PASCO capstone™

Contents
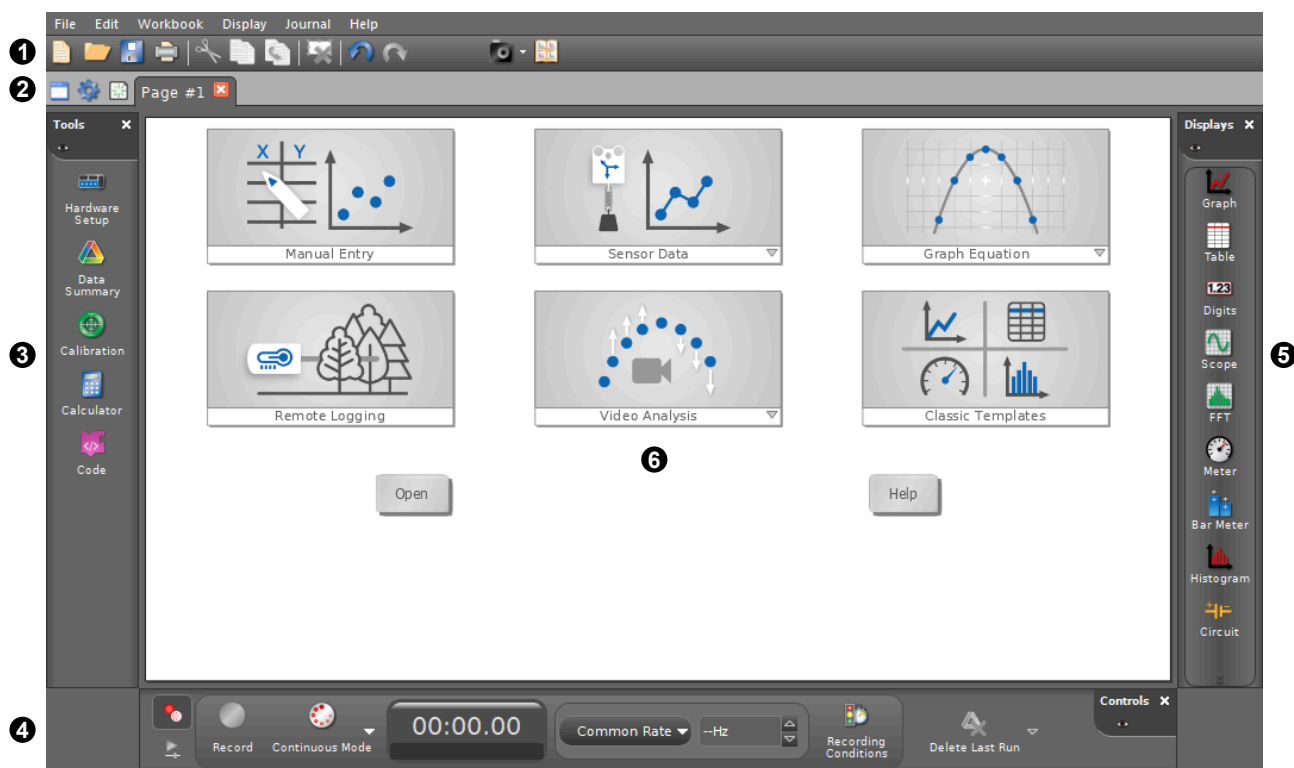
Getting Started

Start here to get an overview of the interface and use the Entry Screen options to quickly set up an experiment.

Tour the Interface

The Capstone interface consists of a workbook page surrounded by palettes containing tools, displays, and controls used for data collection and analysis.

1 **Menu and Toolbar**

   The Capstone menu includes common application functions such as file open and save, import and export data, and undo. Also included are application specific functions such as display settings and Journal tools. Some functions are available as toolbar buttons below the menu.

2 **Workbook Page Tools**

   The Workbook Page tools include tools to add pages, change page properties, and edit the master page. On the page tab, double-click to rename the page or click ✕ to delete the page.

3 **Tools Palette** *(on page 18)*

   The Tools Palette includes tools to add interfaces and sensors, edit data properties, calibrate sensors, define calculations, define curve fit parameters, control accessories, and create programs.

4 **Controls Palette** *(on page 84)*

   The Controls Palette is used to start and stop data collection, set the data collection mode, set the sampling rate,delete data runs, define start and stop conditions, and playback synchronized video.

5 **Displays Palette** *(on page 32)*

The displays provide multiple ways to visualize and analyze data. Add a display to the workbook page by double-clicking the display or dragging the display from the palette to the workbook page.

6 **Workbook Page**

Use the workbook page to customize layouts using displays from the Displays palette. When starting a new experiment, you can use the Entry Screen *(on page 4)* options to quickly set up an experiment. When creating a new page, you can use the Templates to create quick layouts.

Entry Screen

Choose an option on the Entry Screen to quickly set up an experiment. The Entry Screen appears when you open Capstone or start a new experiment.
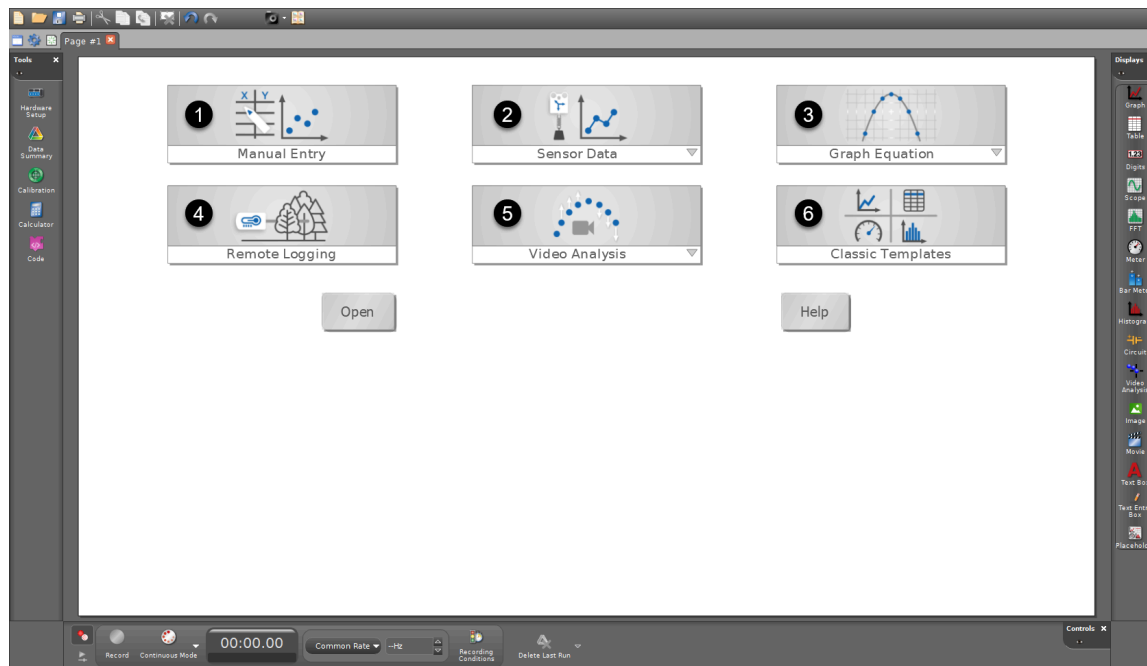
① Manual Entry *(on page 11)*

> Enter non-sensor data into a table and display it in a graph.

② Sensor Data *(on page 5)*

> Quickly connect a sensor and display measurements. Select from continuous or manual sampling in a graph or monitoring data in a scope or FFT.

③ Graph Equation *(on page 12)*

> Model an equation on a graph and vary the equation parameters.

④ Remote Logging *(on page 9)*

> Collect data on a Wireless Sensor without being connected to a computer. After data collection is completed, download the data to Capstone for analysis.

⑤ Video Analysis *(on page 14)*

> Analyze the motion of an object in a video or synchronize sensor data with a video. Track the motion of the object in a Video Analysis display and analyze the data in a graph display.

⑥ Classic Templates *(on page 7)*

> Build a customized experiment page using Classic Templates, Quick Start Experiments, or dragging a display onto the page.

Set up and display sensor data

Quickly connect a sensor and display measurements. Select from continuous or manual sampling in a graph or monitoring data in a scope or FFT.

Step 1: Set up the Experiment

1. Click ![icon] to create a new experiment.
2. Click the **Sensor Data** menu and select an option:

> **Continuous Sampling**
>
> Graph a sensor measurement versus time.
>
> > **ⓘ Tip:**
> > If you are new to Capstone, this is likely the option you want!
>
> **Manual Sampling**
>
> Manually select when data points are recorded instead of continuously recording data. This mode is useful when recording a sensor measurement versus a non-sensor measurement.
>
> **Fast Monitor (Scope)**
>
> Monitor data at high sample rates in an oscilloscope display. This display is typically used with voltage, current, and sound sensors.
>
> **FFT**
>
> Monitor data in a Fast Fourier Transform (FFT) displaying a sensor measurement versus frequency. This display is typically used with sound sensors to identify resonant frequencies.

3. Connect a sensor to Capstone *(on page 21)* under **Hardware Setup**.

4. Click ![icon] to close **Hardware Setup**.
5. A measurement is pre-selected on the display. To display a different measurement, click the current measurement and select a measurement from the list.

Step 2: Collect Data

Continuous Sampling

1. Click **Record** ● begin recording data.
2. Click **Stop** ■ when finished collecting data.
3. Analyze the data using the graph *(on page 37)* display tools.

Manual Sampling

1. Enter the non-sensor data in the **x** column of the data table. If desired, click **x** or **units** to rename each value.
2. Click **Preview** ○ to begin monitoring data. The live measurement is displayed in the table and graph but not recorded.
3. Select a data cell to record the sample then click **Keep Sample** ✓ . Repeat for additional data samples.
4. Click **Stop** ■ when finished collecting data.
5. Analyze the data using the graph *(on page 37)* and table *(on page 57)* display tools.

Fast Monitor (Scope)

1. Click **Monitor** ○ to begin monitoring data.
2. Use the trigger ⬆ to get a stable trace *(on page 67)*.
3. Use the scope *(on page 64)* display tools to further adjust the display and analyze the trace.
4. Click **Stop** ■ to freeze the trace on the display.

FFT

1. Click **Monitor** ○ to begin monitoring data.
2. Adjust the scale using the FFT display tools *(on page 74)*.
3. Click **Stop** ■ to freeze the data on the display.

Create a custom experiment page

Build a customized experiment page using Classic Templates, Quick Start Experiments, or dragging a display onto the page.

> **ⓘ Tip:**
> For a quick setup with less steps, select one of the Sensor Data *(on page 5)* options on the Entry Screen *(on page 4)*.

1. Click to add a new page or click Classic Templates on the Entry Screen:
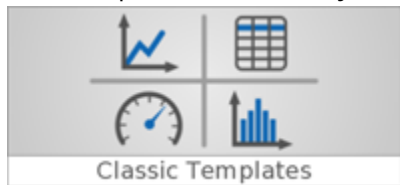
2. Add displays to the experiment page using one of the following options:

   • Select a template or a Quick Start Experiment on the page.
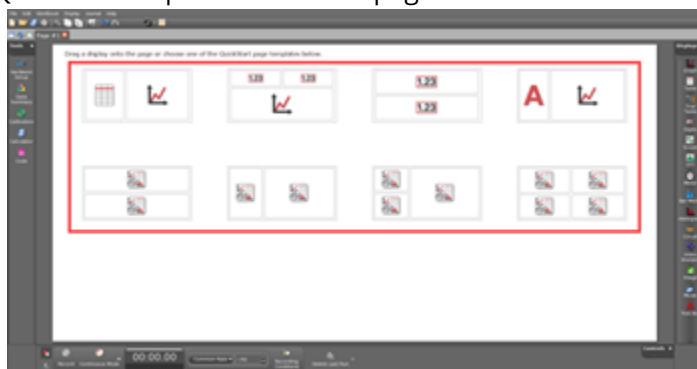
   • Drag a display icon from the Displays palette *(on page 32)* to the page or double-click a display icon.

   > **ⓘ Tip:**
   > Drag the display icon over a layout target to quickly format the page.
   >
   >
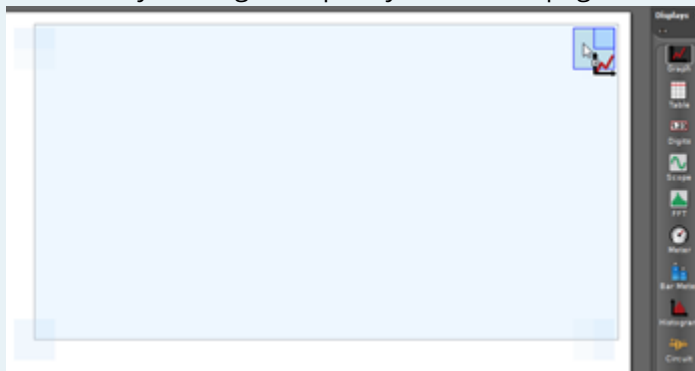
3. If a template with Placeholders was selected, click each then select a display from the menu.

