Ball Toss

Grades 6-8

Lesson Overview

60 - 120 mins

During this lesson, students will design and code an experiment exploring how mass affects the kinetic energy of a tossed ball. They will integrate Vernier sensors with Google Sheets and Sam Labs blocks in their coding solution.

Learn

Warm-Up
Mini-lesson

Identify situations where energy is transferred from one object to another.
Explore how the mass of an object affects its kinetic energy.

Do

Guided Lab Part 1
Debug Opportunity
Guided Lab Part 2
Extension Activities

Design, **code** and **extend** a program using a Motion Sensor that collects motion data and automatically determines the maximum height a ball reaches; extending to visualize the data using a RGB LED and Google Sheets; to explain how mass affects kinetic energy.

Reflect

Wrap-Up

Reflect upon and **evidence** learning.

Standards Focus

NGSS DCI PS3.A and PS3.B, MS-PS3-1, MS-PS3-5
CSTA Data and Analysis 2-DA-07, 2-DA-08, 2-DA-09

Equipment Required

SAM Labs RGB LED, Vernier Go Direct Motion, a variety of balls of different sizes/masses

Link to lesson code on Workbench

https://edu.workbencheducation.com/cwists/preview/60114x

Ball Toss

Learn

Warm-Up

“How much energy does it take to throw a ball?”

Key Information

- Energy is the ability to do work. When an object has energy, it can exert a force on another object.
- There are different forms of energy, for example:
    - Kinetic energy is the energy of motion. A moving object will have kinetic energy.
    - Potential energy is associated with a system (or group) of objects and determined by their positions.
- When one object exerts a force on a second object, it transfers some of its energy into it. For instance, when you toss a ball, you transfer some of your energy into the ball.
- An object’s energy can change forms because of the forces acting on it. For instance, a tossed ball will start with kinetic energy. As it rises into the air, the gravitational force will transform some (maybe all) of its kinetic energy into gravitational potential energy. As it falls, that gravitational potential energy is transformed back into kinetic energy.

Unplugged Activity

- Using Think Pair Share, students can discuss the questions on the slides, using the images as prompts.
    - What are some different forms of energy?
    - What are some situations where energy is transferred from one thing to another?
    - What are some situations where energy is transformed from one kind to another?
- Students can complete an paired/independent KWL chart to record their prior knowledge, establish questions and set expectations for recording learning at the end of the lesson

Link Forward
Students explore how mass affects kinetic energy.

Ball Toss

Mini-lesson

What factors determine how much energy is transferred in a ball toss?

Key Information

- The greater a ball's mass, the greater force needed to throw it into the air.
- Exerting more force on the ball means you are transferring more energy into the ball.
- As the ball rises into the air, the gravitational force will transform some (maybe all) of its kinetic energy into gravitational potential energy.

Unplugged Activity

- Students are grouped in pairs or threes
- Students take a variety of balls (large, small, heavy, light) and practice tossing them above the Go Direct Motion Detector.
- As they toss the balls, they should pay particular attention to how much force they need to exert on the ball to get it to a given height.
    - Which balls require more force?
    - Do bigger balls always require more force?
    - If the hoop is higher, does it require more force?
- Students will find that the size of the ball is less important than how heavy it is. The greater the mass, the greater the force required to toss the ball. Because of this, heavier objects have greater kinetic energy for a given speed.

Note regarding Go Direct Motion: Go Direct Motion emits short bursts of ultrasonic sound waves, a "clicking" sound, from the gold foil of the transducer. These waves fill a cone-shaped area about 15 to 20° off the axis of the centerline of the beam. Go Direct Motion then "listens" for the echo of these ultrasonic waves returning to it. The equipment measures how long it takes for the ultrasonic waves to make the trip from Go Direct Motion to an object and back. Using this time and the speed of sound in air, the distance to the nearest object is determined. More details about Go Direct Motion can be found here: https://www.vernier.com/manuals/gdx-md/

When tossing the ball above the Motion Detector, students will need to practice tossing the ball in such a way as to avoid measuring the motion of their hands rather than the motion of the ball.

