Ballista Science

GRADE LEVEL:
6th

UNIT NAME:
Unit 1, Ballista Science

TIME:
5 days/40 minutes each day

SCIENCE TEXAS ESSENTIAL KNOWLEDGE AND SKILLS (TEKS)
(6.8A) Compare and contrast potential and kinetic energy
(1Ai) Students must become familiar with different modes of scientific inquiry, rules of evidence, and ways of formulating questions.
(1Aii) All investigations require a research question, careful observations, data gathering, and analysis of the data to identify the patterns that will explain the findings.

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LESSON SCHEDULE & MATERIALS:

Day #1	Day #2	Day #3	Day #4	Day #5
Introduction to Science (7 min) Introduce concepts of potential energy, kinetic energy, and energy transformations. Introduce the project for the week and go over class objectives. **Introduction to Circuits (10 min)** Introduce basic circuit concepts: closed and open circuits, energy transformations, electrical and mechanical energy. *Class Discussion: What is an electric circuit?* **Unplugged Activity (10 min)** Students will perform a circuit re-enactment to model the battery, load, and switch using rope as a depiction of wires. **Introduction to Arduino (10 min)**	**Recap: Computers and Arduinos (5 min)** Go over what an Arduino is, how it is a computer and can function as a digital switch and a power source. **Making activity: Build a simple circuit (20 min)** Students will assemble the Ballista Model using Table Chart 1 and create a simple motor circuit using Arduino and a paper switch. Rebuild the circuit and remove the paper switch (Arduino as a digital switch). **Programming activity (15 min)** Introduction to programming and Ardublockly. Students will log into their class using a Join Code and their personal passwords. One-line code for the circuit. **(Optional) Conclusion**	**Ballista Model Assembly (20 min)** Students will assemble 3D printed parts to build the Ballista model. Introduce the rack and pinion simple machine. Introduce the potential and kinetic energy in the Ballista model. **Making activity: Build a circuit (10 min)** Students will create a circuit using Table Chart 2 using Arduino, a motor, and a paper switch. Remove the paper switch from the circuit using Table Chart 3. **Programming activity (10 min)** Students will log into their class using a Join Code and their personal passwords. One-line code to fire the Ballista.	**Ballista Model Assembly (15 min)** Students will reassemble the Ballista model using Table Chart 3. Students will write a one-line program to turn a motor on and off (single instruction). **Programming activity (25 min)** Introducing a Sequence in programming. Students will write a program to turn the motor on and then off after a certain period of time, and will do measurements to find the appropriate amount of time to pull the bolt. *Exploration (if time permits):* Students will write a short, simple program to vary the amount of waiting time. Students will practice modifying the program.	**Introduction to Experiment (5 min)** Go over relevant science concepts: work, scientific method. Discuss the experiment. Introduce calculating averages. **Ballista Model Assembly and Ardublockly programming (15 min)** Students will rebuild the Ballista Model and the code from Day 4. **Experiments (15 min)** How do different measures of potential energy settings affect the distance a block travels? Students will make predictions, conduct trials, and collect data as a class, and the teacher will record on the board. **Class Discussion & Conclusion (5 min)** Teachers will analyze the data as a class and draw conclusions.

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Go over what an Arduino is, how it is both a computer, can function as a digital switch, and as a power source. **Electricity and Safety (3 min)** Difference between the electricity we use in the classroom and the house electricity **(Optional) Conclusion:** *Summarize and wrap up*: build connections between the making and the science lesson.	*Summarize and wrap up:* build connections between the making and the science lesson.	**(Optional) Conclusion** *Summarize and wrap up:* build connections between the making and the science lesson.	**(Optional) Conclusion** *Summarize and wrap up:* build connections between the making and the science lesson.	*Summarize and wrap up:* Discuss science models and topics and relate/make connections to the science lesson. Optional: End-of-Week CS Assessment