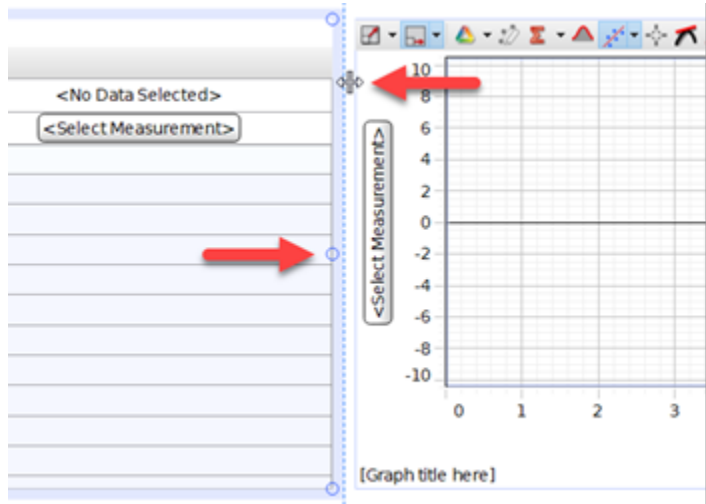4. Resize displays by dragging the handles on a display or the border between two displays.

5. For each display, click **<Select Measurement>** then select a measurement from the menu.

> ✏️ **Note:**
> You need to first connect a sensor *(on page 21)* to Capstone before you can select a measurement in a display.

After setting up your display, click 🔴 to start recording data. You can also change the recording options in the Controls Palette *(on page 84)*.

Set up remote logging

Collect data on a Wireless Sensor without being connected to a computer. After data collection is completed, download the data to Capstone for analysis.
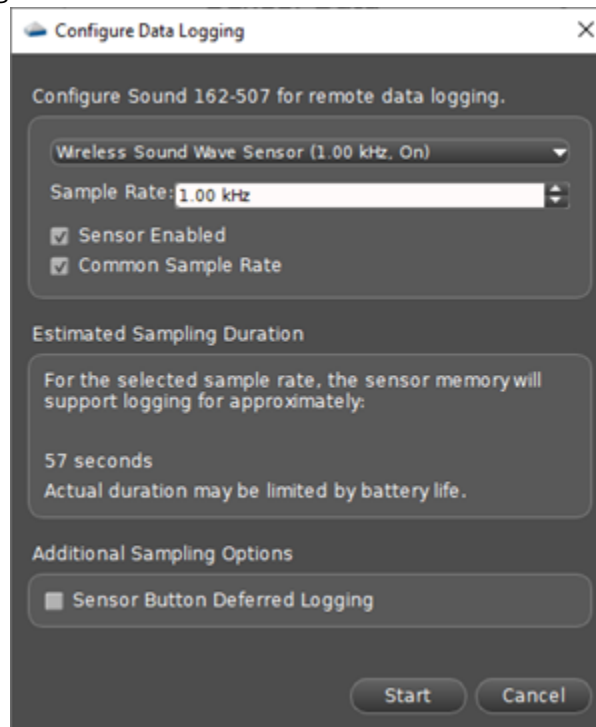
> 🖊 **Note:**
> Remote Logging is only available for PASCO Wireless Sensors.

1. Click 📄 to create a new experiment.
2. Click **Remote Logging**.

Remote Logging

3. Power on the sensor then click the sensor that matches the device ID.

4. Configure remote data logging for each sensor:

a. Select a sensor to configure from the menu.
b. Set the sample rate using the up and down arrows.
c. Deselect **Sensor Enabled** if you do not want to log data with this sensor. Deselect **Common Sample Rate** to set different sample rates for each sensor, .

> ⓘ **Tip:**
> The amount of time that the sensor will be able to log data is indicated under **Estimated Sampling Duration**. To increase the logging time:
>
> • Decrease the sample rate.
> • Disable unused sensors.

5. Optional: Select **Sensor Button Deferred Logging** to start data logging by pressing the power button on the sensor.
6. Click **Start** (or **OK** if **Sensor Button Deferred Logging** is selected).

Data logging begins immediately after you click **Start** or press the power button on the sensor (if **Sensor Button Deferred Logging** was selected). The Bluetooth status light will blink yellow and green until data logging begins. When the sensor starts logging data, the Bluetooth status light will blink yellow.

Click **OK** and close Capstone. To stop data logging, turn off the sensor or connect it to Capstone to download the data .

Manually enter data in a graph

Enter non-sensor data into a table and display it in a graph.
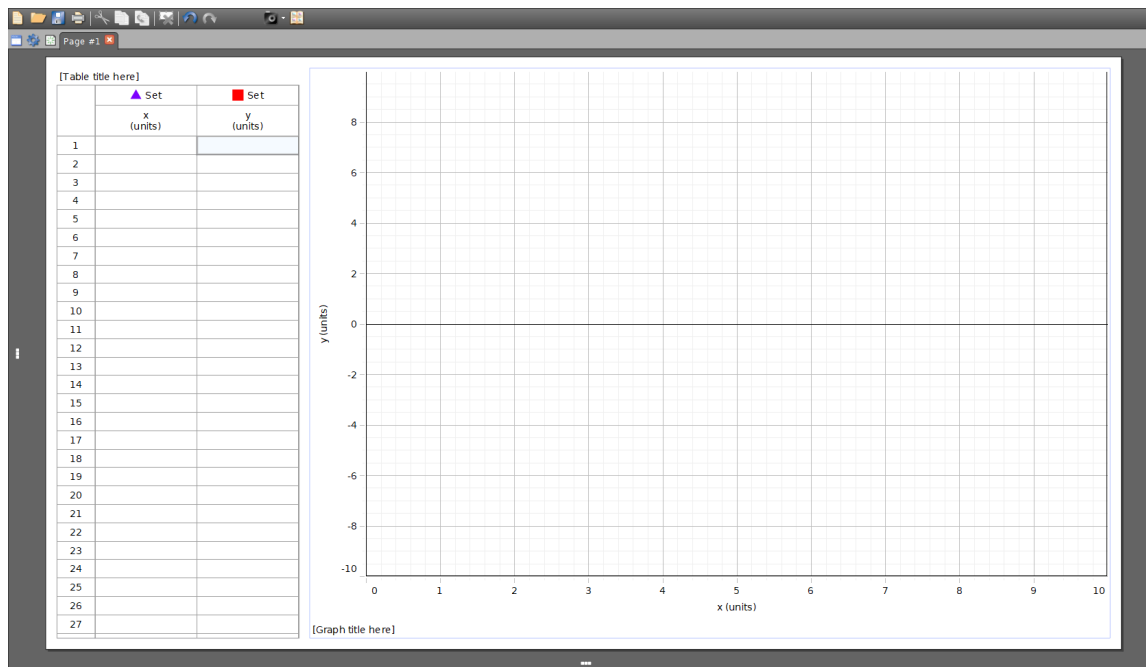
1. Click ![icon] to create a new experiment.
2. Click **Manual Entry**.

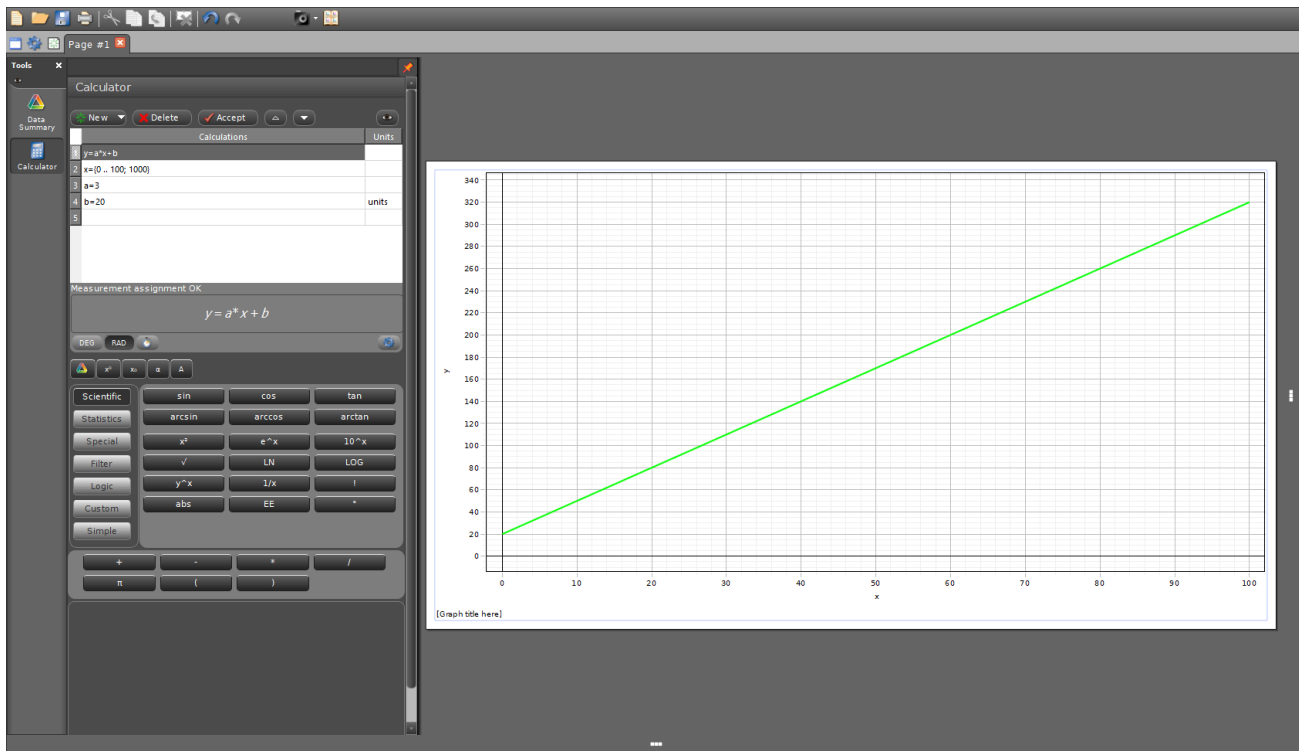3. Enter a data point for x and y in row 1 of the table. A data point will appear on the graph.
4. Repeat for additional data points.

> ⓘ **Tip:**
> Use the **Tab** key on your keyboard to quickly move between cells when entering data.

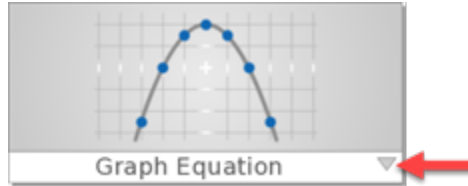5. Analyze the data using the graph *(on page 37)* and table *(on page 57)* tools.

Graph an equation

Model an equation on a graph and vary the equation parameters.

1. Click to create a new experiment.
2. Click the **Graph Equation** menu and select an equation to model:

- **y = mx + b**

    Graph a linear equation.
- **y = A sin (ωx + φ) + C**

    Graph a sine wave.
- **y = A e^(-Bx) + y$_o$**

    Graph an exponential function.
- **y = User-defined**

    Create a custom function to display on a graph.

3. Change the items provided in the **Calculator** by double-clicking a line:

- **Line 1**

    Contains the equation. If you create a new parameter in the equation, you must set a value for the parameter on another line.
- **Line 2**

    Contains the range (min and max) of x and the number of data points displayed using the format `x={<min> .. <max>;<data points>}`. For example, `x={0 .. 10; 1000}` represents a range of 0 to 10 displayed with 1000 data points.
- **Lines 3 and higher**

    Contains the equation parameters.

