Slider block by selecting the connection and pressing the 'X'. Drag the Car Controller onto the Workspace and connect it to the motors. Test your system.		*Now, demonstrate to students an alternative way of controlling the car. We have changed the input from the Slider block/Virtual Slider to the Car Controller.*
Step 6. Decide which of the systems will help you conduct the experiment in Challenge 1.		*Provide students with choice. Students are preparing to conduct an experiment with their car. Which of the car's designs do they think will provide the most accurate results and why?* *It is important to test the system to ensure you are able to control the speed and movement of the car.*

Challenge 1 - ‘Magnet Car’ — 7 minutes

At what point is magnetic force visible?

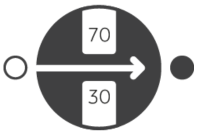
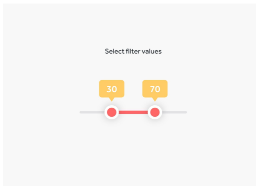
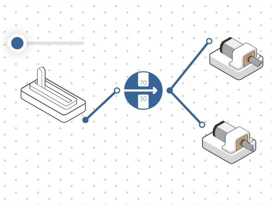
Instructions	Workspace	Notes for Teachers
Step 1. Attach a magnet to the front of the car.		*Use blu tack to attach the magnet.*
Step 2. Build a small wall using Lego bricks. Secure another magnet to the back of the wall.		*Use blu tack to attach the second magnet to the wall.* *Allow children to attach the magnet whichever way round the wish. Provide them with several minutes to discuss their predictions for what will happen when they drive the car towards the wall.*
Step 3. Drive the car towards the wall and see what happens.		*You may need to use blu tack to secure the wall to the floor.* *Does the car hit the wall or is it pushed away? Does the same thing happen to everyone’s car? How is the magnet behind the wall impacting on the movement of the car?* *Encourage students to ensure the design of their car enables the magnet to align with the wall.*
Step 4. Place a marker on the floor at the point the force of the magnet is first visible. Measure the distance between the marker and the wall.		*Students will need to use a ruler to measure the distance between the marker and the wall.* *You may wish to repeat this step several times to ensure a fair test. Students can then compare measurements, ordering them from shortest to longest.*

Step 5. Alter the orientation of the magnet behind the wall so it is the opposite way round. Repeat Steps 3 and 4.		*Predict the expected outcome after changing the orientation of the magnet.* *Will the force of the magnet be visible earlier/later/at exactly the same point?* *How close can students drive the car to the wall?* *Can they knock it down?* *Do they need to build a stronger wall?*

Checks for understanding: *When opposing poles are facing, the car will… When similar poles are facing the car will…*

Challenge 1 - Debug it 5 minutes

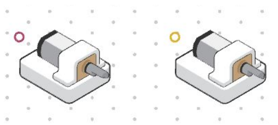
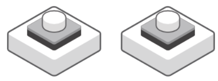
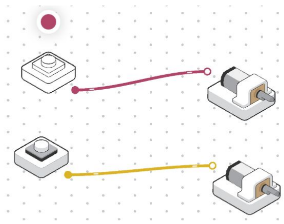
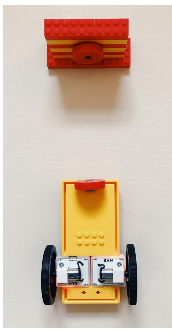
How can we prevent the car from moving too quickly?

Instructions	Workspace	Notes for Teachers
Step 1. Drag a Filter block onto the workspace.		*This debug relates specifically to the Slider design.* *The Filter block will only allow certain values through. If a value is above a certain amount, the car will stop moving. If the value is below a certain amount, the car will begin to move. We can alter the settings to prevent the car from moving too quickly.*
Step 2. Enter the settings of the Filter block. Select a filter of '15 - 50'.		*The car will not move if the value is less than 10.* *The filter block is now acting as a conditional.*
Step 3. Connect the Filter between the Slider and DC motors. Test your system.		*The Slider is being used to control the car.* *Does the filter reduce the speed of the car? Does this make it easier to control?*

Challenge 2

7 minutes

Does using a different input provide more or less control over the car when faced with the effect of the magnet?

Instructions	Workspace	Notes for Teachers
Step 1. Delete the Filter block and Slider block from the workspace.		*To delete a button select it and press the “X” key.*
Step 2. Turn on and pair: • 2 x Button/Virtual Button Drag them onto the workspace.		*It may be easier for students to use 2 x Virtual buttons rather than one hardware and one software block.* *Ask students to consider if this design provides more or less control over the car than the system from Challenge 1 when faced with the effect of the magnet? Is the car easier or harder to control with two buttons?*
Step 3. Connect each Button to one of the motors.		
Step 4. Use your new design to repeat the experiment in Challenge 1.		*Ask students to reflect on which system gives them greatest control over the car when it encounters the force of the magnet?*

Extension Ideas:
Science:
- Add an extra magnet behind the wall. Will increasing the surface area of the magnet alter the effect the force has on the car? What would happen if the extra magnet was placed on the car instead of behind the wall?
- If the weight of the car increases, will this alter the effect the force of the magnet has on the car? Investigate by securing blocks to the car and driving it towards the wall.

Earth Science:
- Explore magnetic poles of the earth.
- Connect a piece of string to the wall and slide a series of paper clips over the string, arranging them at intervals. As the car drives towards the wall, how many paper clips can it pick up? Do they paper clips move towards or away from the car?

Design Technology:
- Students work collaboratively to build a stronger wall. Can they include a range of other materials in their build?

Math:
- Students work out the speed of the car by measuring the distance it travels and the time it takes. How much faster/slower does the car travel when the magnet is included?

Checks for understanding: *Which of the following was used as an input in our system to control the car? Driving towards the magnet wall made the car harder to control because...?*

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 2.7

Energy in Motion

Overview

During this lesson, students will work collaboratively to investigate how the speed of an object relates to its energy and how energy can be transferred resulting in motion of a stationary object.

Key Information

Level 2: (Ages 8-10) US Grades 3 and 4   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 that the speed of an object affects the amount of energy it has
Worked Example	7 mins	➜ Demonstrate that when a moving object collides with a stationary one, energy is transferred resulting in motion
Challenge 1	7 mins	
Challenge 1 - Debug	5 mins	➜ Create a system to test how the speed of an object relates to the energy produced
Challenge 2	7 mins	➜ Observe the effect of speed on a range of objects and the impact created through the energy generated
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

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.

Science
Motion and Stability: Forces and Interactions

Math
Measure and estimate lengths in standard units.

English Language Arts
Participate in collaborative conversations.

Materials required

➜ SAM Labs Kit

➜ Student Workbook

➜ Ruler

➜ Aluminum cans or plastic bottles

➜ Assortment of materials (e.g. tissue paper, aluminum foil, craft paper, lasagne sheet)

➜ Tape or blu tack, table legs

Energy in Motion

Warm Up — 5 minutes

Does a faster object have more or less energy than a slower object?