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Day #1	Day #2	Day #3	Day #4	Day #5
Materials • Maker kit • Table Chart 1 • Table Chart 2 • Laptop • Science notebook	**Materials** • Maker kit • Table Chart 3 • Table Chart 1 • Laptop • Ardublockly Guide • Science notebook	**Materials** • Maker kit • Table Chart 3 • Ballista Assembly • Laptop • Ardublockly Guide • Science notebook	**Materials** • Maker kit • Table Chart 3 • Ballista Assembly • Laptop • Ardublockly Guide • Science notebook	**Materials** • Maker kit • Table Chart 3 • Laptop • Ardublockly Guide • Ruler • Data logging table • Science notebook • Ballista Assembly • Optional: End-of-Week CS Assessment

Ballista Science

Vocabulary

Science:

- energy
- potential energy
- kinetic energy
- energy transformation
- energy loading
- scientific question
- hypothesis/prediction
- running trials
- average
- analyzing data
- conclusion

Computing:

- pseudocode
- code
- code reading
- tracing
- modifying and writing
- debugging
- electricity
- volt
- pins
- computer port
- algorithm

Making:

- maker
- ballista
- Arduino
- pinion gear
- rack and pin
- crossbow base
- bolt
- DC motor

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Day 1

LESSON SUMMARY

Introduction to Science (7 min)
Introduce concepts of potential and kinetic energy. Introduce the project for the week and go over class objectives.

Introduction to Circuits (10 min)
Introduce basic circuit concepts: closed and open circuits, energy transformations, electrical and mechanical energy.

Class Discussion: What is an electric circuit?

Unplugged Activity (10 min):
Students will perform a circuit re-enactment to model the battery, load, and switch using rope as a depiction of wires.

Introduction to Arduino (10 min)
Go over what an Arduino is, how it is both a computer, can function as a digital switch, and as a power source.

Electricity and Safety (3 min)
Difference between the electricity we use in the classroom and the house electricity

(Optional) Conclusion:
Summarize and wrap up: build connections between the making and the science lesson.

MATERIALS NEEDED
Per Group

- Maker kit
- Table Chart 1
- Table Chart 2
- Laptop
- Science notebook

TEACHING GUIDELINES

PHASE 1: Introduction to Science (7 min)

Introduce concepts of potential energy, kinetic energy, and energy transformations. Introduce the project for the week and go over class objectives.

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Contents:

- Potential and kinetic energy:
    - Potential energy is energy that is stored in an object
    - Kinetic energy is energy that an object has because of movement
    - Energy Transformations
        - Energy cannot be created or destroyed
        - It can be converted to another type of energy
- The project for the week:
    - We will be modeling the potential and kinetic energy transformation with a ballista
    - Build the ballista
    - Write a program to fire the ballista
    - Measure how far the block travels
- Place students in groups of two and pass out all materials to each group.

Notes: **Slide 4** - Teacher Slides

PHASE 2: Introduction to Circuits (10 min)

Introduce basic circuit concepts: electrical and mechanical energy, closed and open circuits, circuit components.

Objectives:

- To learn about what a circuit is
- To learn about closing and opening a simple circuit
- To learn to use table charts to build a maker system
- To learn the components of a led circuit

Contents:

- What is a circuit?
    - A circuit is a 'circle of electricity' – goes from positive to negative and back
        - A simple electric circuit can consist of a battery (or other energy source), a light bulb (or other device that uses energy), and conducting wires that connect the two terminals of the battery to the two ends of the light bulb or other device.
    - A complete and closed path around which a circulating electric current can flow
        - An Open Circuit is an incomplete circuit
        - Closed Circuit is a complete circuit, an uninterrupted path through which electricity can flow.
- Circuit components
    - Power: Has VOLTAGE (like a battery)

        - A battery is a device that gives energy to the electrons for electric current to flow.
    - Conductors: Wires for electricity to flow
    - Load: does work when current flows
        - A device or an appliance refers to something that consumes the electric current like an electric bulb, a computer, heater, etc.
    - Switch: To open and close the circuit
- Discuss what circuits we can see in real life
        - the classroom lights
        - a string of christmas lights
        - water heaters
        - lamps
        - refrigerators

Notes: **Slide 5** - Teacher Slides

Phase 3: Unplugged Activity (10 min)

Students will perform a circuit re-enactment to model the battery, load, and switch using rope as a depiction of wires.