Set up and use video analysis

Analyze the motion of an object in a video or synchronize sensor data with a video. Track the motion of the object in a Video Analysis display and analyze the data in a graph display.
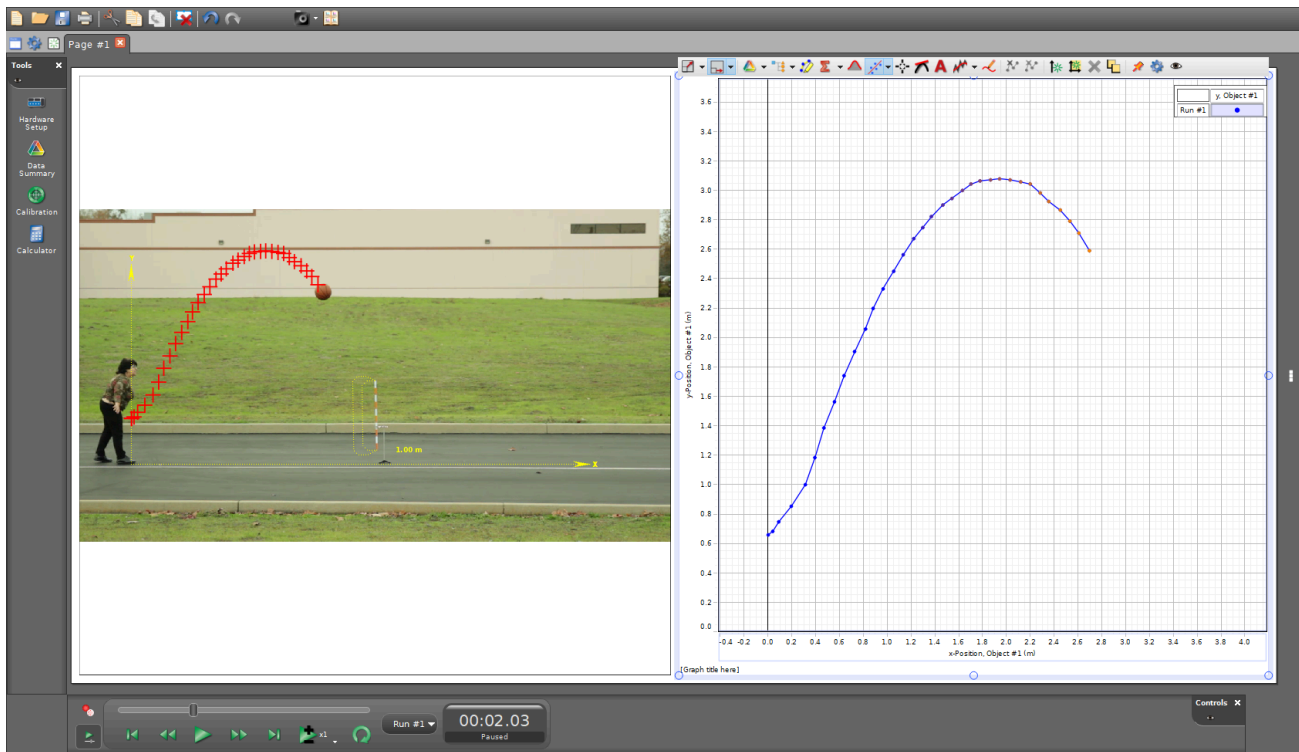
1. Click ![icon] to create a new experiment.
2. Click the **Video Analysis** menu and select an option:

- **Open video file**

  Open an existing video file to analyze.
- **Capture video**

  Use a connected camera to record a video to analyze.
- **Capture video with sensor data**

  Collect data from a sensor and synchronize the data with video recorded from a connected camera.

3. Get a video to analyze. Follow the steps based on the option you previously selected:

- **Open video file**

  Select a video file to open.

- **Capture video**

  a. Connect a camera to the USB port of your computer and set up the experiment.

  > **ⓘ Tip:**
  > See Video Capture for Video Analysis for tips on how to best record a video for video analysis.

  b. Click 🔴 to begin video recording.

  c. Click 🟥 to stop video recording.

- **Capture video with sensor data**

  a. Connect a camera to the USB port of your computer and set up the experiment.
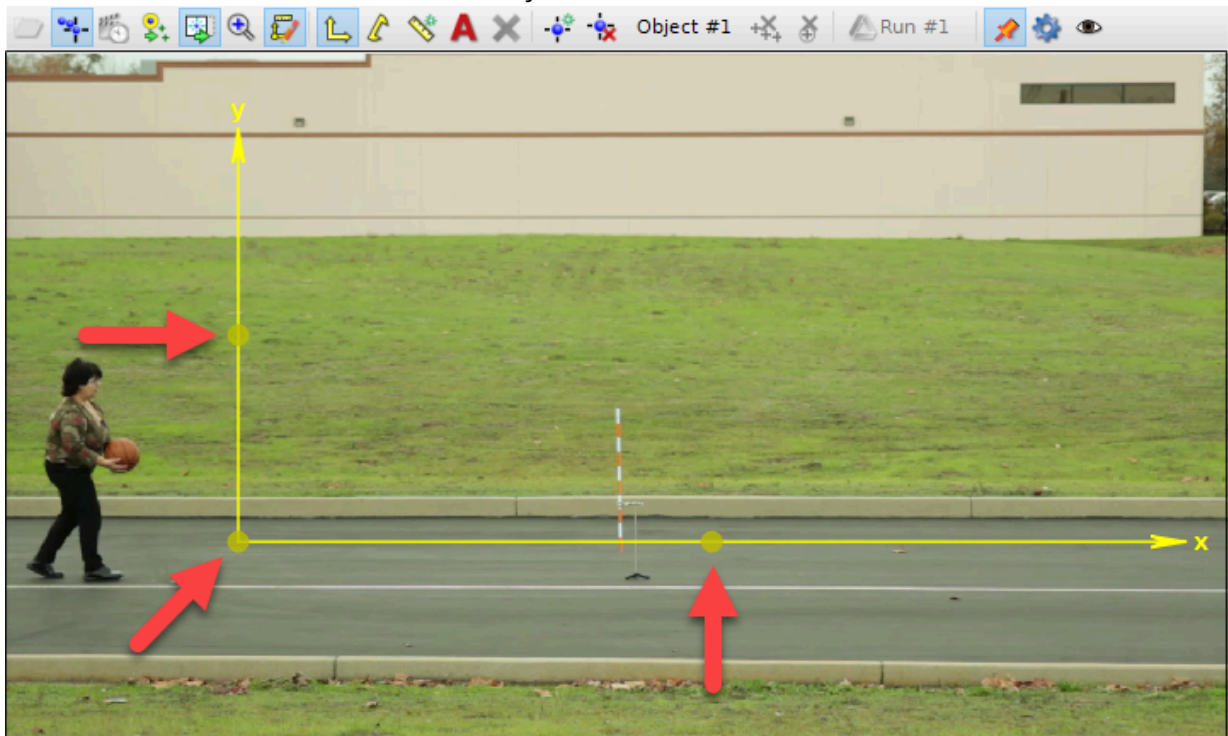
  b. Connect a sensor to Capstone. *(on page 21)*

  c. Click 🔴 to begin recording the video and sensor data.
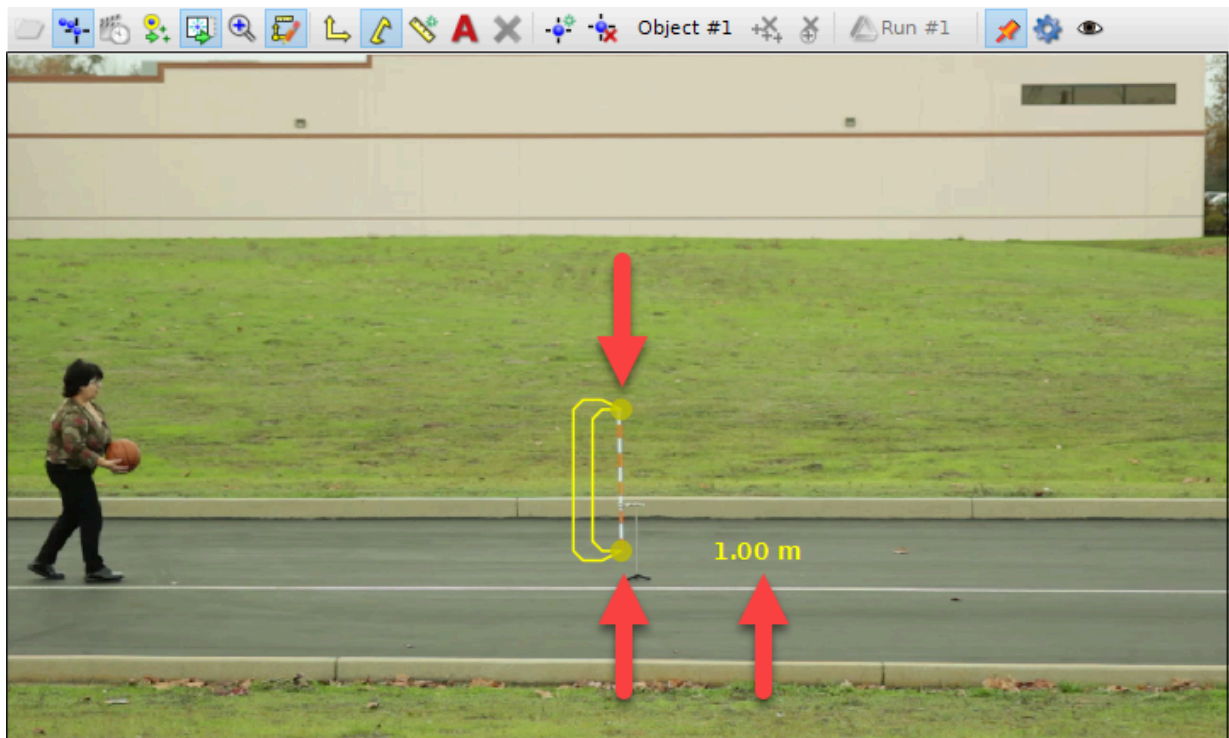
  d. Click 🟥 to stop recording.

  e. Proceed to step 8 *(on page 16)*.

4. Use the coordinates tool to set the coordinate system in the video:

- Drag the handle on the origin to move the coordinate system.
- Drag the handles on the axes to rotate the coordinate system.

5. Use the calibration tool to set the scale in the video:

- Drag the handles to set the start and ending positions.
- Double-click the number to set the magnitude.
- Click the unit to change the units.

6. Click the object in the video to start tracking its motion. A marker will appear on the video, a data point will appear on the graph, and the video will advance one frame.

> **ⓘ Tip:**
>
> - Instead of tracking from the beginning of the video, click ▶▶ to advance the video to an alternate starting point.
> - Use the magnification tool to make it easier to see the object when tracking it.

7. Repeat the previous step to track the motion. Stop clicking to end tracking.
8. Analyze the data in the graph using the Graph tools *(on page 37)*.

Tools Palette

Connect interfaces and sensors, edit data properties, calibrate sensors, define calculations, and control accessories.

Tools Palette Overview

Get an overview of what each tool in the Tools palette is used for in Capstone.

> ✎ **Note:**
> Not all of the tools will appear on the palette by default. Some tools will remain hidden until the hardware that uses the tool is connected.

> ⓘ **Tip:**
> Click 👁 to select which tools are visible. Click ✕ to hide the palette.

Tools ✕

🔲 **①** Hardware Setup

🔲 **②** Timer Setup

🔺 **③** Data Summary

🎯 **④** Calibration

🔢 **⑤** Calculator

〰️ **⑥** Signal Generator

🔳 **⑦** Digital Output

🖊️ **⑧** Curve Fit Editor

🌼 **⑨** Smart Fan

⑩ Smart Motor

🔲 **⑪** Vector Display

🕹️ **⑫** Ballistic Cart

🧩 **⑬** Code

1   **Hardware Setup** *(on page 21)*

Connect and configure sensors and interfaces.

2   **Timer Setup**

Create timers for photogates and other timing devices.

3   **Data Summary**

Manage experiment data and data properties.

4   **Calibration**

Calibrate sensor measurements.

5   **Calculator**

Define new data sets as functions of measurements and other data.

6   **Signal Generator**

Control the signal output on the 550 Interface, 750 Interface, 850 Interface, Wireless AC/DC Module, and Function Generator.

7   **Digital Output**

Specify behavior for the expansion port inputs and output on the 850 Interface.

8   **Curve Fit Editor** *(on page 50)*

Edit curve fits created in Graph displays.

9   **Smart Fan** *(on page 24)*

Control the thrust and direction of a Smart Fan Accessory attached to a Smart Cart.

10   **Smart Motor** *(on page 26)*

Control the speed and direction of a Smart Cart Motor attached to a Smart Cart.

11   **Vector Display** *(on page 28)*

Change the measurement displayed on a Smart Cart Vector Display and configure the range and sign of the measurement.

12   **Ballistic Cart** *(on page 28)*

Launch a projectile from the Smart Ballistic Cart Accessory by setting a position or time based trigger.

13   **Code** *(on page 92)*

Create programs with the Code Tool using Blockly to control outputs using sensor measurements.