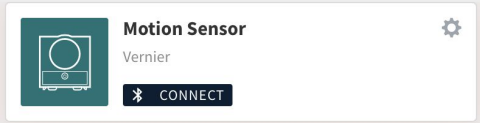
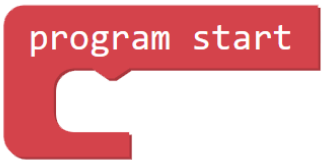
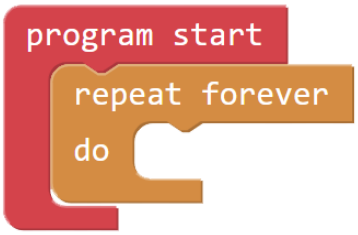
Ball Toss

Link Forward
Students code a program to measure the height of a tossed ball.

Do

Guided Lab - Part 1

Design and code a program that measures the height of a tossed ball.

Instructions	Workspace
Step 1 Click 'ADD DEVICE' and select: ● 'Motion Sensor' Connect the Motion Detector, click 'CONNECT' and 'Pair'.	 **The sensor is paired when it appears under your 'Connected Devices' menu on the left hand side of the screen.** **When the Motion Detector is connected, it will start clicking rapidly.**
Step 2 From 'General', drag onto the workspace: ● 1 'program start' block.	
Step 3 From 'Loops', drag onto the workspace: ● 1 'repeat forever do' block. Snap into the 'program start' block.	 **Ensure students understand that the 'repeat forever do' block will run all code within it until the program is stopped.**

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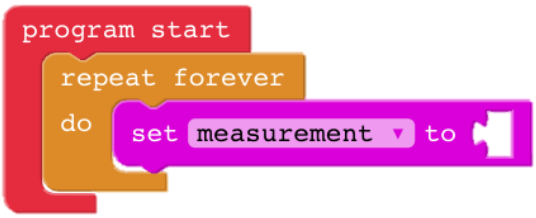
Step 4
From 'Variables', create variable 'measurement'. Drag onto the workspace:

- 1 'set measurement to [ ]' block.

Snap into the 'repeat forever do' block.

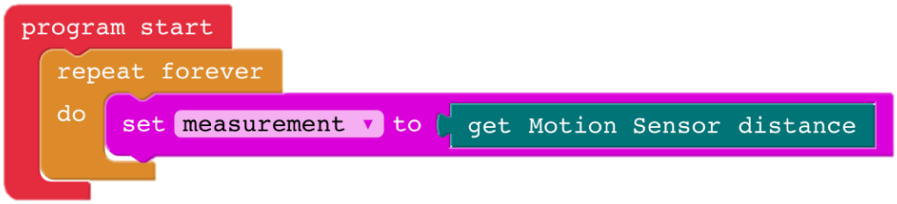


You can define and access variables from the 'Variables' tab. Remind students that a variable is a temporary storage location and in each loop this value can be changed.

Step 5
From 'Motion Sensor' > 'Values' tab, drag onto workspace:

- 1 'get Motion Sensor distance]' block.

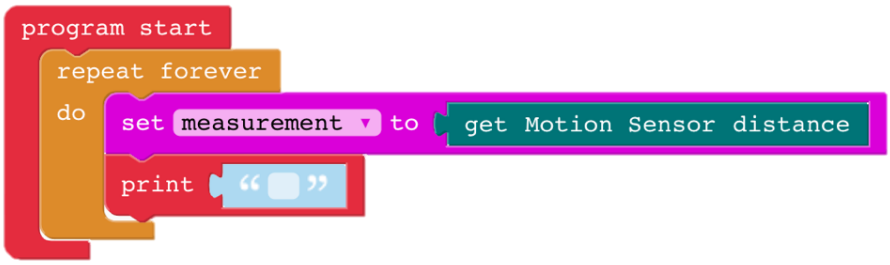
Snap into the 'set measurement to' block.



Step 6
From 'General', drag onto the workspace:

- 1 'print [" "]' block.

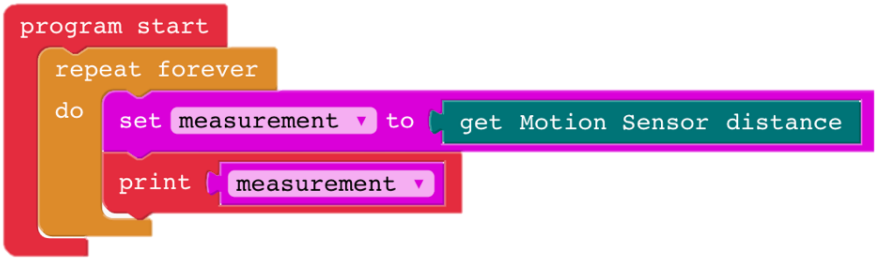
Snap into the 'repeat forever do' block below the 'set measurement to [ ]' block.