Objectives:

- To understand that a complete (closed) circuit occurs when electricity can flow through a loop without interruption and becomes incomplete (or open) when the flow is interrupted

Contents:

- Act
    - Place students in groups of three in a circle, ask them to hold on to the ropes used to represent wires.
    - Assign roles to them: battery, load, and switch. Explain that their ropes are like wires through which electricity runs.
    - The “battery” person supplies the power and electricity while the “load” person “turns on” by waving their hands. When the “switch” person breaks the circle, the “load” person stops waving their hands.
    - Call out instructions to the “switch” people to “open or close” the circuit.
- Check students’ understanding
    - Questions to ask: what is a circuit?
        - A circuit is a ‘circle of electricity’ that travels from positive to negative.
    - Questions to ask: what are circuit components?

- It consists of a power source that has voltage (battery, Arduino), conductors through which electricity flows (wires), a load that does work when there is current flowing (light bulb, motor), and a switch that interrupts the flow of electricity and effectively opens the circuit.

Notes: **Slide 6** - Teacher Slides

Phase 4: Introduction to Arduino (10 min)

Go over what an Arduino is, how it is both a computer, can function as a digital switch, and as a power source.

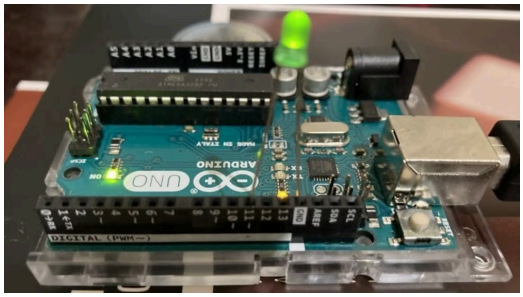
Objectives:

- The goal of this discussion is to help students realize different types of computers are part of their daily lives, including microcontrollers such as Arduino.

Contents:

- Guide students to point out computers in daily life such as:
  - Motherboards on PCs and laptops
  - Garage door openers
  - Cell phones
  - Robots
- Guide students to point out computers in daily life without screens such as:
  - Washing machine - When the cycle is set for a load and the start button is pushed, the washer will use its sensors and complete the wash and rinse process. It does so by turning on and off devices that control the rest of the machine, such as the motors that spin the tub and the agitator or the water pump.
  - Car - A car's brake-by-wire system that controls the brakes electronically. A position sensor monitors how far the driver has pushed the brake pedal, which is used to determine the amount of braking force requested.
  - Vending machine - At the bottom of the vending machine, a line of laser beams determines if your product has been released by the metal spirals. Each laser beam is paired with an electronic light sensor. When the product falls it breaks this path, telling the computer that it was a successful transaction.
- Tell students about little computers called microcontrollers
  - All of the parts of a microcontroller work together to execute a pre-programmed set of specific tasks.
  - A microcontroller is a single integrated circuit that comprises various elements, including a microprocessor, timers, counters, input/output (I/O) ports, random access

memory (RAM), read-only memory (ROM), and some other components. These parts work together to execute a pre-programmed set of specific tasks.
    - A microcontroller is like a little computer that processes and even executes control in an electronic device.
    - Arduino is a microcontroller.
- Formally introduce Arduino.
    - To be able to answer questions accurately, it's important for you to understand what an Arduino is and what it does. If you need a refresher, review Arduino and its components here: https://all3dp.com/2/what-is-a-microcontroller/



- Plug-in activity
    - Plug in your Arduino to your laptop.
        - Students should be able to see the light when it's plugged in.

Notes: **Slide 7** - Teacher Slides

Phase 5: Electricity and Safety (3 min)

Difference between the electricity we use in the classroom and the house electricity.

SAFETY: High voltage electricity, such as in a house, can be dangerous; however, the electricity we're using has low power and voltage and is much less dangerous. Do not allow students to play open the wires or other components of the circuit.

Notes: **Slide 8** - Teacher Slides

(Optional) Conclusion

Summarize and wrap up: Teachers will tie and make connections between today's STEM+C topics, models, and the science concepts.

Day 2

LESSON SUMMARY

Recap: Computers and Arduinos (5 min)

Go over what an Arduino is, how it is a computer and can function as a digital switch and a power source.

Making activity: Build a simple circuit (20 min)

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Students will assemble the Ballista Model using Table Chart 1 and create a simple motor circuit using Arduino and a paper switch.
Rebuild the circuit and remove the paper switch (Arduino as a digital switch) Table Chart 3

Programming activity (15 min):
Introduction to programming and Ardublockly. Students will learn to use and get comfortable with the platform. One-line code for the circuit.