Objective: Identify that the speed of an object affects the amount of energy it has

Procedures: "*Today we are going to learn that the faster an object is going, the more energy it has.*"
- Discuss that energy takes many forms, today we are looking at moving objects.
- Look at pairs of pictures of moving objects, discuss which pair has more energy.
- Have children come up with their own pairs of similar moving objects, one traveling fast and one slower, ask other children to complete the sentence 'the object with the most energy is…'

Sample photo ideas: Person running/walking; Horse running/walking; Tree still/blowing

Link forward: Link to testing the impact of a moving object

Mini-lesson — 10 minutes

What can happen to the energy of a moving object?

Objective: Demonstrate that when a moving object collides with a stationary one, energy is transferred resulting in motion.

Procedures:
- Show the following video clip (56 seconds) (https://www.youtube.com/watch?v=0ppXNv9hDMU)
- Discuss how the water changes when the energy from motion of the bird collides with the water.
- Explain that sometimes when objects collide, movement is created, as with the water in the clip. Sometimes sound is also created.
- Introduce the concept of energy being transferred and how movement or sound is evidence of this.
- Discuss the following objects and whether it is sound, movement or both that is created when they collide with a stationary object: football, river, plane, skier, insect. You can use the images on the slide to support this.

Keywords
- Energy
- Motion
- Speed
- Impact
- Force

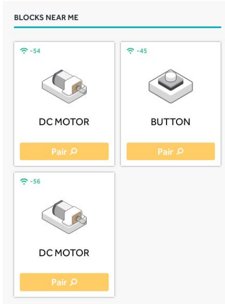
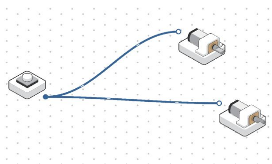
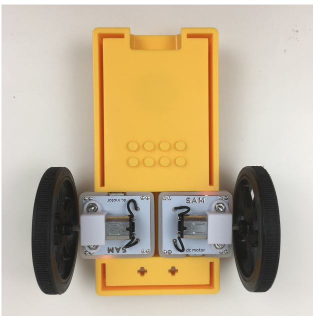
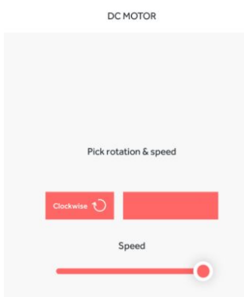
Let's Discuss: *How can we see the transfer of energy? Share an example with a partner what the effect of a moving object transferring its energy by colliding with another object is.*

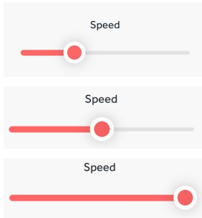
Link forward: Link to creating a car with controllable speed to test the effect of collisions with different materials.

Lesson 2.7
Energy in Motion

Worked Example — 7 minutes

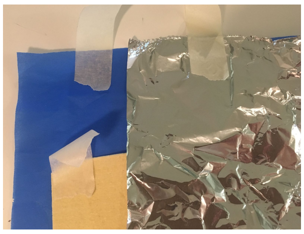
Create a system to move a car that drives forward.

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: ● 2 DC Motors ● 1 Button/Virtual Button		*The light will be red on the block when first switched on but will change colour when the block is paired with the workspace.*
Step 2. Drag the DC Motor and Button blocks onto the workspace. Connect the Button block to both DC Motor blocks.		*When all 3 blocks are connected, they will have the same colour.*
Step 3. Connect the 2 Wheels to the DC Motors and insert into the Yellow Car Chassis. Insert the Rollerball underneath the car.		*Ensure the lights in the blocks are all the same colour and not red, which means that all are connected to the system.*
Step 4. Test the car using the Button block to control the start and stop of the car's movement.		*Test the different surfaces in the classroom and make sure there is enough clear floor space. To sustain the movement of the Car, the Button block needs to be held down.*
Step 5. Open the Settings icon of both the DC Motor		*Encourage students to check the direction setting for both DC Motor blocks. What happens when they are both set to clockwise? Counterclockwise?*

Step 6. Test the speed slider in the Settings icon of the DC Motor blocks.		*Group students so that there are 3 different speeds tested. Have 1 group set the speed of their car at 100% (all the way to the right); 1 group set to 50% (half way along the slider). Students can test what the slowest speed to move the car is, shown approximately in the top image.*

Challenge 1 — 7 minutes

Create a system to test how the speed of an object relates to the energy produced

Instructions	Workspace	Notes for Teachers
Step 1. Select 2-3 different materials to test the car colliding with and attach blu tack or sticky tape to the corners.		*There should be a variety of density or hardness in the material, such as tissue paper, aluminum foil and a lasagne sheet shown here.*
Step 2. Attach the first material to test to two table legs with approximately a foot between them.		*Make sure the material is not above the ground, students will need to observe the impact the car has with the materials rather than whether the car can navigate under the material.*
Step 3. Test the impact of the car driving towards the material.		*How did the car's energy affect the material? Encourage students to discuss the change in motion they observed.*
Step 4. Attach a different material to the table legs.		*Have students predict whether there will be movement with the second material. Encourage them to use energy in their descriptions of their observations.*

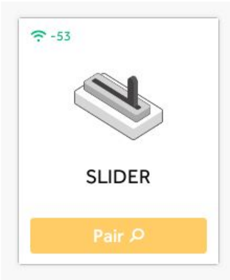
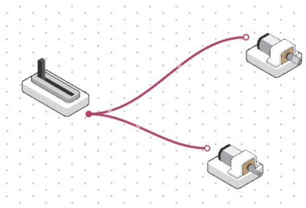
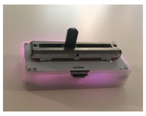
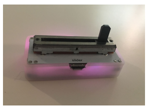
Checks for understanding: *What can be the effect of a moving object colliding with a stationary one? Why do you think there was a difference in the movement of the different materials?*

Lesson 2.7

Energy in Motion

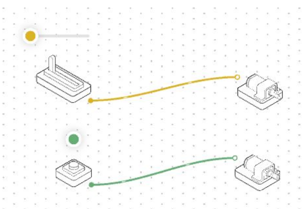
Challenge 1 - Debug it — 5 minutes

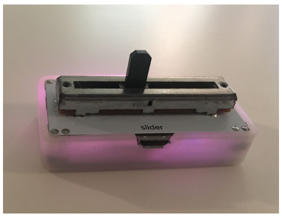
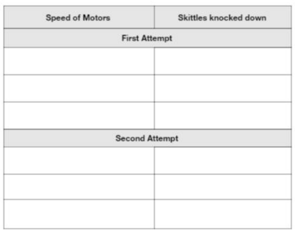
How can we see the effect of speed on the transfer of energy?