Connect a Sensor to Capstone

Connect current and legacy PASCO sensors to Capstone including sensors from the Wireless, PASPORT, and Science Workshop lines.

Wireless Sensors

Wireless Sensors can be connected using Bluetooth or USB (if available):

- USB: Connect the sensor directly to the computer using a USB cable.
- Bluetooth:

    1. Power on the sensor.
    2. Click to open the Hardware Setup panel.
    3. Select the sensor that matches the device ID.
    4. Click to close the Hardware Setup panel.

PASPORT Sensors

PASPORT sensors require an interface or data logger that accepts PASPORT sensors.

1. Power on the interface.
2. Connect the interface to your computing device using USB or Bluetooth:

    - USB: Connect the interface directly to a computing device using a USB cable.
    - Bluetooth:

        a. Pair the interface with your computing device using your device's Bluetooth settings.
        b. Click to open the Hardware Setup panel.
        c. Select the interface that matches the device ID.
3. Connect the sensor to a PASPORT port on the interface.
4. Click to close the Hardware Setup panel.

Science Workshop Sensors

Science Workshop sensors require a Universal Interface, Science Workshop Interface, or a PASPORT interface using a Digital or Analog adapter.

1. Power on the interface.
2. Connect the interface to your computing device using USB or Bluetooth:

    - USB: Connect the interface directly to a computing device using a USB cable.
    - Bluetooth:

        a. Pair the interface with your computing device using your device's Bluetooth settings.
        b. Click to open the Hardware Setup panel.
        c. Select the interface that matches the device ID.
3. Connect the sensor to a Science Workshop port on the interface.
4. In Hardware Setup, click the port that you connected the sensor to then select the sensor from the menu.
5. Click to close the Hardware Setup panel.

Download remotely logged data

Download data remotely logged on a Wireless Sensor for data analysis. You can download the data to multiple devices as long as data is not deleted from the sensor after downloading it.

1. Click ▢ to create a new experiment.
2. Click **Remote Logging**.

3. Turn on the sensor or press the power button if the sensor is currently logging.

> ✎ **Note:**
> The sensor will not appear in the **Remote Logging** window if the Bluetooth status light is blinking yellow. Press the power button to make the sensor appear.

> ⓘ **Tip:**
> Connect the sensor using USB (if available) to download data at a faster rate.

4. Select the sensor under **Sensors with data**.
5. In the **Logged Data** window, select **Download Data**.
6. Select a destination to download the data:

   Current experiment

   Download the data to the current Capstone session. You will need to select a display *(on page 32)* to view the data after clicking **Download Data**.

   Existing file...

   Download the data to a previously saved Capstone file. You will be prompted to select the file after clicking **Download Data**.

   Quick Start Experiment

   Names of Quick Start Experiments will appear if available for the connected sensor. Select a Quick Start Experiment then click **Download Data**.

> ✎ **Note:**
> It may take a few minutes to download the data depending on the amount of data logged.
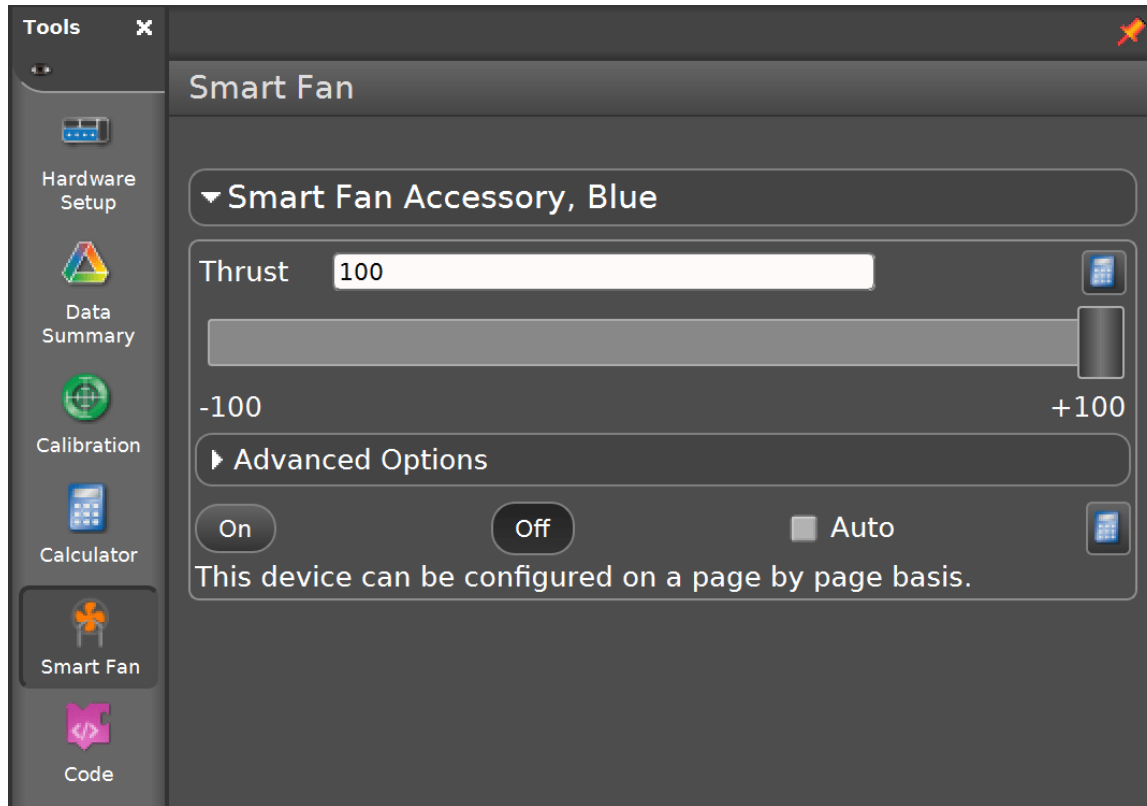
Rename a Data Run

Rename runs to provide a useful description your data.

1. Go to the Tools palette on the left and click ![icon].
2. Double-click the run you want to rename.
3. Type a new name for the run then press Enter on your keyboard.

Control the Smart Fan Accessory

Control the thrust and direction of a Smart Fan Accessory attached to a Smart Cart.

Access the Control Panel

1. Connect the Smart Fan Accessory to a Smart Cart.
2. Connect the Smart Cart to Capstone.
3. Select Smart Fan ![fan icon] in the **Tools** palette.

Turn the Fan On or Off

Do either of the following to turn the fan on or off:

- Click the **On** or **Off** buttons.
- Select the **Auto** checkbox. The fan will automatically turn on when collecting data and turn off when data collection stops.

Set the Thrust and Direction

Do either of the following to set the thrust and direction of the fan:

- Enter a value between -100 and +100 in the **Thrust** field.
- Click and drag the **Thrust** slider between -100 and +100.

Create a Program

A program can be created to control the Smart Fan using the Code *(on page 92)* tool. The following two blocks are provided in the **Hardware** group:

On/Off Block `turn  Smart Fan Accessory ▾  on: ( true ▾ )`

> Use this block to turn the fan on when its parameter is set to `true` and off when set to `false`. A Logic block can be used in place of the true/false block to create a logical expression to turn the fan on or off.

Thrust Block `set  Smart Fan Accessory ▾  to ( 1 )`

> Use this block to set the thrust of the Smart Fan between -100 and +100. You can either use the default number block to set the thrust or replace this block with a block from the Math group.

Set a Start and Stop Condition

A measurement or time based condition can be set to start (turn on) or stop (turn off) the fan. Click **Advanced Options** to access the start and stop condition tools.
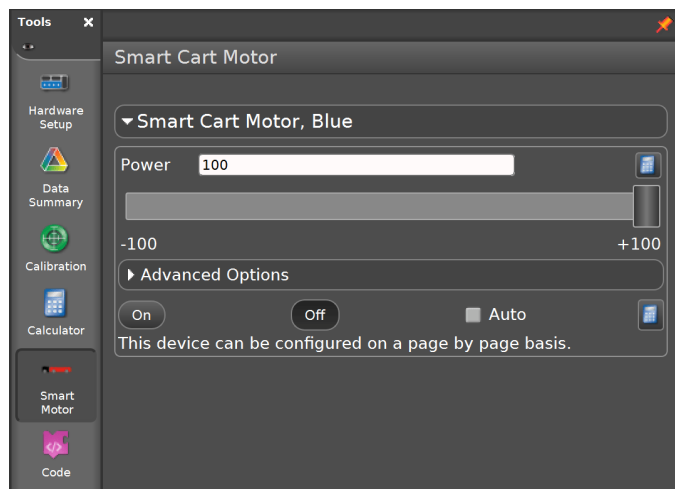
Create a Calculation

The Smart Fan Thrust and On/Off state can be controlled by creating a calculation. Click to enter an equation.
To return to using the control panel buttons, click then deselect **Use Calculation**.

Control the Smart Cart Motor

Control the speed and direction of a Smart Cart Motor attached to a Smart Cart.

Access the Control Panel

1. Connect the Smart Cart Motor to a Smart Cart.
2. Connect the Smart Cart to Capstone.
3. Select Smart Cart Motor in the **Tools** palette.

Turn the Motor On or Off

Do either of the following to turn the motor on or off:

- Click the **On** or **Off** buttons.
- Select the **Auto** checkbox. The motor will automatically turn on when collecting data and turn off when data collection stops.

Set the Speed and Direction

Do either of the following to set the speed and direction of the motor:

- Enter a value between -100 and +100 in the **Power** field.
- Click and drag the **Power** slider between -100 and +100.

Create a Program

A program can be created to control the Smart Cart Motor using the Code *(on page 92)* tool. The following two blocks are provided in the **Hardware** group:

On/Off Block
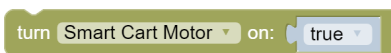
   Use this block to turn the motor on when its parameter is set to `true` and off when set to `false`. A Logic block can be used in place of the true/false block to create a logical expression to turn the motor on or off.

Power Block

Use this block to set the power of the Smart Cart Motor between -100 and +100. You can either use the default number block to set the power or replace this block with a block from the Math group.

Set a Start and Stop Condition

A measurement or time based condition can be set to start (turn on) or stop (turn off) the motor. Click **Advanced Options** to access the start and stop condition tools.

Create a Calculation

The Smart Cart Motor Power and On/Off state can be controlled by creating a calculation. Click to enter an equation. To return to using the control panel buttons, click then deselect **Use Calculation**.
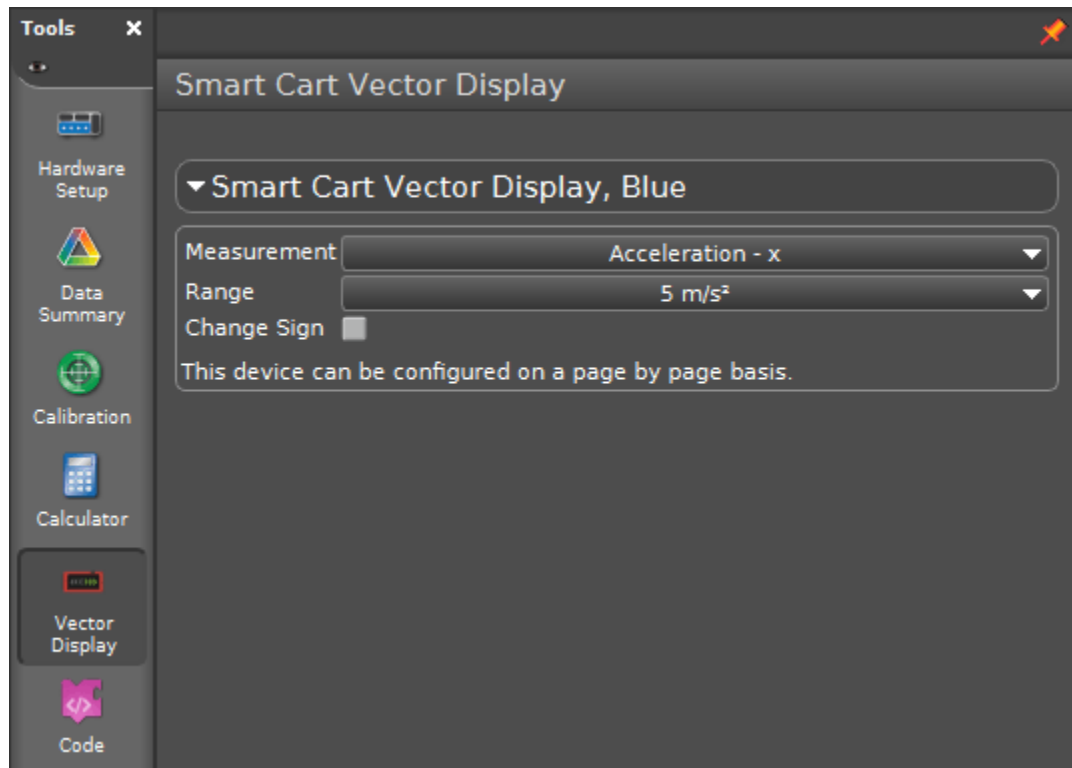
Change the Smart Cart Vector Display Measurement

Change the measurement displayed on a Smart Cart Vector Display and configure the range and sign of the measurement.