(Optional) Conclusion:
Summarize and wrap up: build connections between the making and the science lesson.

MATERIALS NEEDED
Per Group
- Science notebooks
- Maker kit
- Table Chart 1
- Table Chart 3
- Laptop
- Ardublockly Guide

TEACHING GUIDELINES
PHASE 1: Recap: Computers and Arduinos (5 mins)
Go over what an Arduino is, how it is a computer and can function as a digital switch and a power source

Objectives:
- To understand what a computer is.
- To understand computers can function as a switch.
- To understand that computers need a sequence of ordered instructions.
- To learn to write a simple program.
- To learn what a arduino is

Contents:
- What is a computer?
  - A device that stores, processes, and retrieves information based on the given instructions
- What can contain a computer?
  - (microwave oven, television, projector, laptop – computers follow programs to do work)
- What is an arduino?
  - Arduinos are computers and can function as a digital switch and power source
- Show students an Arduino

- There are many computers like this in a car to control different things like fuel injection, braking, when to turn on lights, signals, wipers, radio/music system etc.

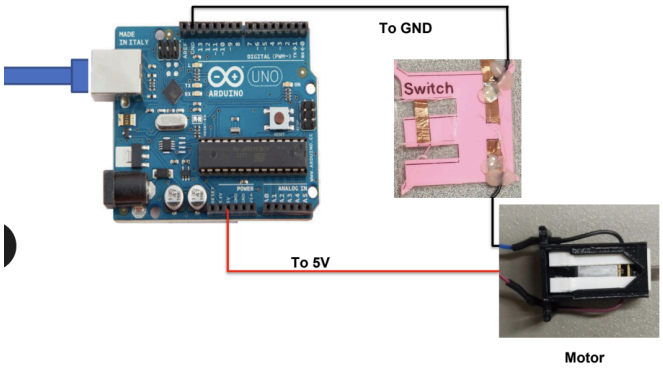
Notes: **Slide 10** - Teacher Slides

PHASE 2: Making activity: Build a simple circuit (20 min)

Students will assemble the Ballista Model using Table Chart 1 and create a simple motor circuit using Arduino and a paper switch.
Rebuild the circuit and remove the paper switch (Arduino as a digital switch).

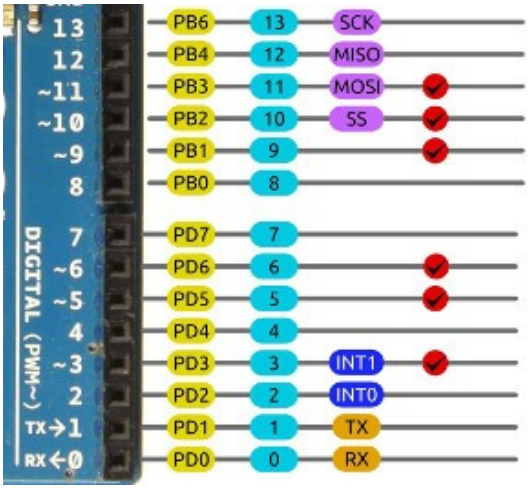
Contents:

- Making activity 1: building a simple circuit.
  - Arduino, motor, paper switch (explain how motors and paper switches work)
    - When the path is closed (folded), that means the electricity flow is continuous and the motor turns on/rotates.
    - When the path is open (unfolded), that means the electricity flow is stopped and motor turns off
    - Point out the parts of a circuit to students. The battery, which provides the power source, is like the “battery” person. The wires are like the arms and the motor is the load.
  - Provide the students with the table charts and circuits and let them assemble.



- **Making activity 2:**
  - Rebuild the circuit
    - Remove the paper switch
    - Connect the motor to a digital pin

- Arduino functions as a digital switch
  - An input/output pin, or I/O pin, is the interface between a microcontroller and another circuit. There are 14 digital pins on an Arduino board and they can be used to read data from some components (sensors) and write data to other components (actuators).