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair a Slider block.		*You can use a Virtual Slider if you do not have access to the physical block.*
Step 2. Delete the Button block from the workspace and replace with the Slider block. Connect the Slider block to both DC Motor blocks.		*Remove the Button block by clicking on it and selecting the 'x'.*
Step 3. Test the impact of the car driving into the material at two different speeds.	 	*Encourage students to move the slider slowly, the position for the slowest and fastest speeds are shown approximately in the images.*

Challenge 2 — 7 minutes

Observe the effect of speed on a range of objects and the impact created through the energy generated

Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • 2 DC Motor blocks • 1 Button/Virtual Button block • 1 Slider/Virtual Slider block		*Discuss what is different about this system compared to Challenge 1 and how this may affect the driving of the car.*
Step 2. Drag onto the workspace and connect the Slider to one motor and the Button to another.		

<table>
<tr><td>Step 3.
Test driving the car with one student on the Slider block control and one on the Button block.</td><td></td><td>Is it easier to control the car travelling in a straight line? How may this affect the test on impact?</td></tr>
<tr><td>Step 4.
Set up plastic bottles or aluminum cans like skittles.</td><td></td><td>The number of skittles doesn’t matter, as long as they remain the same while students conduct the fair test.</td></tr>
<tr><td>Step 5.
Test the result of impact from the car’s energy into the skittles.</td><td></td><td>Discuss the importance of identifying a start point. Discuss what evidence of transfer of energy there was. Students should recognise there was both movement and sound. Would all objects react to the transfer of energy with both movement and sound?</td></tr>
<tr><td>Step 6.
Use the Slider to vary the speed of the car and test the effect.</td><td></td><td>Decide on positions on the Slider to test the effect of speed on the car so it is a fair test of speed when it gets repeated.
Use the table to record the results of each speed.</td></tr>
<tr><td>Step 7.
Repeat the test as a fair test to record results.</td><td><table><tr><th>Speed of Motors</th><th>Skittles knocked down</th></tr><tr><td colspan="2">First Attempt</td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td colspan="2">Second Attempt</td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr></table></td><td>Encourage students to ensure the test remains fair, recording the results in their student workbook.
As well as the speed of the Slider, Students should consider marking the start point of the car, so the distance from skittles is the same each time.
Opportunity to take results recorded in the table for students to present in different formats such as a bar chart or time graph.</td></tr>
</table>

Extension Ideas:

- **Science**:
  - How else could the transfer of energy be measured?
  - What could we add to increase the speed of the car?
- **Computing**:
  - How does adding in the Car Controller Virtual block change the SAM system?
- **History**:
  - When were the first cars produced? How have they changed over time? What is the top speed that can be reached by a car?
  - What precautions are taken with racing cars to avoid collisions?
- **Geography**:
  - Do different countries have different limits of speed cars can travel on public roads?

Checks for understanding: *How have we seen evidence of the transfer of energy? What difference did the increased speed have?*

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.

Erosion

Overview

During this lesson, students will gain understanding of water erosion and the effects on landscape. Students will integrate and exhibit learning by creating a system to generate waves, demonstrating the effect erosion has on sand.

Key Information

Level 2: (Ages 8-10) US Grades 3 or 4

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 different forms of erosion.
Worked Example	7 mins	➔ Explain the different forms of water erosion and their effects.
Challenge 1	7 mins	➔ Create a SAM system to test the erosion of sand by ocean waves.
Challenge 1 - Debug	5 mins	➔ Design a SAM system to show the effects of erosion from ocean waves.
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Earth Science
➔ Types and causes of erosion

Computing
➔ Inputs, outputs, abstraction, debugging

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

Math
➔ Measure and estimate lengths in standard units

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

English Language Arts
➔ Participate in collaborative conversations.
➔ Use information gained from illustrations and text to demonstrate understanding.
➔ Determine the meaning of key vocabulary relevant to the learning objectives.

Materials required

- SAM Labs Alpha Kit
- Plastic tupperware
- Sand
- Scissors or tool to make a hole in the tupperware
- Ruler
- Student workbook
- Water
- Lego

Warm Up — 5 minutes

What are the different forms of erosion?

Objective: Identify the different forms of erosion.

Procedures: *"Today we are going to learn about erosion and the effects it has on the landscape, particularly the effects ocean waves have on sand".*

- Discuss what erosion is and how it has an effect on land and helps sculpt the earth.
- Identify whether the changes caused by erosion are reversible or irreversible.
- Students look at the images given to them and discuss whether it is a form of erosion.
- Look at the different forms of erosion and where these forms would be seen e.g. glacial in Antarctic, sea/soil by coastlines, water.

Link forward: Link to defining water erosion and its various forms.

Mini-lesson — 10 minutes

What is water erosion?

Objective: Identify and explain the different forms of water erosion and their effects.

Procedures: "*There are four main types of water erosion; river, rain, waves and floods".*

- Water, a natural resource, is the main and most powerful force of erosion on Earth.
- Rainfall causes erosion when it hits the surface of the Earth; called 'splash erosion'.
- Rivers cause erosion over time as they break up the riverbed and carry it further downstream.
- Ocean waves can have such force they can break rocks and shift sand and soil causing erosion of coastlines.
- Large floods can cause erosion as water travels quickly over surfaces (8 minutes).

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

Keywords

- Erosion
- Waves
- Rain
- River
- Flood

Let's Discuss: *What are the four types of water erosion? In your workbook or with a partner, record, discuss, or share an example of erosion and how it can shape the landscape*

Link forward: Link to creating a system that demonstrates wave erosion on sand.

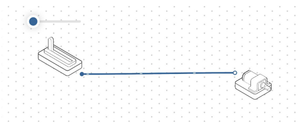
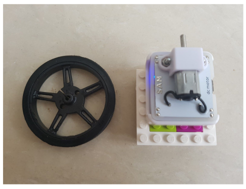
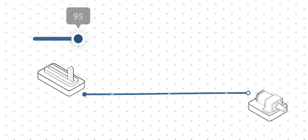
Lesson 2.8

Erosion

Worked Example

7 minutes

Create an adjustable motor for speed

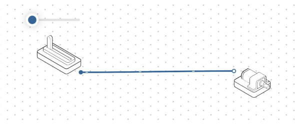
Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • 1 Slider/Virtual Slider block • 1 DC Motor	 	*The Slider/Virtual Slider block will be the adjustable input, determining the speed of the output DC Motor.*
Step 2. Connect the Slider to the DC Motor.		*If you do not have the Slider 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 up and down to increase and decrease the speed of the motor.		*The Slider will increase the speed of the motor, which in turn will create more waves. In order to see the waves it is important the speed is considered.*

Challenge 1

7 minutes

Create a SAM system to test erosion on sand by waves

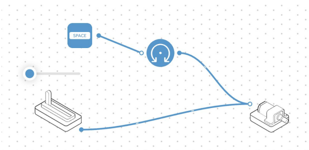
Instructions	Workspace	Notes for Teachers
Step 1. Make a small hole in the end of a plastic tub (to fit the motor axel).		*The hole needs to be big enough for the motor to go through but also for it to spin.*
Step 2. Push the DC Motor through the hole and attach the wheel.		*Depending on the size of 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. Adjust the speed of the Slider to increase and decrease the intensity of the waves.		*Make sure the blocks are paired by checking the color on the blocks are not red. Using the slider, increase the speed of the DC Motor to generate waves.*

Checks for understanding: *Does the input or output generate the waves? Which block is the input?*

Challenge 1 - Debug it — 5 minutes

Can the waves be intensified by changing the direction of the DC Motor?