Access the Control Panel

1. Connect the Smart Vector Display to a Smart Cart.
2. Connect the Smart Cart to Capstone.
3. Select Vector Display ![icon] in the **Tools** palette.

Configuration Options

Measurement

Indicates the current measurement displayed on the Vector Display. To change, click the current measurement then select the measurement you want to display.

Range

Indicates the maximum magnitude that will be displayed on the Vector Display. To change, click the current range then select a range to display.

Change Sign

Select the checkbox to change the positive direction of the measurement.
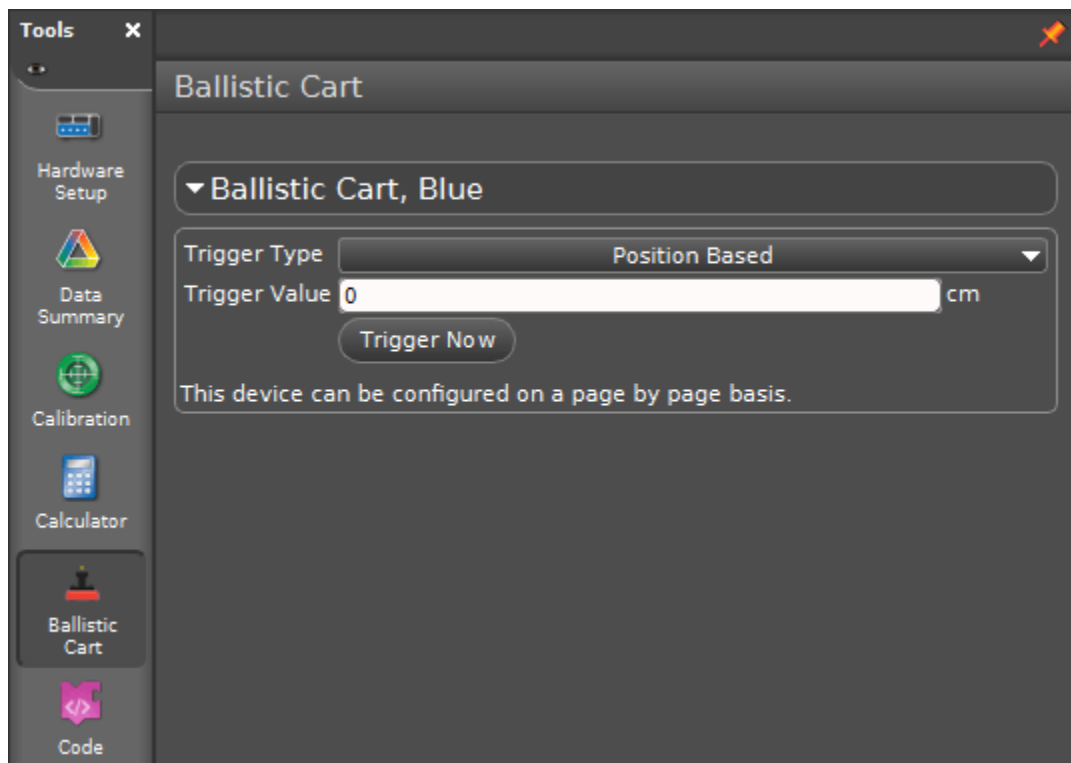
Launch the Smart Ballistic Cart Accessory Projectile

Launch a projectile from the Smart Ballistic Cart Accessory by setting a position or time based trigger.

> ⚠ **Warning:**
> Wear safety glasses while using the Smart Ballistic Cart Accessory. Do not look down the barrel.

Access the Control Panel

1. Connect the Smart Ballistic Cart Accessory to a Smart Cart.
2. Connect the Smart Cart to]Capstone.
3. Select Ballistic Cart ⬚ in the **Tools** palette.

Launch Options

Trigger Type

Select to trigger the launch mechanism based on the Smart Cart's position or a duration of time after starting data collection.

Trigger Value

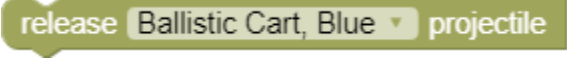Enter a value that will trigger the launch mechanism based on the **Trigger Type**.

> ⓘ **Tip:**
> Set a **Position Based** measurement with a value of 0. Start data collection, pull the cart back, then roll it forward. The projectile will launch when the cart returns to its starting position.

Trigger Now

Click to launch the projectile manually. This button can be used while data is being collected or not.

Create a Program

A program can be created to launch a projectile from the Smart Ballistic Cart Accessory using the Code *(on page 92)* tool. The block shown here is found in the **Hardware** group.

Displays Palette

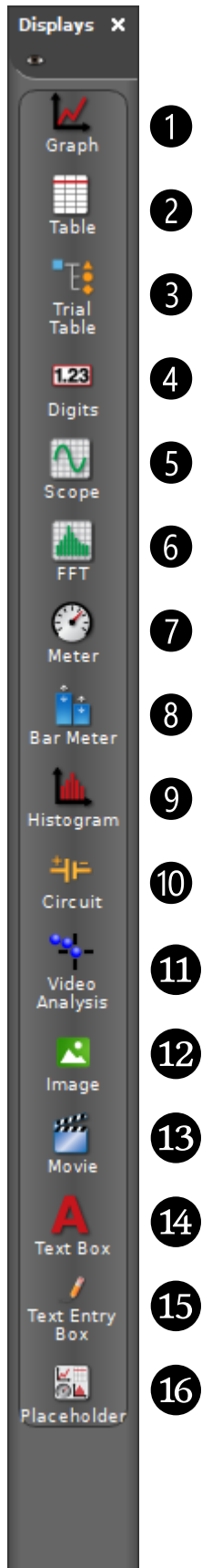Display data multiple ways such as in a line graph, a table, or a digital meter. Learn how to use each display and its tools to analyze data.

Displays Palette Overview

Get an overview on how each display can be used to visualize data.

> **Tip:**
> Click 👁 to select which displays are visible. Click ✕ to hide the palette.

Displays ✕

1 Graph

2 Table

3 Trial Table

4 Digits

5 Scope

6 FFT

7 Meter

8 Bar Meter

9 Histogram

10 Circuit

11 Video Analysis

12 Image

13 Movie

14 Text Box

15 Text Entry Box

16 Placeholder

1 📈 **Graph** *(on page 37)*

Display data in a XY line graph, showing one or more measurements versus time (or another measurement). Modify how the data is displayed and analyze the data using multiple tools.

2 ▦ **Table** *(on page 57)*

Display data using two or more columns and show data statistics.

3 🔲 **Trial Table (coming soon)**

Create a trial table to organize measurement data from multiple runs into trials.

4 🔢 **Digits** *(on page 61)*

Show the most recently recorded data sample as digits, statistics of a single data run, or text output *(on page 123)* from a Blockly program.

5 📉 **Scope** *(on page 64)*

Create a display that functions as a digital oscilloscope. This display is useful for viewing measurements that oscillate rapidly in time such as electrical signals and sound waves.

6 📊 **FFT**

Create a spectral analysis display, which uses a Fast Fourier Transform to measure the relative signal intensity as a function of frequency.

7 ⏲ **Meter** *(on page 77)*

Show the most recently recorded data sample or a statistical value of a single run on an analog display.

8 📊 **Bar Meter** *(on page 78)*

Visually compare the most recently recorded data values across similar measurements.

9 📊 **Histogram**

Create a histogram bar graph. The height of each of the bars is proportional to the number of data that fall within the range of values that the bar represents. Several tools are available for histograms including statistics, setting bin sizes, and overlaying.

10 ⊣⊢ **Circuit** *(on page 81)*

Build a circuit and display measurements recorded by voltage and current sensors.

11 ⋯ **Video Analysis**

Create a display to open a movie file or capture a video for analysis.

12 🖼 **Image**

Create a box to insert an image from a file or capture an image for viewing or analysis.

13 🎬 **Movie**

Create a box to insert a movie file, capture an image from a video camera or microscope connected through a USB port, record a stand-alone video using a USB webcam, or use a USB video camera as a sensor to record a movie along with other sensor data.

14 **A** **Text Box**

Create a text box for explanatory text and images. The text box can be locked for editing.

15 🖊 **Text Entry Box**

Create a text entry box for user input. The input can be linked to other text entry boxes.

16 📊 **Placeholder**

Create a spacer for a display to be defined at a later time or create white space.

Graph Display

Display data in a XY line graph, showing one or more measurements versus time (or another measurement). Modify how the data is displayed and analyze the data using multiple tools.

Graph Display Overview

Get an overview of the Graph display features including the analysis tools and how to modify the display.
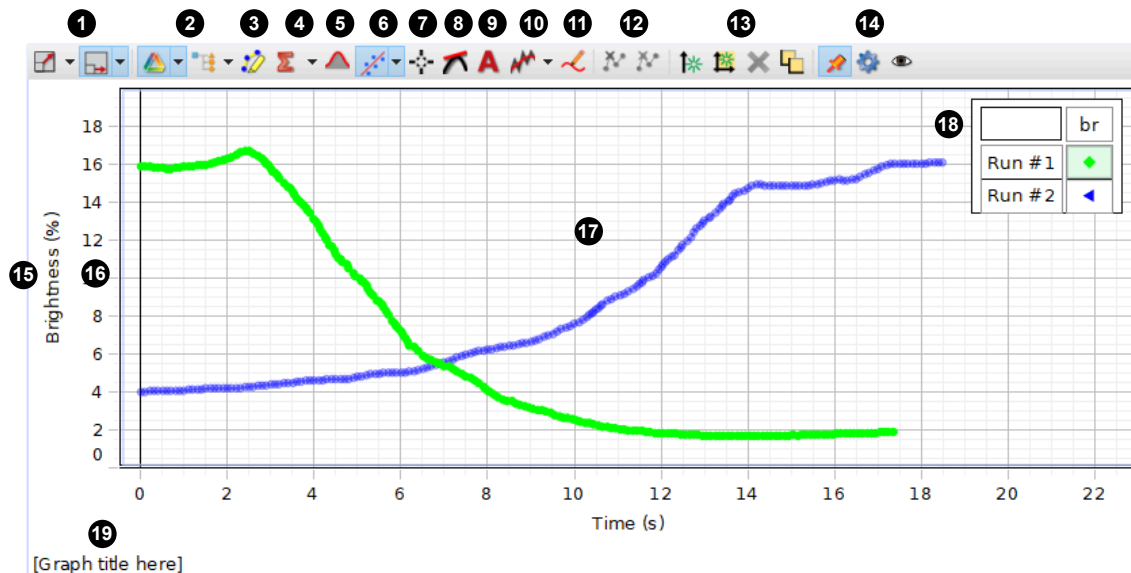
1   ![icon] **Scale to Fit** *(on page 42)*

> Change the scale of a line graph to zoom in on a range of data or to view an entire run of data.

![icon] **Scaling Behavior**

> Use to select how the plot area scales while recording data.

> - Scale Both Axes: Keeps data visible in both axes when data moves out of the current range.
> - Scroll x-axis, Scale y-axis: Keeps data visible in the y-axis, but will only show a constant range on the x-axis. The x-axis will scroll over time, only showing the most recent data.
> - Scroll x-axis, do not scale y-axis: Only shows a constant range on the x and y axes. The x-axis will scroll over time, only showing the most recent data.

2   ![icon] **Run Selector** *(on page 43)*

> Change the visibility of individual data runs without deleting the data.

![icon] **Trial Selector (coming soon)**

3   ![icon] **Highlighter**

> Click to activate the highlighter tool to highlight a range of data to analyze. If more than one run is on the plot, select a run to analyze by clicking the run in the legend *before* clicking the highlighter tool.

4   ![icon] **Statistics** *(on page 51)*

> Use the statistics tool to find the minimum, maximum, mean, and standard deviation of a range of data. Display the statistics visually on the graph or in a tabular format.

5   ![icon] **Area Tool** *(on page 52)*

> Use the area tool to find the area under a curve.

6   **Curve Fit Tool** *(on page 50)*

Use the curve fit tool to fit a curve to data and obtain values about the trend line parameters.