Step 7
From 'Variables', drag onto the workspace:

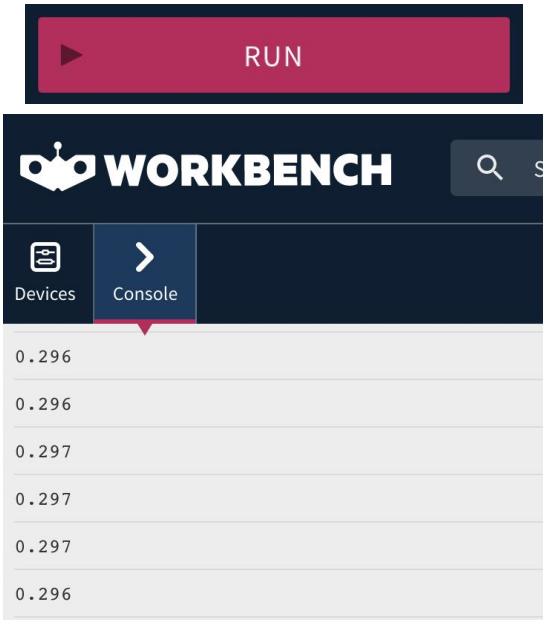
- 'measurement' block'

Snap into the 'print [" "]' block.



The print function allows you to log and view data.

Step 8
Run your program.



Debug Opportunity

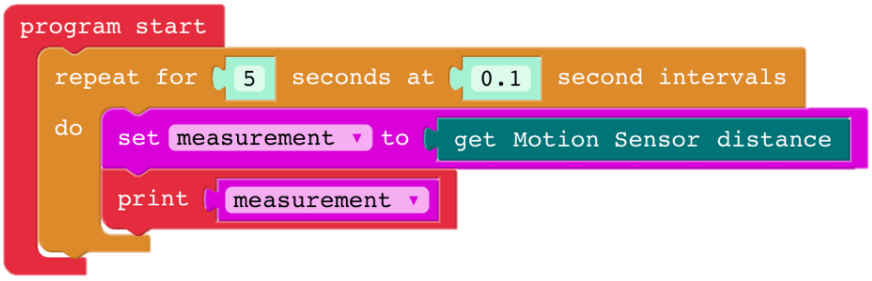
The data is printed to the console until I stop it. How can I get data for just a short period of time so I can better understand it?

Instructions	Workspace

Step 1
From 'Loops' tab, drag onto the workspace:

- 'repeat for 5 seconds at 0.1 second intervals' block

Replace 'repeat forever do' block with 'repeat for 5 seconds...' block.



Encourage students to explore how changing the duration (default 5 seconds) and interval (default 0.1 second) changes the data collection.

Link Forward

Students code a program that automatically finds the maximum height the ball reaches.

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Guided Lab - Part 2

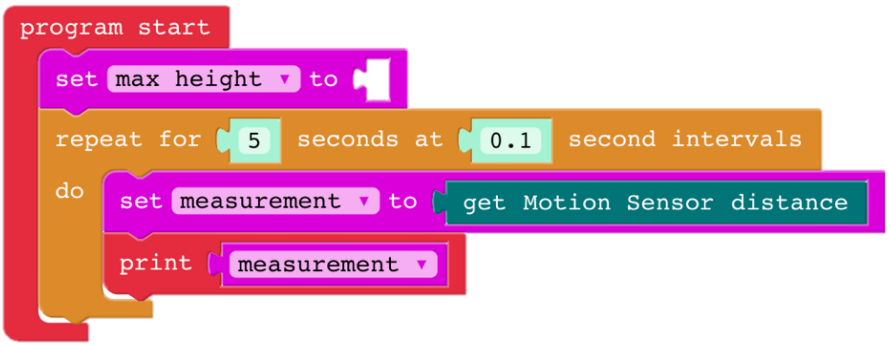
Design and code a program that automatically finds the maximum height the ball reaches.