Instructions	Workspace	Notes for Teachers
Step 1. Drag on a Key Press and Switch Direction blocks to the workspace.		*The Key Press block will become a second input to the system. Alternatively, if you can use a Button/Virtual Button or a Light Sensor (as a button) as the input.*
Step 2. Connect the Key Press block to the Switch Direction block and the Switch Direction block to the DC Motor.		*The system will still be activated by the Slider block but when the Key Press block is pressed the direction of the DC Motor will change.*
Step 3. Test your system.		*Test the system and set the Slider speed and using the Key Press block intermittently to see waves created.*

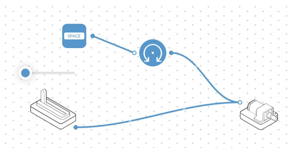
Lesson 2.8

Erosion

Challenge 2

7 minutes

Design a SAM system to show the effects of erosion from waves

Instructions	Workspace	Notes for Teachers
Step 1. Add a few handfuls of sand to one side of the tub.		*It is easier to remove the water and add the sand so that it is secure in one side of the tub like a coastline would be and then add the water to the other side.*
Step 2. Ensure the DC Motor is paired and the wheel is secure.		*Check the wheel is not against the tub as this will stop it from turning and the light on the block is not red.*
Step 3. Measure the depth of the sand.		*Insert a ruler into the middle of the sand and measure the height, if the sand is slightly wet it will stick to the ruler and when removed you can see where the sand reaches.*
Step 4. Start the DC Motor.	 	*Ensure all have the system form the Debug so that they can change direction at different speeds to see the effect.* *Increase the speed on the Slider to start the motor. Use the Key Press block to intermittently to change the direction of the motor to generate waves*
Step 5. Now, measure the effect of water erosion on the sand. Has anything changed?		*Insert the ruler again and see the difference in the height of the sand.*

Extension Ideas:

- **Computing**:
    - Can you create a system to automatically change direction of the DC Motor?
- **Science/Math**:
    - What effect does time have on the erosion? Using the system for differing lengths of time, test the effect of erosion at different intervals.
    - How long does erosion take on different materials? Change to soil to see the difference.
- **Science/Geography:**
    - Where has erosion been most visible and destructive?
- **ELA**
    - Research methods to reduce erosion and create a poster board or news article for your community.

Checks for understanding: *What erosion method can be seen in our system? What are the inputs in 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.

Paired Up Numbers

Overview

During this lesson, students will investigate the factors of numbers with the goal of discovering factor pairs. Students will build a SAM Factoring Machine to identify factors of a number and its factor pair.

Key Information

Level 2: (Ages 8-10) US Grades 3 or 4 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 factors of a number.
Worked Example	7 mins	➔ Prove that two numbers, from a list of factors, are factor pairs for a product.
Challenge 1	7 mins	➔ Design a SAM Factoring Machine to highlight the factors and factor pair of a number.
Challenge 1 - Debug	5 mins	➔ Debug systems when errors arise.
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Math
- ➔ Find all factor pairs for a whole number in the range 1-100
- ➔ Recognize that a whole number is a multiple of each of its factors

Computing
- ➔ Counters, outputs, debugging

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

English Language Arts
- ➔ Engage effectively in a range of collaborative discussions.
- ➔ Report on a topic or text, tell a story, or recount an experience in an organized manner

Materials required

- ➔ SAM Labs Kit
- ➔ Student Workbook
- ➔ Sorting tubs
- ➔ Toys
- ➔ Elastic bands
- ➔ Lego blocks by color
- ➔ Paper clips
- ➔ Erasers

Paired Up Numbers

Warm Up – 'Sorting collections' 5 minutes

How do you organize a number of objects evenly into different quantities?

Objective: Demonstrate that there are a variety of groups into which objects can be sorted.

Procedures: *"Today we are going to investigate how we can group items we want to organize in different ways."*

- Group students into 2s, 3s, 5s or 7s. There might only be 1 group of 5 or 7 but maybe more than one group of 2 or 3.
- Display a range of products in collections for example, 12, 16, 20, 21, 24, 28, 30.
- Ask students if they can work out which collection of objects they can share equally among themselves? Ask students to share their thinking in the student workbook and why they think this.

Link forward: Would it make sense to have more numbers for the boxes when organizing objects?

Mini-lesson 10 minutes

Explore different ways to sort your objects into different quantities

Objective: Demonstrate that when a number of objects can be sorted equally, the number of objects in a grouping is one factor and the number in of groups is the other.

Procedures:

- The classroom will be set up with 4 stations - the numbers for each individual station are 2, 3, 5 and 7
- Each station will have 10 pieces of paper, each will represent one numbered box, and the collections of items that are to be sorted.
- Using collections of objects, students work in small groups organising their collections into the numbered box for their table, students will be at each table for two minutes and have a half minute for movement time. They may not be able to sort all of the collections, which is OK.
- Students will record which collection can be evenly sorted into which numbered box; students will describe what they did with a sentence like, "I can sort 15 items into 5 boxes, with 3 in each one."
- Students will continue around the room this until they have explored the range of collections and attempted to sort collections into the variety of available boxes. (8 minutes)

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

Keywords

- Factor
- Product
- Multiple
- Sort
- Factor pair

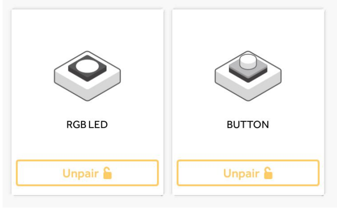
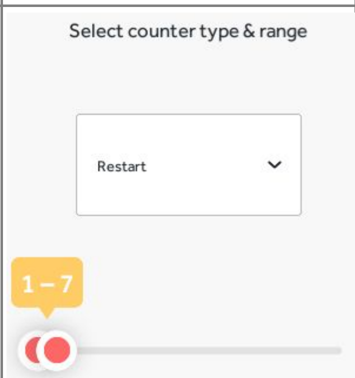
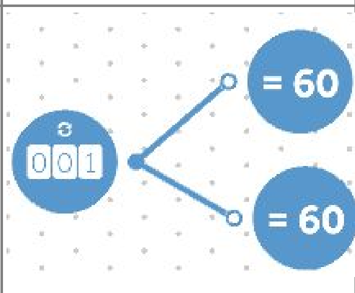
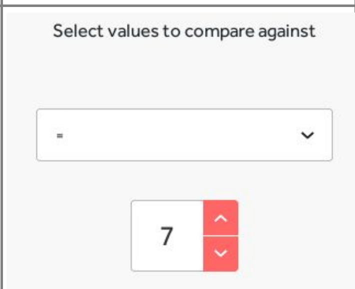
Let's Discuss: *How can we find the factors of a number? In your workbook or with a partner, record or discuss one example of a factor and factor pair.*