  - A digital pin can have only 2 states: LOW or HIGH. You can consider them as binary pins. LOW means that the voltage on the pin is 0V and HIGH means the voltage on the pin is 5V. In our activity, this means that when you set a pin to LOW, you're setting it at zero volts and the motor turns off. HIGH means you're supplying a voltage to the motor so that it turns on.
  - The GND pin connects all grounds of multiple circuits together and must always be connected. The ground is essential for the Arduino board to measure and set any voltage. Basically a voltage is a difference of potential between 2 points: here you take the ground and another point. It's like measuring the height difference between 2 persons: if one of them is standing on a box, then the ground reference is not the same. And you can't get a valuable measurement if you don't place the 2 persons on the same level. If everything in your circuit is connected to the same ground, all the voltages can be compared and their value is relevant.
- Fun Fact (DC motor)
  - The DC motor can be configured to turn in either direction by simply inverting or reversing the polarity of the applied voltage. The change in the flow of current switches the direction of the spinning force, causing the motor's shaft to begin turning in the opposite direction.

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Notes: **Slides 11, 12** - Teacher Slides

PHASE 3: Programming activity (15 min)

Introduction to programming and Ardublockly. Students will learn to use and get comfortable with the platform. One-line code for the circuit.

Objectives:

- The goal of this activity is for students to use their laptops to log in to their class Ardublockly account and learn that Ardublockly is the medium by which Arduino is given instructions.
    - Have students log on to Ardublockly (https://ardublockly.pitsco.com/)
    - Provide a tour of the Ardublockly workspace. For a refresher, visit the document: Ardublockly Guide.

- Teacher Note:
    - Open your own Ardublockly page on the teacher's computer and project a blank workspace on the/screen.

Contents:

- The next goal is for students to write a one-line single instruction to turn the DC motor on and off.

- **Live Coding**
    - Together with students, write a one-line program to show students they need to write instructions to send to Arduino. The instruction is 'sent' when the Ardublockly program's 'infinity' button is clicked.

    - Comments (optional)
        - Be sure to read the comments as they contain pertinent information. Comments are blocks that hold notes for you to understand the code and the computer ignores these blocks. See example:

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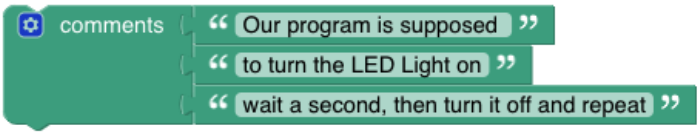

Notes: **Slide 13** - Teacher Slides

(Optional) Conclusion:
Summarize and wrap up: build connections between the making and the science lesson.

Day 3

LESSON SUMMARY

Ballista Model Assembly (20 min)
Students will assemble 3D printed parts to build a Ballista model. Introduce the rack and pinion simple machine. Introduce the potential and kinetic energy in the Ballista model.

Making activity: Build a circuit (10 min)
Students will create a circuit using Table Chart 2 using Arduino, a motor, and a paper switch. Remove the paper switch from the circuit using Table Chart 3.

Programming activity (10 min):
Students will log into their class using a Join Code and their personal passwords. One-line code to fire the Ballista.

(Optional) Conclusion:
Summarize and wrap up: build connections between the making and the science lesson.

MATERIALS NEEDED
Per Group

- Maker kit
- Table Chart 2
- Table Chart 3
- Ballista Assembly
- Laptop
- Ardublockly Guide

- Science notebooks

TEACHING GUIDELINES

PHASE 1: Ballista Model Assembly (20 min)

Students will assemble 3D printed parts to build a Ballista model. Introduce the rack and pinion simple machine. Introduce the potential and kinetic energy in the Ballista model.

Content:

- Rack and Pinion gear machine
    - Convert rotational movement to linear movement
    - Discuss where we can see this machine in real life
- Place students in groups of two and pass out all materials to each group. Students will use the parts in the maker kit to assemble the Ballista model.
- The Ballista
    - The rubber band stores potential energy when it is stretched
    - The rubber band releases kinetic energy when it is fired
    - You can feel the energy being stored when the rubber band is stretched
    - You can see the energy being released and work is done
    - The Ballista can store two levels of potential energy depending on whether you double the rubber band

Notes: **Slide 17- 18** - Teacher Slides

PHASE 2: Making Activity (10 min)

Students will create a circuit using Table Chart 2 using Arduino, a motor, and a paper switch. Close the paper switch and observe what happens. Remove the paper switch from the circuit using Table Chart 3.