Instructions	Workspace

Step 1
From 'Variables', create variable 'max height', drag onto the workspace:

- 1 'set max height to [ ]' block.

Snap into the 'program start' block before the 'repeat for...' loop block..

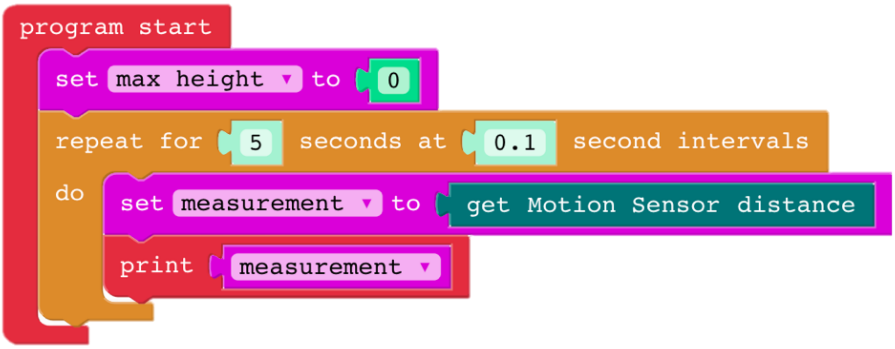


This new variable 'max height' will store the largest value the Motion Detector measures so that we can easily find it after data collection.

Step 2
From 'Math' tab, drag onto the workspace:

- 1 '0' numeric constant block.

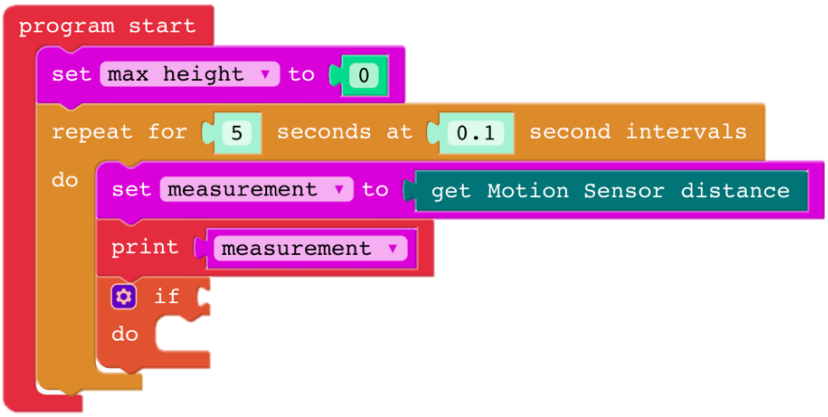
Snap into the 'set max height to' block.



Step 3
From 'Logic' tab, drag onto workspace:

- 'If do' block

Snap under 'print measurement' block



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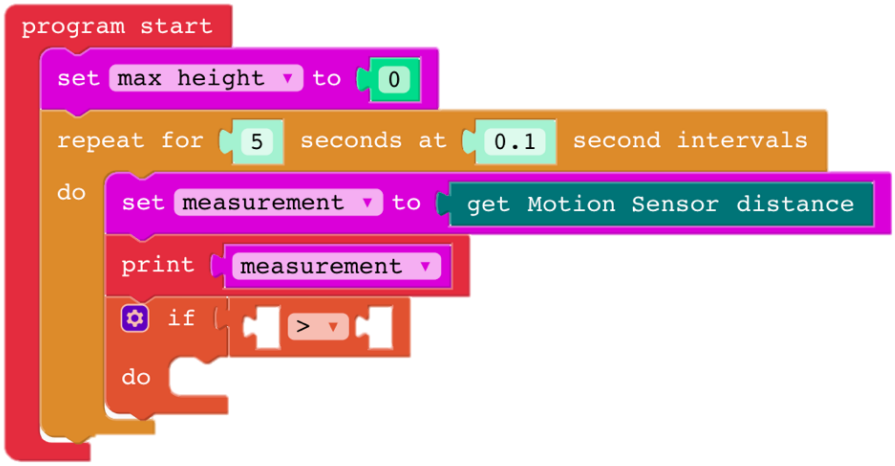
Step 4
From 'Logic' tab, drag onto workspace

- 1 comparison block

Snap inside 'if' block.