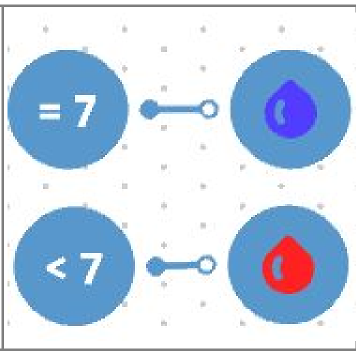
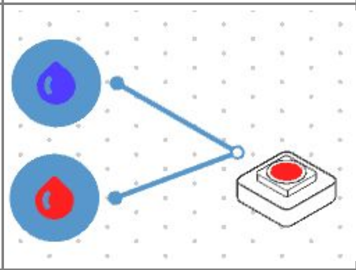
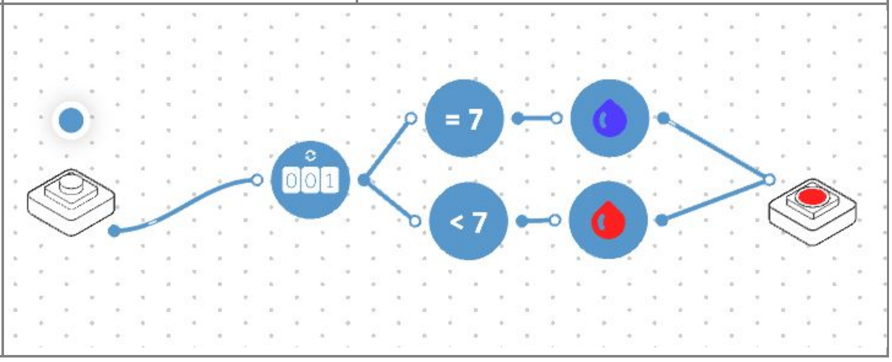
Link forward: What has to be true for a number to be able to be organized equally into a container?

Lesson 2.9
Paired Up Numbers

Worked Example
7 minutes

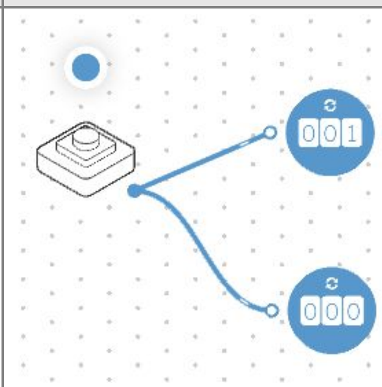
Design a SAM Factoring Machine to identify when a multiple of a chosen number has been reached

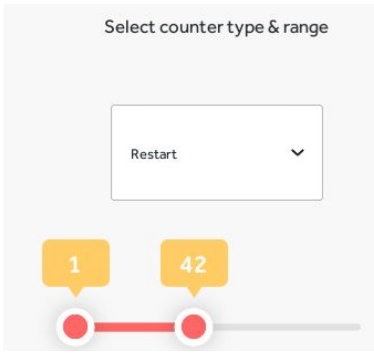
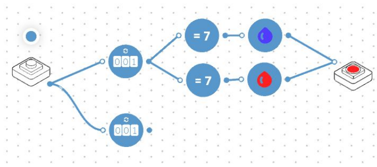
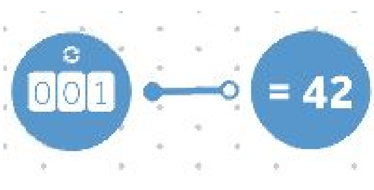
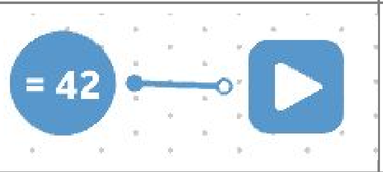
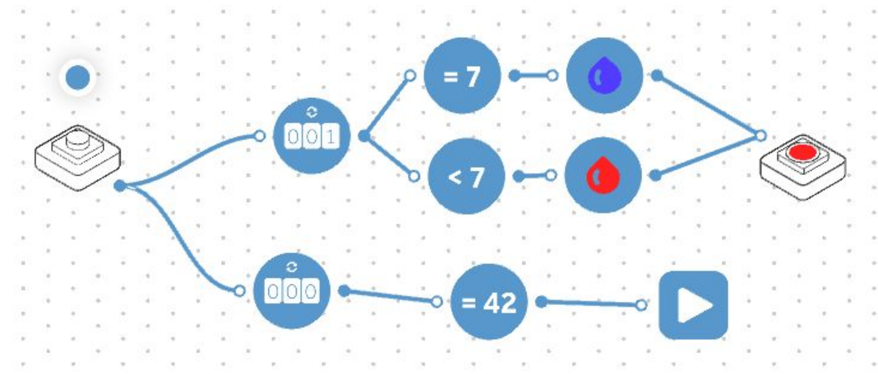
Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • Button/Virtual Button • RGB LED Drag them onto the workspace.		*The Button will be the control for the Counter you will add. You can use a Key Press if you don't have a Button.*
Step 2. Connect the Button and RGB LED.		*When you press the Button the RGB LED turns on.*
Step 3. Drag a Counter onto the workspace. Connect it between the Button and RGB LED.		*Now, as you click the Button, the Counter will increase to a specified number.*
Step 4. Click the settings for your Counter to go from 1 to a number of your choosing.		*It is important that you choose from 1 to the number as, when the Counter begins again, it will start at 0. For example, 0 - 7 would be 8 numbers but 1 - 7 is 7 numbers. I chose 7.*
Step 5. Add two Compare blocks to the workspace. Connect them between the Counter and RGB LED.		*Next, we will specify the numbers of the Compare blocks.*
Step 6. Click for the settings icon on the Compare and make one '=' a number of your choice and one '<' using the same number of your choice.		*The image shows '= 7' has been selected for one Compare block. Choose the number you want and choose < 'whichever number you chose for the first Compare'.* *It is important that both numbers are the same.*

Step 7. Drag two Color blocks onto the workspace, one for each of the Compare blocks. Choose a different color for each.		*It is important that each Compare block has a different color because that is what you will be using to show factors later on.*
Step 8. Connect both of the Color blocks to the RGB LED block.		*Click on the Button to test that the color changes with the counter.*
Step 9. An example of the system.		

Challenge 1 — 7 minutes

Add a counter to indicate if one number is a factor of another

Instructions	Workspace	Notes for Teachers
Step 1. Add a second Counter block and connect it to the Button. Think of a number to factor.		*This will allow for one Counter to be the 'factor' and the second Counter to be the number you are 'factoring'.*

Step 2. Enter a range of 1 - 'the number you want to factor' for the second Counter.		*Make sure both factors start at 1. In this example, 1 - 7 has been chosen for Counter 1 and 1 - 42 for Counter 2.*
Step 3. Test to see if the RGB LED changes color when the Counter reaches the number you are trying to factor.		*If the RGB LED does not change, Counter 1's number is not a factor of Counter 2.*
Step 4. Add a Compare block and connect it to the Counter. Set the number to be what you want to factor, I chose '42' in step 3.		*The image shows 42 as the number the system will factor. The number it is testing to see if it is a factor is 7.*
Step 5. Add a Sound Player block to the Compare block to alert the student when they have reached their number.		*This will result in a lot of sound testing but, hopefully, will not last forever.*
Step 6. An example of the system.		