7   **Coordinates Tool**

- Add a coordinates tool *(on page   )* to determine the coordinates of a single data point. Use the delta tool *(on page 46)* to determine the difference between two points of data.
- Add a multi-coordinates tool *(on page   )* to compare coordinates across multiple runs or measurements.
- Add an alignment tool to align a run to an axis or to another run *(on page 47)*.

8   **Slope Tool** *(on page 53)*

The slope tool provides the slope of a line tangent to a curve at a single point.

9   **Annotation Tool** *(on page 54)*

Use the annotation tool to label a data point in a graph with a brief note.

10   **Smoothing**

Use this tool to smooth out noisy data. Click ▼ and drag the slider to adjust the amount of smoothing applied to the data.

11   **Prediction Tool** *(on page 55)*

Before collecting data, draw a prediction of the results directly on the graph.

12   **Exclude Data**

Use to exclude, but not permanently delete, data points from analysis. Highlight the data you want to exclude then click the tool to remove the data.

Delete Data

Use to permanently delete data from a run without having to delete the entire run. Highlight the data you want to delete then click the tool to remove the data.

13   **Add y-axis** *(on page 40)*

Display multiple measurements on the same plot area by adding additional y-axes to a line graph. Align the axes so that the origin is the same for each axis.

Add Plot Area *(on page 41)*

Display an additional measurement in a line graph on separate plot area located below the current plot area.

Remove

Use to remove a y-axis or plot area from a graph display. Click the axis or plot area you want to remove then click the remove button.

Rearrange

Use to rearrange y-axes or plot areas in the graph display. Click the tool then click and drag the axes and plot areas as desired.

14 📌 **Pin**

Click to prevent the toolbar from hiding automatically.

⚙️ **Properties**

Click to access the display properties.

👁️ **Show or Hide Tools**

Click to show or hide specific tools from the toolbar.

15 **Measurement Selector**

Click the measurement to select a different measurement to display. Click the unit to select a different unit for the current measurement.

16 **Axis** *(on page   )*

- Click and drag to scale each axis individually.
- Double click the maximum or minimum value to set to a specific value.
- Right-click to access axis properties and lock the scale.

17 **Plot Area** *(on page   )*

- Click and drag to move the plot area.
- Right-click the plot area to access the plot area properties.
- Right-click the data to show or hide connecting lines and data points *(on page 44)*.

18 **Legend**

Select a run to analyze by clicking the run in the legend. Right-click the run symbol to change the run color and other data set properties.

19 **Graph Title**

Click then enter a custom title for the display.

Add or remove an additional y-axis to a graph

Display multiple measurements on the same plot area by adding additional y-axes to a line graph. Align the axes so that the origin is the same for each axis.

> **ⓘ Tip:**
> If you want to add a another plot area below the current plot area, see Add a Plot Area *(on page 41)*.

Add an axis

1. Add a y-axis using one of the following methods:

   • In the graph toolbar, click ↑※.

   • Click the y-axis of the current graph then click ⬆+ .
2. On the new axis, click Select Measurement then select a measurement from the list.

Remove an axis

Click the axis you want to remove then click **✗** .

Add or remove a plot area to a line graph

Display an additional measurement in a line graph on separate plot area located below the current plot area.

> **ⓘ Tip:**
> If you want to add a second y-axis to graph on the same plot area, see Add a y-axis *(on page 40)*.

1. Add a plot area using one of the following methods:

    • In the graph toolbar, click .

    • Click the horizontal axis then click .

2. In the new plot area, click Select Measurement then select a measurement from the list.

To remove a plot area, click the plot area you want to remove then go to the graph toolbar and click . You can also press the Delete button on your keyboard.

Change the scale and range of a line graph

Change the scale of a line graph to zoom in on a range of data or to view an entire run of data.

Automatically scale to view all data

To automatically scale the graph to fit all data in the screen, do one of the following:

- In the graph toolbar, click ▧.
- Click the horizontal axis then click ⤢ .

> **i** **Tip:**
> To automatically scale the graph while keeping the origin at the bottom left corner, click the drop-down menu next to ▧ then select **Auto scale from zero**.

Scale each axis individually

Click and drag on the axis to change the scale of a single axis:

- Drag away from the origin to zoom in.
- Drag toward the origin to zoom out.

> **i** **Tip:**
> When viewing a graph with more than one y-axis, you may want to prevent other axes from scaling. To prevent an axis from scaling, right-click on the axis then select **Lock Axis Scale** from the menu.

Change the range of the graph but not the scale

You can change the range of data displayed in a graph without changing the scale by moving the graph. To move the graph, click and drag the graph to the desired range.

> **i** **Tip:**
> When viewing a graph with more than one y-axis, you may want to prevent the range from changing. To do this, right-click on the axis then select **Lock Axis Panning** from the menu.

Zoom in on a range of data

> **✎** **Note:**
> If multiple runs of data are displayed on the graph, first select the data you want to zoom in on by clicking a data point or selecting the run in the legend.

1. In the graph toolbar click to make the highlighter appear.
2. Click and drag the highlighter over the data you want to analyze. Use the handles on the highlighter to resize the highlighter.
3. In the graph toolbar click ▧.
4. Optional: Remove the highlighter by clicking it then clicking .

Show or hide runs in a line graph

Change the visibility of individual data runs without deleting the data.

> ✏️ **Note:**
> This article explains how to hide data runs from display. If you wish to delete data runs, see Delete Runs *(on page 88)*.

View Only One Run

Go to the graph toolbar and click ▼ next to 🔺 then select the run you want to display from the menu.

View Multiple Runs

1. Click 🔺 to activate the multiple-run view.
2. Click ▼ next to 🔺 then select the runs you want to display.

Show or hide data points and connecting lines in a graph

Change the visibility of data points, symbols, and lines connecting data points in a line graph.

To quickly change the visibility of data points, run symbols, and connecting lines, right-click on a data point in a run then select or deselect the options that appear in the menu.

For more detailed control over the data appearance such as data point size and connecting line width, right-click on a data point and select **Run Properties** .

Determine the coordinates of points on a graph

Determine the coordinates of a single data point or compare data point coordinates from multiple measurements and runs.

Coordinates of a Single Point

Use the coordinates tool to determine the coordinates of a single data point.

1. Click the data point you want to analyze then click ⌖ .

2. Place the tool on a different data point by click and dragging the tool or clicking ‹ or › .

To remove the tool from the screen, click the coordinates tool then click ✗ .

> **ⓘ Tip:**
>
> Click △⁺ to determine the difference between two data points *(on page 46)*.

Compare Coordinates of Multiple Points

Use the multi-coordinates tool to compare coordinates across multiple runs or measurements.

1. Click ⌖ in the graph toolbar then select **Add Multi-coordinates Tool**.

2. Place the tool on a different data point by click and dragging the tool or clicking ‹ or › .

Determine the difference between two data points on a line graph

The coordinates tool includes a delta tool to determine the difference between two data points in a run of data. When the delta tool is activated it will display the difference of the vertical (Δy) and horizontal (Δx) coordinates between the two points.

1. Click the point you want to analyze then click ⊕ .

2. Click △⁺ to make the delta tool visible.

3. Place the tool on a different data point by click and dragging the tool or clicking ‹ or › .

Remove the tool by clicking the tool then click △⁺ or △⊗ .

Align a run to an axis or another run

Shift a data run in a graph display by aligning a data point with an axis or a second data run.

> ✎ **Note:**
> The alignment tool is only available when x-axis measurement is Time.

Align a run to an axis

Shift a data run by aligning a data point with the y-axis, x-axis, or the origin of a graph.

1. In the graph toolbar, click ⊹ then select **Add Alignment Tool**.
2. Drag the coordinates tool and attach it to the data point you want to shift.

3. Click ⬚ then select the type of alignment:


[Graph title here]
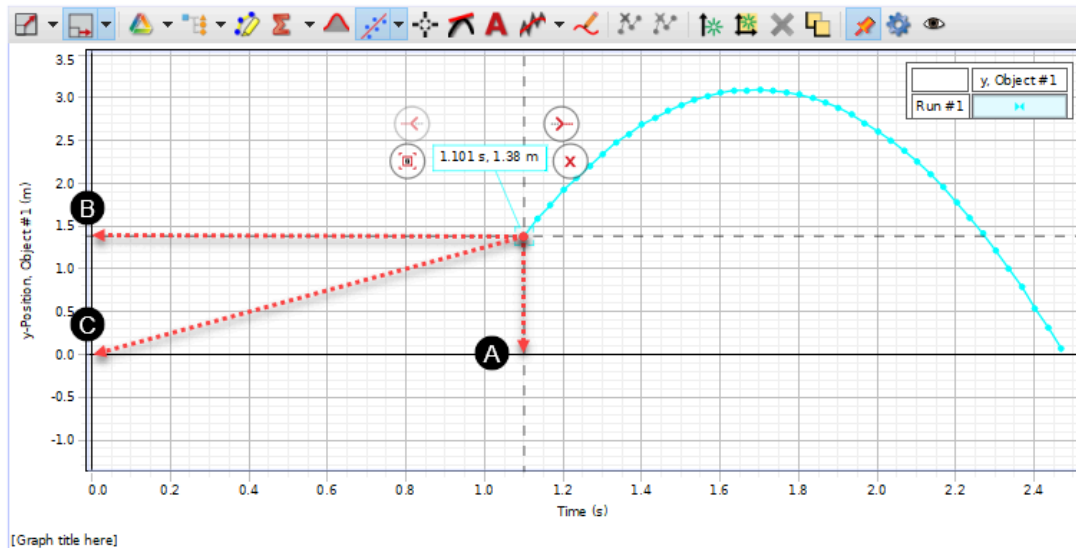
(A) **Align x-axis**

　　Shift the data point to make its x-coordinate equal to zero.

(B) **Align y-axis**

　　Shift the data point to make its y-coordinate equal to zero.

(C) **Align to origin**

　　Shift the data point to make its x- and y-coordinate equal to zero.

Align two data runs

Shift a data run along the Time axis to align it with a second data run.

1. In the graph toolbar, click ⊹ then select **Add Alignment Tool**.
2. Drag the coordinates tool and attach it to the data point where you want to align the runs.

3. Click ▣ then select **Align Runs**. A second coordinates box appears.
4. Drag the second coordinates box and attach it to the data point you want to shift.


[Graph title here]
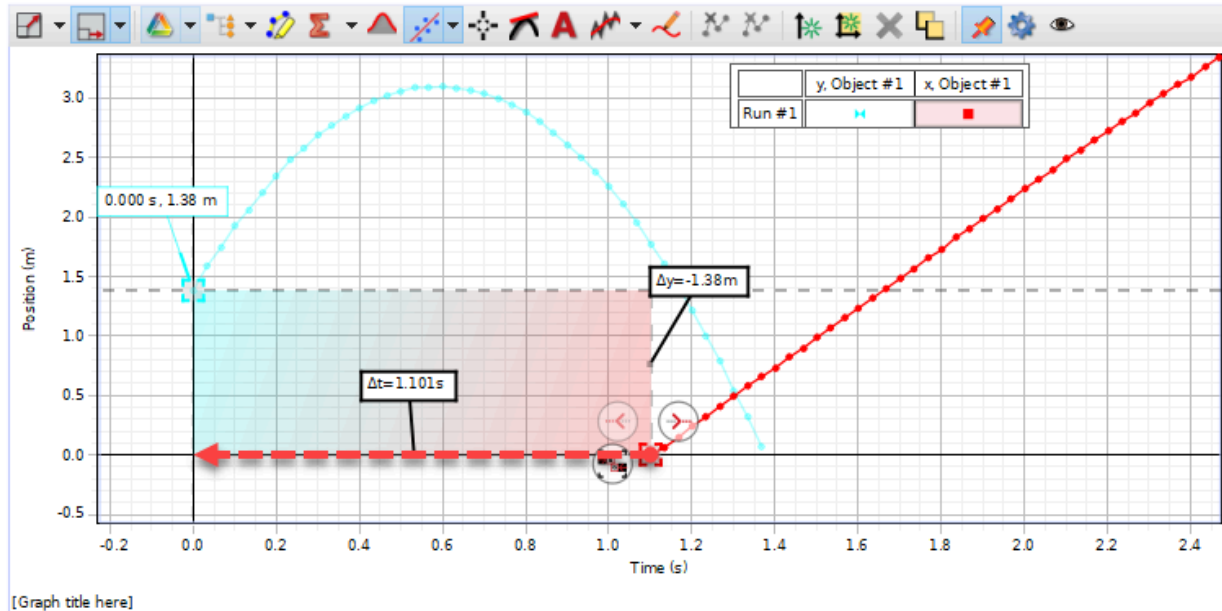
5. Click ⊡ to align the runs.