Set comparison block to '>' using the drop down menu.



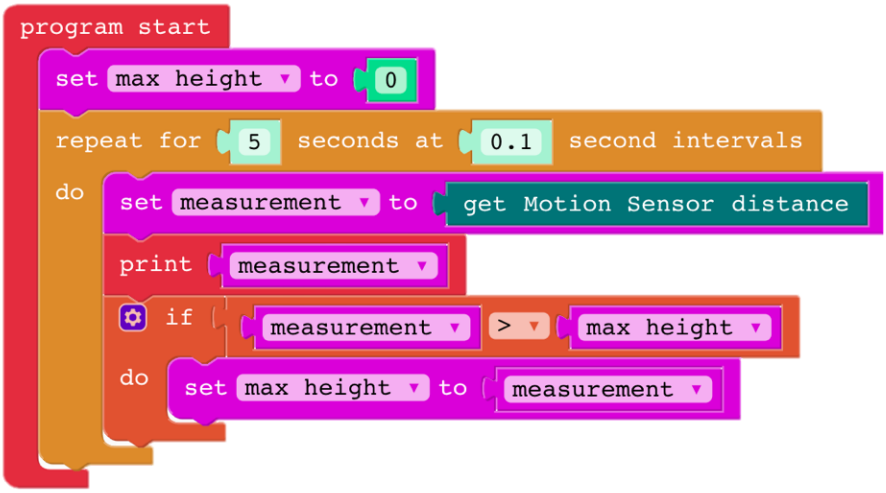
Step 5
From 'Variables' tab, drag onto workspace

- 2 measurement blocks
- 1 max height block
- 1 'set max height to' block

Snap one measurement and one max height block into the comparison block.

Snap the 'set max height to' block to the 'do' block.

Snap the second measurement block to the 'set max height to' block.



The if-do block compares the current Motion Detector measurement to the maximum height it has recorded so far. If the measurement is greater than the max height, that measurement becomes the new max height.

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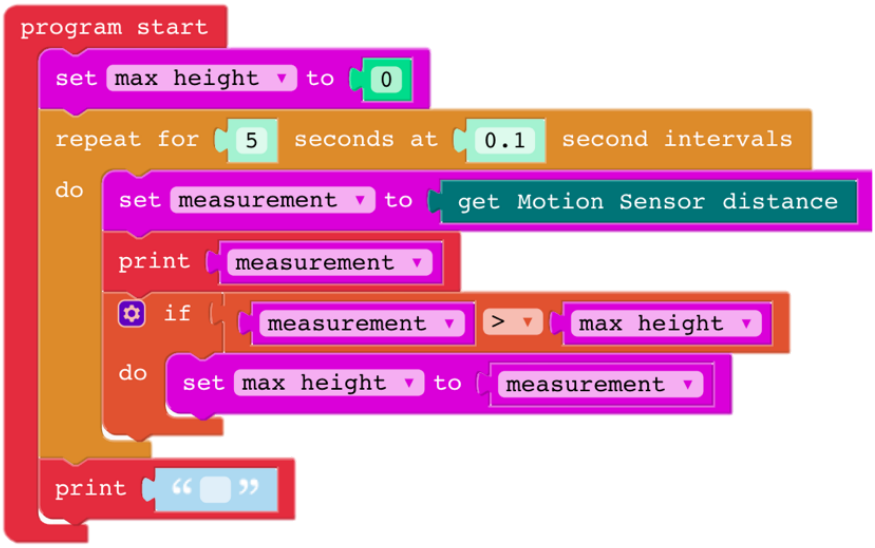
Step 6
From ‘General’, drag onto the workspace:

- 1 ‘print [“ “]’ block.