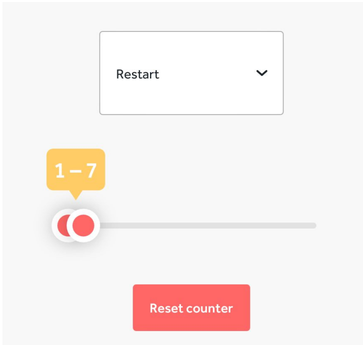
Checks for understanding: *What is a factor? Give two different ways to find a factor of a number.*

Lesson 2.9

Paired Up Numbers

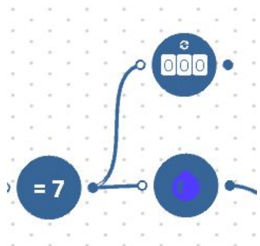
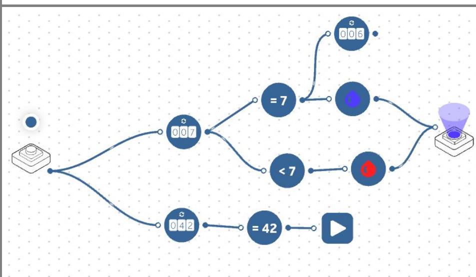
Challenge 1 - Debug it — 5 minutes

Why does the RGB LED stop working properly when you start the system again?

Instructions	Workspace	Notes for Teachers
Step 1. Open the settings for both Counter blocks. Ensure that you reset them both.		*If you do not reset both of the blocks, the Counter blocks will not 'count' together and they need to for the system to work as intended. If the Counter block, which is set from 1 - 4 in this instance, is not reset but the Counter block that is set from 1 - 100* ***is*** *reset, the LED Light will not change to blue when a multiple of 4 is reached.*

Challenge 2 — 7 minutes

Improve your SAM Factoring Machine to alert you if one number is a factor of another and to help to identify the factor pair.

Instructions	Workspace	Notes for Teachers
Step 1. Drag a new Counter block onto the workspace. Connect it to the topmost Compare block.		*This Counter needs to start at 0 as the first time this block is true it will become 1. This counter is added to indicate the value of the other factor of the chosen multiple. In challenge 1, the multiple is 42, this new counter will display 6 when 42 is reached.*
Step 2. Test your system to see if the factor pairs are accurate!		*In this instance, the system is finding factors of 42. We can test to see if 7 is a factor, it is, and the factor pair is 6.*

Extension Ideas:

- **Computing**:
  - Can you find another way to increment the counter? Can you find a different place to connect the sound?
  - Could you make this automatic so that when your suggested factor is reached, the program stops?
- **Math:**

- Can you use this system to identify prime factors?

Checks for understanding: *What does it mean if the color does not change? Why does one color show more often than the other one when checking for factors for 3, 5 and 7?*

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.

There Can Be Only, Two

Overview

During this lesson, students will use their knowledge of prime numbers, between 2 and 10, to determine if a number more than 10 but less than 100 is a prime or non-prime (composite) number. Students will integrate and exhibit learning by building a SAM system which verifies if a number is prime or non-prime (composite).

Key Information

Level 2: (Ages 8-10) US Grades 3 or 4   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	14 mins	➔ Identify whether a number is a prime or non-prime number
Worked Example	7 mins	➔ Create a clear definition of prime number and non-prime number
Challenge 1	7 mins	➔ Design a system to identify if a number is a non-prime
Challenge 1 - Debug	5 mins	➔ Debug systems when errors arise
Challenge 2	7 mins	
Tidy Up / Exit Ticket	4 mins	

Lesson Topics

Math
- ➔ Determine whether a given whole number in the range 1-100 is prime or non-prime

Computing
- ➔ Counters, outputs, debugging

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

English Language Arts
- ➔ Engage effectively in a range of collaborative discussions.
- ➔ Report on a topic or text, tell a story, or recount an experience in an organized manner

Materials required

- ➔ SAM Labs Kit
- ➔ Student Workbook
- ➔ Counting blocks
- ➔ Calculators
- ➔ Number tiles (2 - 10) 1 set per table

Lesson 2.10

There Can Be Only, Two

Warm Up — 5 minutes

What are the prime and non-prime numbers between 0 and 10?

Objective: Identify what the prime numbers are, and, as a result, the non-prime numbers between 2 and 10.

Procedures: *"Today we are going to organize numbers into two categories and identify how we know."*

- Students will be asked to organize the numbers tiles from 2 to 10 into two categories.
- Students have freedom to choose how to categorize numbers, explaining why they chose the method they did.
- Record suggestions on a display so that everyone's thoughts can be seen.
- If all of the groups suggest even / odd, as a way to categorize, then suggest a organizing the numbers as multiples. For example, these numbers are multiples of 3, these others are not.
- If primes and non-primes are not suggested as a way of organizing, which is fairly likely, display the numbers organized in that way and ask students to discuss what system might have been used.

Link forward: Link to students sorting numbers that are greater than 10

Mini-lesson — 10 minutes

Use the primes you know to find the primes you don't

Objective: To use the multiples of prime numbers between 2 and 10 to discover if a number more than 10 is a prime or a non-prime (composite).

Procedures:

- At a table of 4, students opt to find factors between 11-100 of one of these numbers: 2, 3, 5 or 7.
- Students should:
    - Find all factors of the number they've selected
    - If the number has only two factors, 1 and itself, then it is prime.
    - If the number has more than two factors, then it is non-prime.
- Have counting blocks ready to support counting at this time, particularly for 7s.
- Once students have completed their task, make sure that all members of the group check their work, calculators could be used at this point.
- Ask one volunteer to start counting from 11. Students should indicate if the number read is prime or non-prime (composite), according to their selected number. Students could raise hand, say, "got it," knock on the desk, etc.
- If students miss one, teach into how they can find out whether a number is a prime or non-prime. (8 minutes)

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

Keywords

- Prime
- non-prime
- Multiple
- Divisibility
- Rule

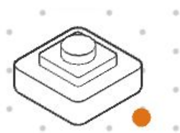
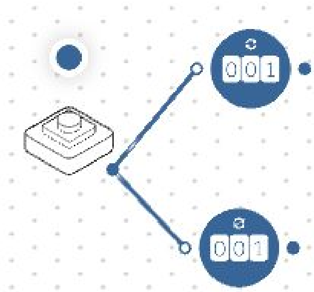
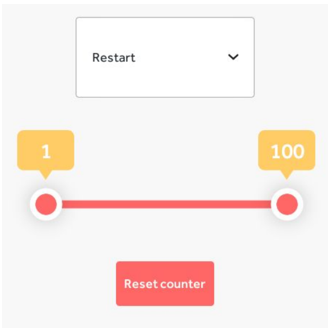
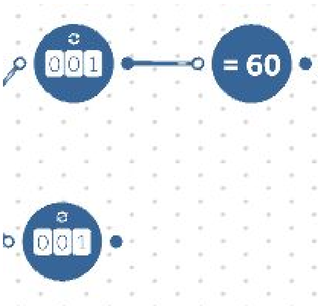
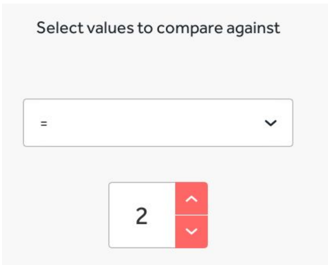
Let's Discuss: *Are there more prime or non-prime numbers overall? In your workbook or with a partner, record or discuss how you can use math to identify a prime and non-prime (composite) number.*