Fit a curve to data in a line graph

Use the curve fit tool to fit a curve to data and obtain values about the trend line parameters. Use the Curve Fit Editor to make adjustments to the curve fit parameters.

Apply a Curve Fit

> **Note:**
> If multiple runs of data are displayed on the graph, first select the data you want to zoom in on by clicking a data point or selecting the run in the legend.

1. In the graph toolbar click to make the highlighter appear.
2. Click and drag the highlighter over the data you want to analyze. Use the handles on the highlighter to resize the highlighter.
3. Click then select the desired curve fit from the menu.

> **Tip:**
> If the curve fit fails, use the curve fit editor *(on page 50)* to suggest possible values for the curve fit parameters.

A curve appears over the data with an information box. The information box includes values about the trend line parameters. Also included are the mean square error (MSE) and the root mean square error (RMSE) which provide information on well the curve fits the data.

Edit the Curve Fit Parameters

A curve fit may fail for data that has a complex trend. For these cases you will need to use the Curve Fit Editor to suggest approximate values for some of the curve fit parameters. You can also use the Curve Fit Editor to make precise adjustments to successful curve fits.

1. Click the curve fit information box then click .
2. In the Curve Fit Editor, enter an Initial Guess for at least one of the curve fit parameters.
3. Click **Update Fit**.

> **Tip:**
> If the fit fails, click **Lock** to prevent a parameter from automatically changing, then click **Update Fit** again.

Edit the Curve Fit Properties

Use the Curve Fit Properties to adjust properties such as the number of significant digits used, visibility of information displayed, and how the information appears.

1. Click the curve fit information box then click .
2. Navigate through the menus in the Properties window then make adjustments to the desired properties.
3. Click **OK** to apply the properties.

Find the statistics of a range of data in a line graph

Use the statistics tool to find the minimum, maximum, mean, and standard deviation of a range of data. Display the statistics visually on the graph or in a tabular format.

> ✏️ **Note:**
> If multiple runs of data are displayed on the graph, first select the data you want to zoom in on by clicking a data point or selecting the run in the legend.

1. In the graph toolbar click to make the highlighter appear.
2. Click and drag the highlighter over the data you want to analyze. Use the handles on the highlighter to resize the highlighter.
3. Click Σ then select the statistics you want to display.

The selected statistics are displayed visually on the graph by default. You can also display all statistics in a single information box by clicking a statistic value then clicking . To return to the visual statistics format, click the information box then click .

Find the area under a curve in a line graph

Use the area tool to find the area under a curve.

> **Note:**
> If multiple runs of data are displayed on the graph, first select the data you want to zoom in on by clicking a data point or selecting the run in the legend.

1. In the graph toolbar click to make the highlighter appear.
2. Click and drag the highlighter over the data you want to analyze. Use the handles on the highlighter to resize the highlighter.
3. In the graph toolbar, click .

Capstone will show a shaded area under the curve to indicate what area is being measured. An information box appears displaying the magnitude of the area with units.

> **Tip:**
> To change the number of digits displayed, right-click the information box then select **Tool Properties**. Adjust the numerical format as desired.

Determine the slope of the tangent to a curve

The slope tool provides the slope of a line tangent to a curve at a single point.

> **ⓘ Tip:**
> If you are interested in finding the slope of a range of data, perform a linear fit *(on page 50)*.

1. Click the data point you want to analyze then click .
2. Place the tool on a different data point by click and dragging the tool or clicking or .

To remove the tool from the screen, click the tool then click .

Label a data point in a line graph

Use the annotation tool to label a data point in a graph with a brief note.

Add an Annotation to a Data Point

1. Click the data point where you want to leave a note then click ⊞ .
2. Click the annotation box then use your keyboard to type a note.

> ℹ **Tip:**
> To enter superscripts, subscripts, or special characters, right-click the annotation box and then select the character you want to enter from the menu.

To remove the tool from the screen, click the tool then click .

Modify the Appearance of the Annotation

1. Right-click the annotation box then go to **Text Annotation Tool** and select **Text Annotation Tool Properties**.
2. Modify the annotation tool properties as desired.
3. Click OK to exit the Properties window.

Draw a prediction on a line graph

Before collecting data, draw a prediction of the results directly on the graph.

Draw a Prediction Containing Curves

1. Go to the graph toolbar then click .
2. Select **Create Free Form Prediction** from the menu.
3. Click and drag on the screen to draw your prediction. Release the mouse button when finished.

Draw a Prediction as a Series of Lines

1. Go to the graph toolbar then click .
2. Select **Create Point-by-Point Prediction** from the menu.
3. Click on the graph to mark your first point then click at another location to mark your second point. The two points will connect with a line. Repeat to draw additional lines.
4. Click **Done** at the top of the graph when finished.

Delete a Prediction

1. In the Tools palette click .
2. Under **Sensor Data Summary** select the prediction you want to delete.
3. Click next to the prediction you want to delete.
4. Click Yes to confirm deletion.

Table Display

Display data using two or more columns and show data statistics.

Table Display Overview

Get an overview of the Table display tools.

1   **Table Title**

Click then enter a custom title for the display.

2   **Column Tools**

Use these tools to insert and remove columns and cells.

Insert Column

Select a column then click the button to insert a column to the right.

Remove Column

Select a column then click the button to remove the column.

Insert Calculation Column

Select a column then click the button to insert a calculation column. After inserting the column, enter an equation at the top of the table.

Insert a Cell

This tool only works with columns containing user entered data. Click a cell then click the button to insert an empty cell above.

Remove Cell

This tool only works with columns containing user entered data. Click a cell then click the button to remove the cell.

3   **Number Format Tools**

Use these tools to increase 0.0➜ or decrease 0.0← then number of displayed digits of a selected column. Click **1.23** to display the default number of digits.

4   **Data Analysis Tools**

        Statistics

        Use this tool to display the statistics of a column of data at the bottom of the column. Use the highlight tool to only display the statistics for the highlighted data.

        Highlight Cells

        Use with the statistics, exclude data, and delete data tools to select data to apply to those tools. When used on an experiment page that also contains a Graph display, the highlighted data in the column will also automatically highlight the data in the graph.

        Remove Highlighting

        Use to remove the highlighting for a specific column. First select a column then click the remove highlighting tool.

        Exclude Data

        Use to exclude data from analysis without permanently deleting the data. Select data using the Highlight Cells tool then click Exclude Data.

        Delete Data

        Use to permanently delete specific data points from a run. Select data using the Highlight Cells tool then click Delete Data.

5   **Display Tools**

        Pin Toolbar

        Click to prevent the toolbar from hiding automatically.

        Display Properties

        Click to access the display properties.

        Show or Hide Tools

        Click to show or hide specific tools from the toolbar.

6   **Run Selector**

        Click to change the displayed run or rename the run.

7   **Measurement Selector**

        Click the measurement to select a different measurement to display. Click the unit to select a different unit for the current measurement.

Add or remove columns in a table

Insert up to eight columns of data and remove unwanted columns in a table display.

Add a Column

1. Click a column to the left of where you want to insert a new column.
2. Go to the table toolbar then click ![icon].
3. Click Select Measurement to add a measurement to the table.

Remove a Column

1. Click the column you want to remove.
2. Go to the table toolbar then click ![icon].

Show the statistics of a measurement in a table

Use the statistics tool to display the minimum, maximum, mean, and standard deviation of data and display it at the bottom of the column.

Show Statistics for All Data

1. Go to the table toolbar and click Σ .

2. Optional: To change which statistics are displayed, click ▾ next to Σ then select or deselect the statistics you want to display.

Show Statistics for a Range of Data

1. Activate the statistics tool as describe in Show Statistics for All Data *(on page 60)*.
2. Go to the table toolbar and click .
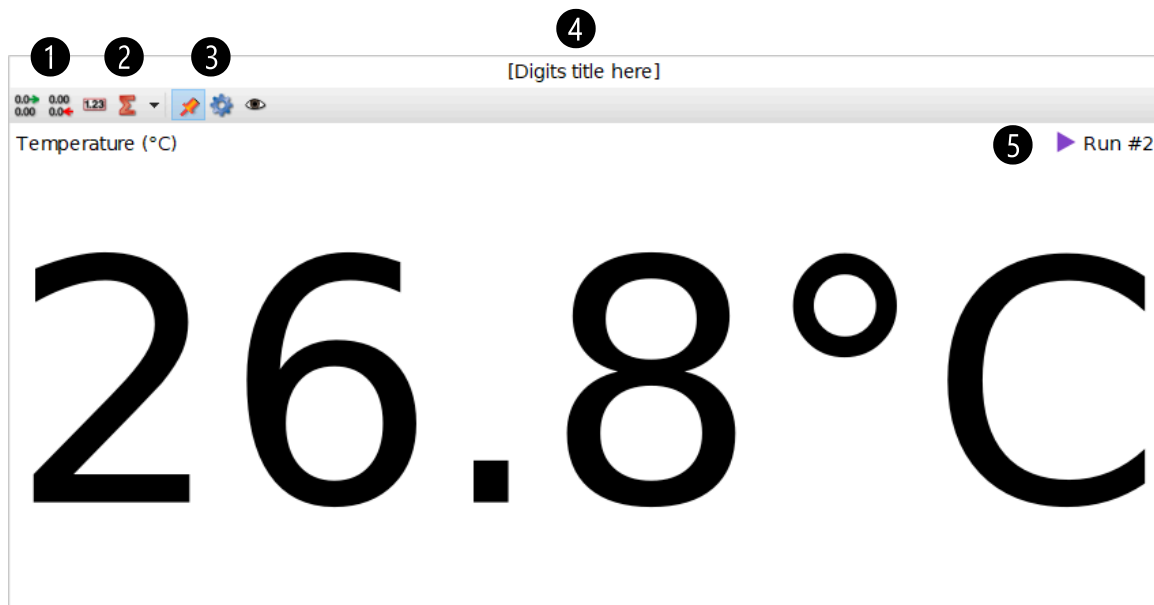3. Click and drag over the data you want to analyze.

To remove the highlighter, go to the table toolbar and click .

Digits Display

Show the most recently recorded data sample as digits, statistics of a single data run, or text output *(on page 123)* from a Blockly program.

Display Overview

1. **Numerical Format Tools**

    Use these tools to change the number of digits displayed.

    - 0.0→ / 0.00 / 0.00 Click to increase the number of digits.
    - 0.00 / 0.0← Click to decrease the number of digits.
    - **1.23** Click to restore the default number of digits.

2. **Statistics Tool**

    Click to display the minimum, maximum, mean, or standard deviation for the selected run.

3. **Display Tools**

    - 📌 Click to pin the toolbar to the display.
    - ⚙️ Click to access the display properties.
    - 👁 Click to show or hide specific tools from the toolbar.

4. **Display Title**

    Click then enter a custom title for the display.

5. **Run Selector**

    Indicates the currently selected run. Click to select a new run to display.

Change the Displayed Measurement or Units

- To change the measurement, click the current measurement then select a new measurement from the list.
- To change the unit, click the current unit then select a new measurement from the list.

Display Statistics for the Current Run

1. Click ∑ to activate the statistics tool. The mean is shown by default.
2. Click ▼ next to the tool to select which statistic to display.

Display Text Output from a Blockly Program

1. Create a program using the Code tool *(on page 92)* that includes text output *(on page 123)*.
2. Click **Select Measurement** then select the name of the text output under **Code Output Data**.