Objectives:

- To learn how potential energy is transformed to kinetic energy to produce work.
- To practice programming a simple program and execute tasks.
- To make predictions.
- To understand why multiple trials in investigations are important.
- To draw conclusions from class data.

PHASE 3: Programming Activity(15 min)

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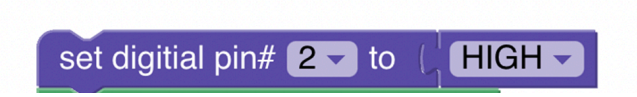
Students will log into their class using a Join Code and their personal passwords. One-line code to fire the Ballista.

Contents:

- Instruct students to write a simple program instructing the Arduino to turn on the motor.



- To find out how long the motor should stay on for the bolt to launch, have students reference the observations they made on Day 1 in their science notebooks.

Notes: **Slides 19-20** - Teacher Slides

(Optional) Conclusion
Summarize and wrap up: Teachers will tie and make connections between today's STEM+C topics, models, and the science concepts.

Day 4

LESSON SUMMARY
Ballista Model Assembly (15 min):
Students will reassemble the Ballista model using Table Chart 3.
Students will write a one-line program to turn a motor on and off (single instruction).

Programming activity (25 min):
Introduce a Sequence in programming.

Students will write a program to turn the motor on and then off after a certain period of time, and will do measurements to find the appropriate amount of time to pull the bolt.

Exploration (if time permits): Students will write a short, simple program to vary the amount of waiting time. Students will practice modifying the program.

MATERIALS NEEDED
Per Group

- Maker kit
- Table Chart 3
- Ballista Assembly

- Laptop
- Ardublockly Guide
- Science notebook

TEACHING GUIDELINES

PHASE 1: Ballista Model Assembly (15 min)

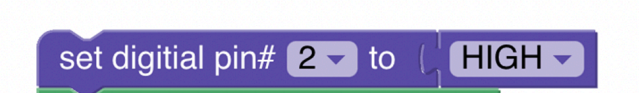
Students will reassemble the Ballista model and circuit using Table Chart 3.
Recap: Students will write a one-line program to turn a motor on and off (single instruction).

Objectives:

- Recap previous making and programming concepts from Days 2 and 3.
- Rebuild the model and circuits for new programming practices.

Contents:

- Making activity:
  - Have the students assemble the circuit and ballista using Table Chart 3 (same as Day 3).
- Programming activity:
  - A one-line code to turn on the motor and fire the ballista (same as Day 2).



- Class Discussion:
  - Can we stop the motor running after the ballista is fired?

Notes: **Slide 22** - Teacher Slides

PHASE 2: Programming activity (25 min)

Introduce the concept of a Sequence in programming. Students will write a program to turn the motor on and then off after a certain period of time, and will do measurements to find the appropriate amount of time to pull the bolt.

Objectives:

- Understand sequential programming
- Experiment with modifying a program

Contents:

- What do we want to do?
  - Turn on the motor
  - Leave the motor on for a certain amount of time
  - Turn off the motor

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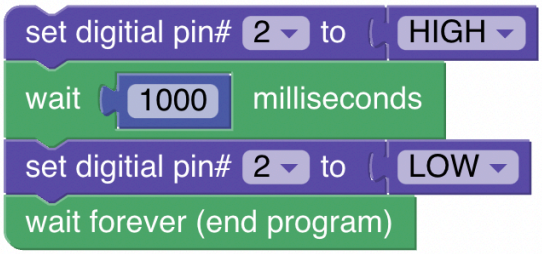
- Programming concepts:
  - What is a ‘Sequence’?
    - As students observe what they’re doing, they’ll notice the motor turns on but not off. Ask students why the motor stays on.
    - Explain that the computer needs a specific set of instructions to follow to do what you want it to do. A program is a series of single instructions.
    - There is no coding block that tells the program to repeat the instruction. A special feature of the Arduino is that its main program will run in a continuous loop and unless we instruct it to stop, the program will keep running the same code over and over again until the Arduino is turned off, unplugged, or a new program has been uploaded.
    - **Sequences** are a particular order in which related events, movements, or things follow each other. In computer science, sequences are a series of steps that tell the computer or program what to do. Without ordered steps, the computer doesn’t understand and will not carry out its task.
  - ‘Wait time’ and ‘Wait forever’
    - ‘Wait time’ refers to a fixed delay. The delay block tells Arduino to wait for a specific amount of time before moving on to the next instruction.
    - Arduino counts in milliseconds, or counts up to 1,000 per second. This means students will have to make a conversion between the time. Tell them that for each second, they should write 1,000 milliseconds instead. “Wait 1000 milliseconds” means to delay the next instruction for 1 second/1000 milliseconds.
    - ‘Wait forever’ means halting program execution indefinitely. The ‘wait forever’ block tells the computer to end the program.