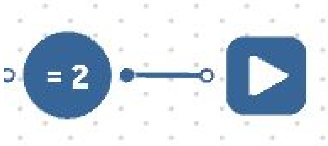
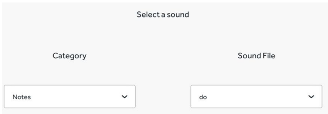
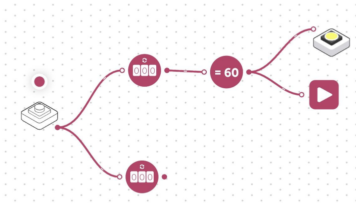
Link forward: What numbers would we need to use to check for prime numbers within 200?

Lesson 2.10
There Can Be Only, Two

Worked Example — 7 minutes

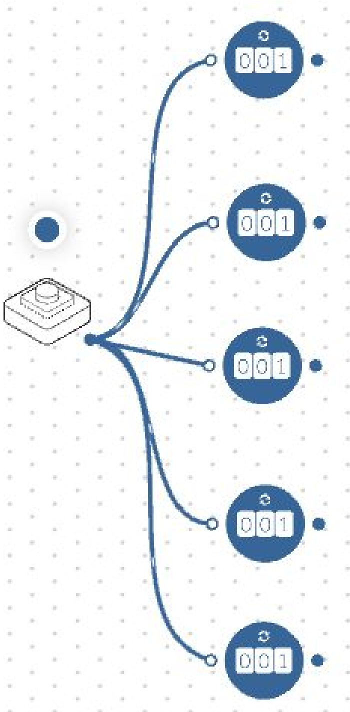
Design a SAM system to check for even numbers.

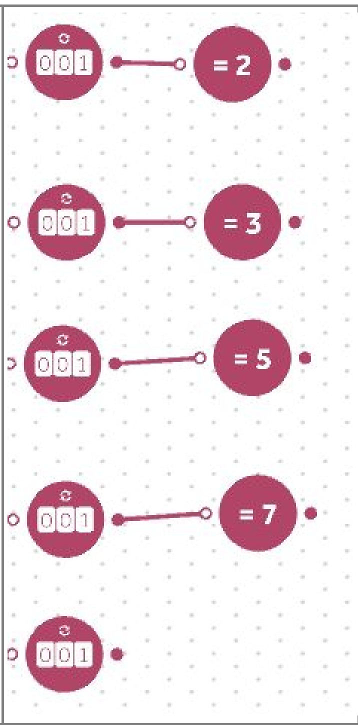
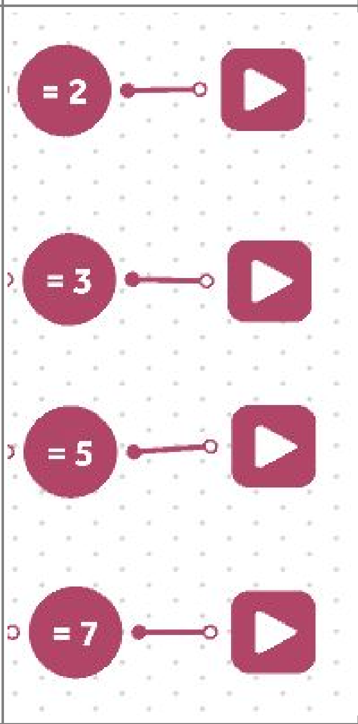
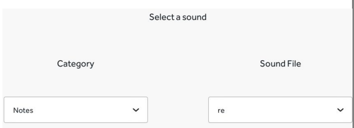
Instructions	Workspace	Notes for Teachers
Step 1. Turn on and pair: • A Button/Virtual Button block Add it to the workspace.		*The Button will be the control for the counter you will add.*
Step 2. Drag two Counters onto the workspace. Connect them to the Button.		*Now, as you click the Button, both the first and second Counter will increase.*
Step 3. Click the settings icon for the first Counter to go from '1 - 2'. Set the second counter from '1 - 100'.		*The first counter will be used to determine even numbers and the second will be used to keep track of how many times the Button is clicked in total.*
Step 4. Drag a Compare block onto the workspace and connect it to the first Counter.		*You will want to keep track of that top Counter and do something when it reaches a certain number.*
Step 5. Set the Compare block to be = to 2.		*In this example, 2 is the multiple being counted. Each time it is reached, something will happen.*

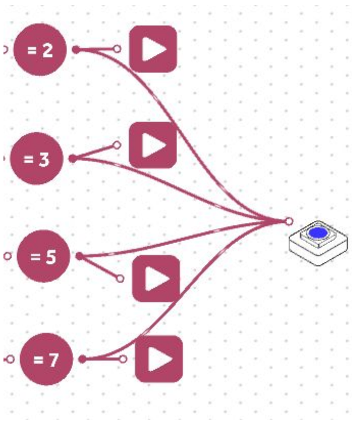
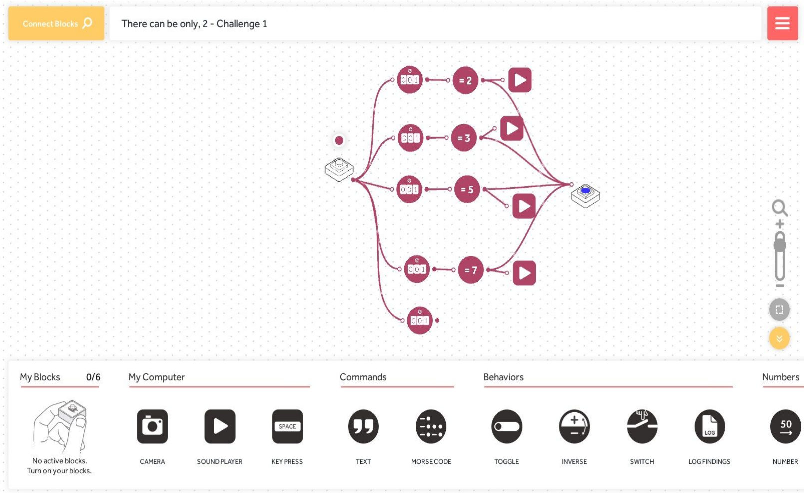
Step 6. Add a Sound Player block to the workspace and connect it to the first Counter.		*This will alert the student every time a multiple of 2 is reached.*
Step 7. Click the settings of the Sound Player block. Choose Note and 'Do'.		*This sound is quick, fairly quiet and will be built upon later in this lesson.*
Step 8. Turn on and pair: ● RGB LED block Connect it to the Compare block. Choose a color through the settings.		*This also also alert the students. Some may be more receptive to seeing than hearing.*

Challenge 1 — 7 minutes

Include prime numbers less than 10.