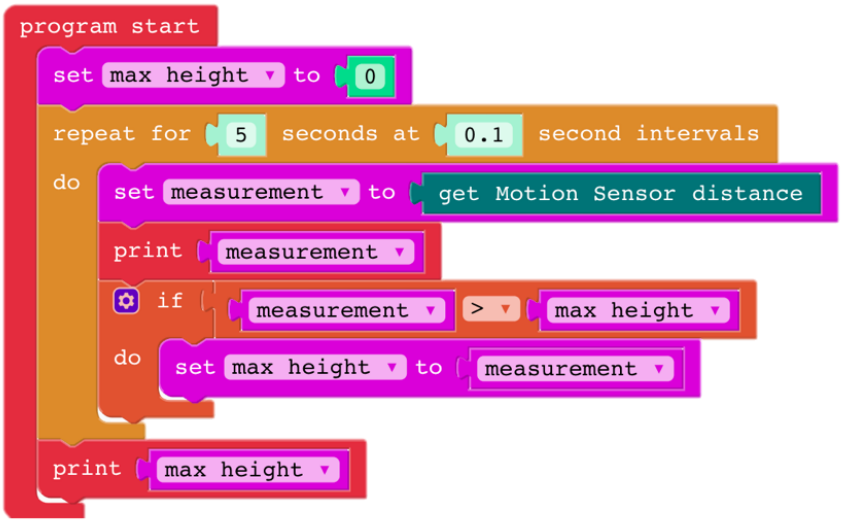
Snap into the ‘repeat forever do’ block below the ‘set measurement to [ ]’ block.



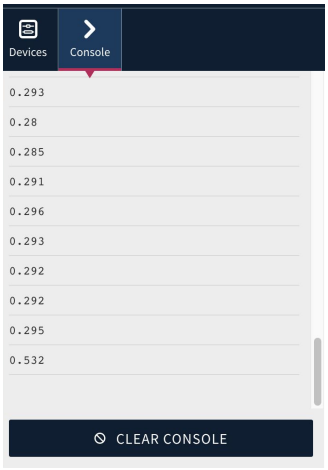
Step 7
From ‘Variables’, drag onto the workspace:

- ‘measurement ’ block’

Snap into the ‘print [“ “]’ block.



Step 9
Run your program.



The last value printed to the Console will be the maximum height recorded by the Motion Detector.

Link Forward
Students extend their to log their data or use a RGB LED to indicate how high the ball is.

Extension Activities

Code a program that visualizes the relationship between the sensor and your data

Option 1 - Google Sheet Design Brief	Workspace
Log your maximum height data to a Google Sheet. Can you add in details about which ball was tossed to better describe each maximum height?	

This shows example code that could be created to meet the design brief. This can be used to support students to develop their designs.

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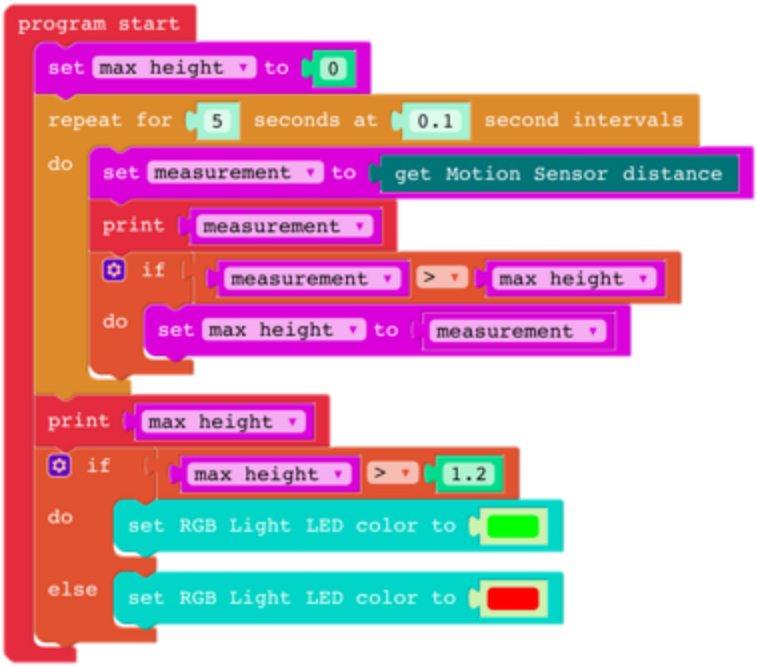
Option 2 - RGB LED
Design Brief

Change the LED color depending on how high you threw the ball. Can you use the LED color to alert you if you reached your desired height?

Workspace



This shows example code that could be created to meet the design brief. This can be used to support students to develop their designs.

Reflection Prompts

When does the ball have the greatest amount of kinetic energy? The least?

At what sensor reading(s) does the ball have the least amount of kinetic energy?