- Programming activity:
  - The goal of this activity is for students to add more instructions by writing a simple program on Ardublockly.
  - Walk the students through the program
    - Turn on the motor (HIGH)
    - Wait 1 second (motor running, Arduinos count in milliseconds - Point out to students that it is similar to counting up to 1000 very fast. “Wait 1000 milliseconds” means to delay the next instruction for 1 second/1000 milliseconds.)
    - Turn off the motor (LOW)
    - Wait forever to stop the program



Exploration (optional if time permits)

Students will write a short, simple program to vary the amount of waiting time. Students will practice modifying the program.

Contents:

- Guide students to change the wait time and see what happens.
- Arduino always executes the last program that was uploaded to it.

Notes: **Slide 23-24** - Teacher Slides

(Optional) Conclusion

Summarize and wrap up: Teachers will tie and make connections between today's STEM+C topics, models, and the science concepts.

Day 5

LESSON SUMMARY

Introduction to Experiment (5 min)

Go over relevant science concepts: work, scientific method. Discuss the experiment.
Introduce calculating averages.

Ballista Model Assembly and Ardublockly programming (15 min)

Students will rebuild the ballista model and the code from Day 4.

Experiments (15 min)

How do different measures of potential energy settings affect the distance a block travels?
Students will make predictions, conduct trials, and collect data as a class and teacher will record on the board.
Class Discussion: Teachers will analyze the data as a class and draw conclusions.

Class Discussion & Conclusion (5 min):

Teachers will analyze the data as a class and draw conclusions.

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Summarize and wrap up: Discuss science models and topics and relate/make connections to the science lesson.

MATERIALS NEEDED

Per Group

- Maker kit
- Table Chart 3
- Laptop
- Ardublockly Guide
- Ruler
- Data logging table
- Science notebook
- Ballista Assembly
- Optional: End-of-Week CS Assessment

TEACHING GUIDELINES

PHASE 1: Introduction to Experiment (5 min)

Go over relevant science concepts: work, scientific method. Explain the experiment.
Introduce calculating averages.

Objective:

- To set the stage for scientific investigation
- To reinforce key scientific concepts

Contents:

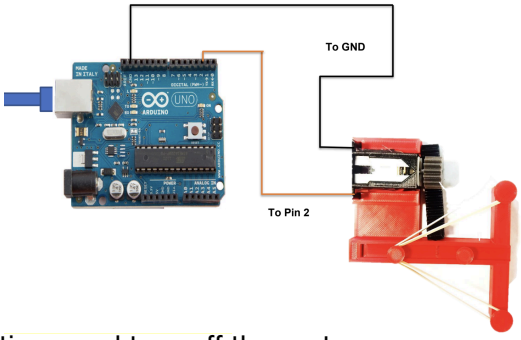
- Go over relevant science concepts
    - Work: the result of a force moving an object over a distance
    - Scientific Method
        - Ask a question
        - Make a prediction
        - Test with an experiment
        - Record an analyze data
        - Draw a conclusion
- Explain today's experiment
    - Students will test how different levels of potential energy affect the distance a block travels when launched by a ballista
- *How do we calculate average?* Introduce the concept of calculating averages as a tool to analyze experimental data
    - Add together the results of all your trials
        - *Example*: If the distances from 3 trials are 45 cm, 50 cm, and 55 cm:
          45 + 50 + 55 = 150 cm
    - Count how many trials you did.