Instructions	Workspace	Notes for Teachers
Step 1. Add 3 more Counter blocks. Connect them to the Button. Arrange it so that the Counter block set to 1 - 100 is at the bottom of the workspace.		*This will allow you to count with a number of prime numbers at the same time.*
Step 2. Enter a range of '1 - 3', '1 - 5' and '1 - 7' for each of the other Counters.		*It is vital that all of the counters start at 1. This could be something to debug. The reason each counter starts at 1 is because the system would consider 0 to 3, for example, a count of 4 and it needs to be a count of 3.*

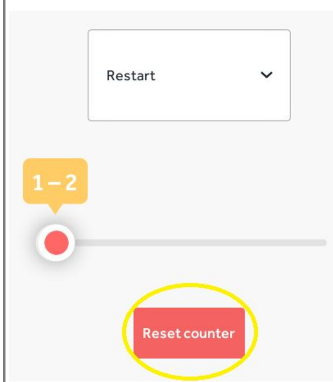
Step 3. Add three more Compare blocks. Connect them to each of the new Counter blocks. Set each of the Compare blocks to = '3, 5 and 7', depending on the Counter to which they are connected.		*This will keep track of all of the multiples of 2, 3, 5 and 7 at the same time.*
Step 4. Add a Sound Player block to each Compare block.		*This will have a sound play each time a multiple of 2, 3, 5 or 7 is reached..*
Step 5. Set the Sound Player blocks to Note and 'Mi' for 3, 'Sol' for 5 and 'La' for 7.		*This will allow for one note sometimes, two notes at others and 3 notes a few times. 4 notes will not play at the same time because the first number to have the factors 2, 3, 5 and 7 is 210 and this system only goes to 100.*

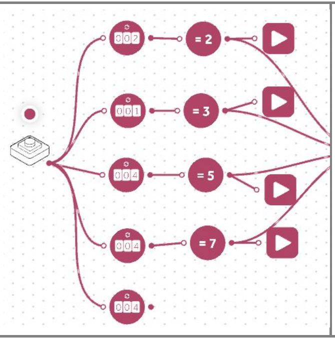
Step 6. Connect all of the Sound Player blocks to the RGB LED. Test it by checking if you hear the correct tone for 2, 3, 5 and 7.		*As with the worked example, some students may respond better to light than sound.*
Example of full system.		

Checks for understanding: *What is a prime number? What is a non-prime number?*

Challenge 1 - Debug it — 5 minutes

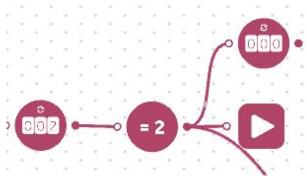
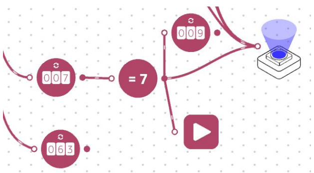
Why might some Counters not make sense with big Counter? Why might some sounds never play?

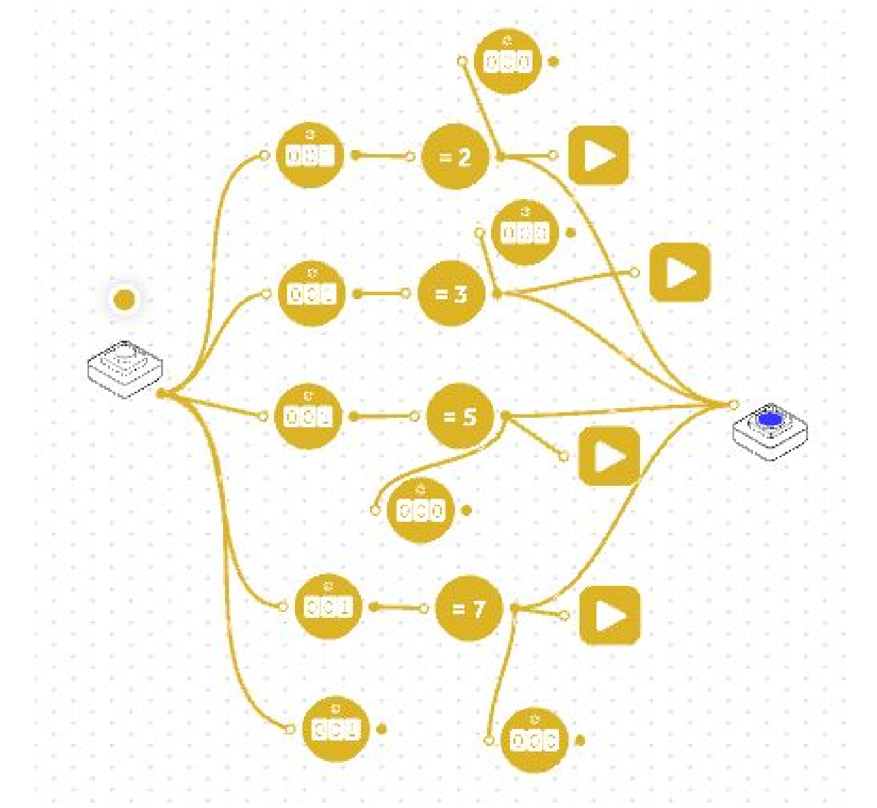
Instructions	Workspace	Notes for Teachers
Step 1. Be sure to reset your Counters after the worked example.		*If the Counter is not reset when the students move from the Worked Example to Challenge one, the count will not be correct for any of the numbers.*

Step 2. Check your connections.		*There are a lot of connections here. If one is missing, or connected to the wrong block, you will not get the intended result.*

Challenge 2 — 7 minutes

Return the factor pair when the bottom Counter displays a non-prime number.

Instructions	Workspace	Notes for Teachers
Step 1. • Drag 4 new Counter blocks onto the workspace used in challenge 1, there will now be 9 Counter blocks in total. • Connect each new Counter block to each of the Compare blocks. Set the counter for ‘0 - 100’.		*This new Counter needs to start at 0 as the first time this block is true it will become 1.*
Step 2. Test the workspace to see if the numbers, identified as prime in the student workbooks, are prime in the workspace. Examples might be 29, 37, 61, etc.		*In this instance, I am checking to see if 63 is prime. It isn’t, it is a non-prime. A factor pair is 7 and 9.*

<table>
<tr><td>Example of the full system.</td><td>
</td></tr>
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Extension Ideas:

- **Computing**:
  - Can you think of a way to make the workspace less busy?
  - Could you think of another way to indicate if a number is prime or non-prime?
- **Math:**
  - What do you think it means when the number is great, like 64 or 81, but only 1 number lights up as a factor?

</td></tr>
</table>

Checks for understanding: *What does it mean if the sound does not change? Why might two or three notes play at the same time?*

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.