        - *In this case:* 3 trials
    - Divide the total distance by the number of trials to find the average.
        - 150 ÷ 3 = 50 cm
    - This average helps us reduce the effect of small differences in each trial and gives us a more reliable result.

Notes: **Slide 26** - Teacher Slides

PHASE 2: Ballista Model Assembly and Ardublockly programming (15 min)

Students will rebuild the ballista model and the code from Day 4.



Objective:

- To prepare devices for controlled testing
- To reinforce coding concepts

Contents:

- Have students rebuild the whole circuit with Ballista
- Practice the programming activities from Day 4, including:
    - Writing code to turn on the motor, waiting a certain time, and turn off the motor
    - Adjusting timing using WAIT to control when ballista fires

Notes: **Slide 27** - Teacher Slides

PHASE 3: Experiments (15 min)

Investigation Question - How do different measures of potential energy affect the distance a block travels?
Students will make predictions, conduct trials, and collect data as a class and teacher will record on the board.

Contents:

- Students load the ballista with one of the two potential energy settings (single or doubled rubber band)
- Each table gets a turn to fire their ballista three times (or twice depending on time)
- For each trial, they measure the distance the block travels and calls out the distance to the teacher who makes a table on the board
- Have the students take the following notes in their science notebooks:
    - Make predictions about how far the block will travel for each energy setting
    - The setting of the ballista that they are using
    - How far the block travels
- Students learn the experimental process that there are variations in repeated experiments, and they will record results in their notebook using the following chart:

Degree of Stretch	*Distance Traveled (cm) Trial 1*	*Distance Traveled (cm)*	*Distance Traveled (cm)*	*Average of Actual*

			Trial 2	Trial 3	Distance
	Predicted	Actual	Actual	Actual	–
No stretch					
Stretch at the first notch					
Stretch at the second notch					

- Class Data Table (on Board)
    - The teacher should create a similar table on the board to gather group averages:

Degree of Stretch	Average Distance Traveled (cm) Group 1	Average Distance Traveled (cm) Group 2	Average Distance Traveled (cm) Group 3	Average of Actual Distance
	Actual	Actual	Actual	–
No stretch				
Stretch at the first notch				
Stretch at the second notch				

    - As each group finishes their trials, they will report their average, and the teacher will compile the data on board.

Notes: **Slide 28** - Teacher Slides

PHASE 4: Class Discussion & Conclusion (5 min)

Teachers will analyze the data as a class and draw conclusions.
Summarize and wrap up: Discuss science models and topics and relate/make connections to the science lesson.

Objective:

- To draw conclusions from the class data

- To connect the experiment to key science concepts

Content:

After all data has been compiled on the board, analyze the data and draw conclusions as a class.

- Have a class discussion about the observations
    - *What trends do we see in the class data table?*
    - *Did increased stretching result in greater distances?*
    - *Were any groups' results unexpected?*
    - *Whether predictions match outcomes?*
- Some other engaging questions:
    - *What happened when we did not have the rubber band pulled back?*
    - *What happened when we had the rubber band pulled a little?*
    - *What happened when we had the rubber band pulled a lot?*
- Check Students' understanding and science connection:
    - Question to ask: *How does potential energy turn into kinetic energy?*
        - Energy can be transformed from potential energy (PE) into kinetic energy (KE) when something acts to release stored energy.
    - Question to ask: *How is potential energy harnessed in the Ballista Model?*
        - The Ballista Model has two potential energy settings, single or doubled rubber band, and a release/trigger mechanism. The amount of PE is determined by how strong the rubber band is or how far it is stretched. It affects the distance the bolt travels.
    - Question to ask: *How can you measure the amount of potential energy in the Ballista Model?*
        - We can measure the amount of potential energy in the trigger mechanism.
    - Question to ask: *How does the Ballista Model transform potential energy into kinetic energy?*
        - The release of the trigger converts the stored PE into KE. As the rubber band is released, it changes the PE into KE as it pushes the object. KE will result in the speed of the object in terms of how far it travels within a certain amount of time. The release of the trigger causes PE to transform into KG.
- Summarize and wrap up*:* Discuss science models and topics and relate/make connections to the science lesson.
- An optional small quiz: End-of-Week CS Assessment

Notes: **Slide 29** - Teacher Slides