Scope Display

Create a display that functions as a digital oscilloscope. This display is useful for viewing measurements that oscillate rapidly in time such as electrical signals and sound waves.
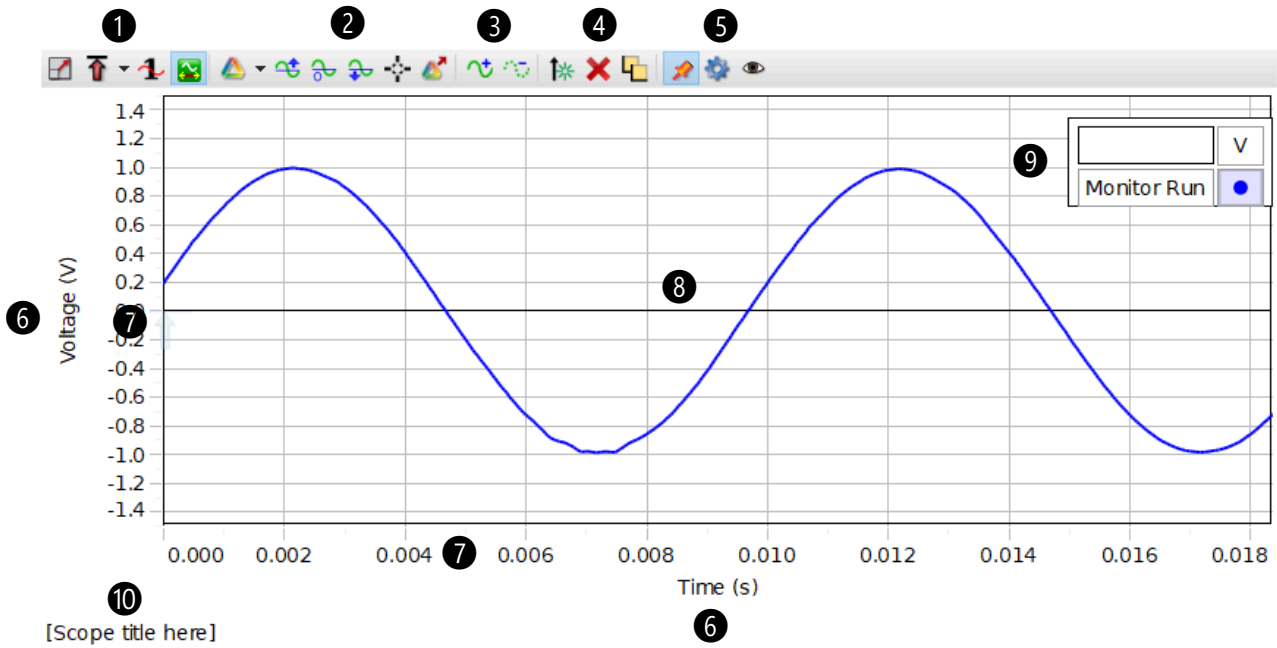
Scope Display Overview

Get an overview of the Scope display tools and how to modify the display.

> **Note:**
> Since the Scope display is used to monitor data at high sample rates, you will need to set the Recording Mode *(on page 84)* to Fast Monitor Mode .

[Scope title here]

1   **Scope Tools**

⬜ **Scale to Fit**

Click to automatically scale the y-axis to the best fit.

⬆ **Trigger**

Click to activate the scope trigger to get a stable trace *(on page 67)*. Click the menu
▼ to switch between using a positive or negative edge trigger.

〜 **Single Trace**

Use with the trigger to capture a single trace *(on page 68)*, which is useful for fast,
non-repetitive events.

📈 **Auto Sample Rate**

When activated, the sample rate will automatically adjust to the best rate as the range
of the time axis is adjusted. This tool is activated by default.

2   **Trace Tools**

🔺 **Run Selector**

Change the visibility of individual data runs without deleting the data.

Offset Trace

Use to offset a trace *(on page 69)* from the x-axis. This is useful when viewing more
than one trace on the display. Click 〜 to increase the offset, click 〜 to decrease
the offset, or click 〜 to remove the offset.

✛

Click to add a coordinates tool to determine the coordinates of a single data point.
Use the delta tool to determine the difference between two data points.

🔺 **Record Trace**

Use this tool to record a snapshot of the trace to analyze in a graph display.

3   **Data Point Tools**

Use these tools to increase 〜 or decrease 〜 the number of data points in a trace. Increasing
the number of data points will make a smoother trace but decrease the displayed range of the
trace.

4   **Axis Tools**

🔆 **Add y-axis**

Click to add an additional y-axis to the plot area.

❌ **Remove y-axis**

Click the axis you want to remove then click the remove button.

🗐 **Rearrange Axes**

Use to rearrange y-axes. Click the tool then drag a y-axis to a different location.

⑤ **Display Tools**

📌 **Pin Toolbar**

Click to prevent the toolbar from hiding automatically.

⚙️ **Display Properties**

Click to access the display properties.

👁 **Show or Hide Tools**

Click to show or hide specific tools from the toolbar.

⑥ **Measurement Selector**

Click the measurement to select a different measurement to display. Click the unit to select a different unit for the current measurement.

⑦ **Axis**

- Click and drag to scale each axis individually.
- Double-click the maximum or minimum value to set to a specific value.
- Right-click to access axis properties and lock the scale.

⑧ **Plot Area**

- Click and drag to move the plot area.
- Right-click the *plot area* to access the Plot Area Properties.
- Right-click the *trace* to access the Run Properties.

⑨ **Legend**

- Click a run to apply the trace tools to that run.
- Right-click a run name to access the Plot Area Properties.
- Right-click a symbol to change the run color and access the Data Set Properties.

⑩ **Display Title**

Click then enter a custom title for the display.

Get a Stable Trace

Use the trigger to get a stable trace on the scope display.

> ✏️ **Note:**
> Since the Scope display is used to monitor data at high sample rates, you will need to set the Recording Mode *(on page 84)* to Fast Monitor Mode .

1. Click **Monitor** ⭕ .
2. Click ⬆️ to activate the scope trigger. The trigger icon appears on the y-axis of the scope display.
3. Drag the trigger along the y-axis to the value that the signal must pass in order to start measuring.

By default, the trigger is set for a **positive edge**. This means that the scope will display the trace as the signal is rising at the trigger point. Click the menu ▼ to change the trigger to a **negative edge** to make the scope display a trace as the signal is falling at the trigger point.

Capture a Single Trace

The single trace tool is useful for fast, non-repetitive events, such as measuring the time between a sound impulse and its echo. When activated, the scope displays one frame of data and stops monitoring. This tool is typically used with the trigger.

> **Note:**
> Since the Scope display is used to monitor data at high sample rates, you will need to set the Recording Mode *(on page 84)* to Fast Monitor Mode .

1. Select to activate the single trace tool.
2. Select to turn on the trigger *(on page 67)*.
3. Drag the trigger on the y-axis to set the trigger threshold.
4. Click **Monitor** . The scope will immediately stop monitoring data once a signal is detected.

Offset a Trace

When more than one trace is displayed on a Scope display, it can be helpful to offset a trace so that the traces do not overlap.

1. Select a trace by clicking the trace or selecting the trace symbol in the legend.
2. Click ⬆ to move the trace upwards or click ⬇ to move the trace downwards.

To return the trace back to its initial position, click ⟲ to remove the offset.

Show More than One Trace

You can display multiple traces on the Scope display by adding a similar measurement or adding another y-axis.

Same type of measurement

Use the **Add Similar Measurement** tool to display another trace that uses the *same* units as the currently displayed measurement.

1. Select the current measurement displayed on the y-axis.
2. In the context menu, hover the mouse over **Add Similar Measurement** then select a measurement to add.

Different type of measurement

Use the **Add y-axis** tool to display another trace that uses *different* units than the currently displayed measurement.

1. Add a y-axis using one of the following methods:

    • In the scope toolbar, click ↑✳.

    • Click the y-axis of the current display then click ⊥₊ .

2. On the new axis, click **Select Measurement** then select the measurement from the list.

Record a Trace to Analyze

Since the scope is monitoring data at high sample rates, a trace is not automatically recorded when monitoring data stops. The record trace tool needs to be used in order to record the trace.

> ✏️ **Note:**
> Since the Scope display is used to monitor data at high sample rates, you will need to set the Recording Mode *(on page 84)* to Fast Monitor Mode .

1. Click **Monitor** ⭕ .
2. Adjust the scope as needed to obtain a desired trace.

3. Click 📈 to record the trace.

By default, the trace will be named **Monitor Run-ScopeSnapshot#**, where # represents the sequential number of the snapshot. You can select this run in a Graph display *(on page 37)* to perform further analysis.

FFT Display

Create a spectral analysis display that uses a Fast Fourier Transform (FFT) to measure the relative signal intensity as a function of frequency.

> **Note:**
> Since data is typically monitored at high sample rates when using an FFT, you will need to set the Recording Mode *(on page 84)* to Fast Monitor Mode ⚡ .
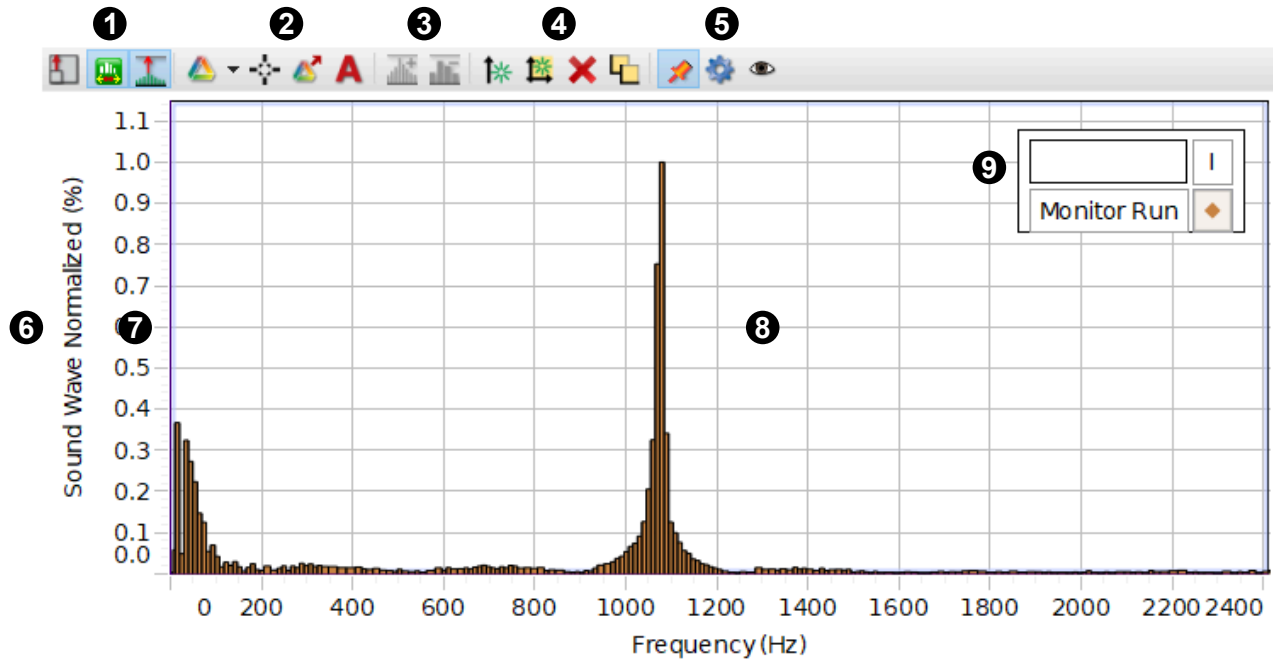
➓ [FFT title here]

① **Scaling Tools**

Scale Vertical Axis

Click to automatically scale the vertical axis so that all the data is in view.

Auto Sample Rate

Automatically adjust the sample rate and number of bins as the frequency axis scale changes. This tool is selected by default.

Normalize Data

Select to change the vertical scale to make 1 the maximum value.

② **Plot Tools**

Run Selector

Change the visibility of individual data runs without deleting the data.

Click to add a coordinates tool to determine the coordinates of a single data point. Use the delta tool to determine the difference between two data points.

Record Trace

Use this tool to record a snapshot of the trace to analyze in a graph display.

Annotation Tool

Use the annotation tool to label a data point with a brief note.

③ **Number of Bins**

Increase or decrease the number of bins on the display. These tools are only available if the automatic sample rate adjustment tool is not selected.

④ **Axis Tools**

Add y-axis

Click to add an additional y-axis to the plot area.

Add Plot Area

Display an additional measurement on separate plot area located below the current plot area.

Remove y-axis

Click the axis you want to remove then click the remove button.

Rearrange Axes

Use to rearrange y-axes. Click the tool then drag a y-axis to a different location.

5   **Display Tools**

📌 **Pin Toolbar**

Click to prevent the toolbar from hiding automatically.

⚙️ **Display Properties**

Click to access the display properties.

👁️ **Show or Hide Tools**

Click to show or hide specific tools from the toolbar.

6   **Measurement Selector**

Click the measurement to select a different measurement to display. Click the unit to select a different unit for the current measurement.

7   **Axis**

- Click and drag to scale each axis individually.
- Double-click the maximum or minimum value to set to a specific value.
- Right-click to access axis properties and lock the scale.

8   **Plot Area**

- Click and drag to move the plot area.
- Right-click the *plot area* to access the Plot Area Properties.
- Right-click the *trace* to access the Run Properties.

9   **Legend**

- Click a run to apply the trace tools to that run.
- Right-click a run name to access the Plot Area Properties.
- Right-click a symbol to change the run color and access the Data Set Properties.

10   **Display Title**

Click then enter a custom title for the display.

Meter Display

Show the most recently recorded data sample or a statistical value of a single run on an analog display.
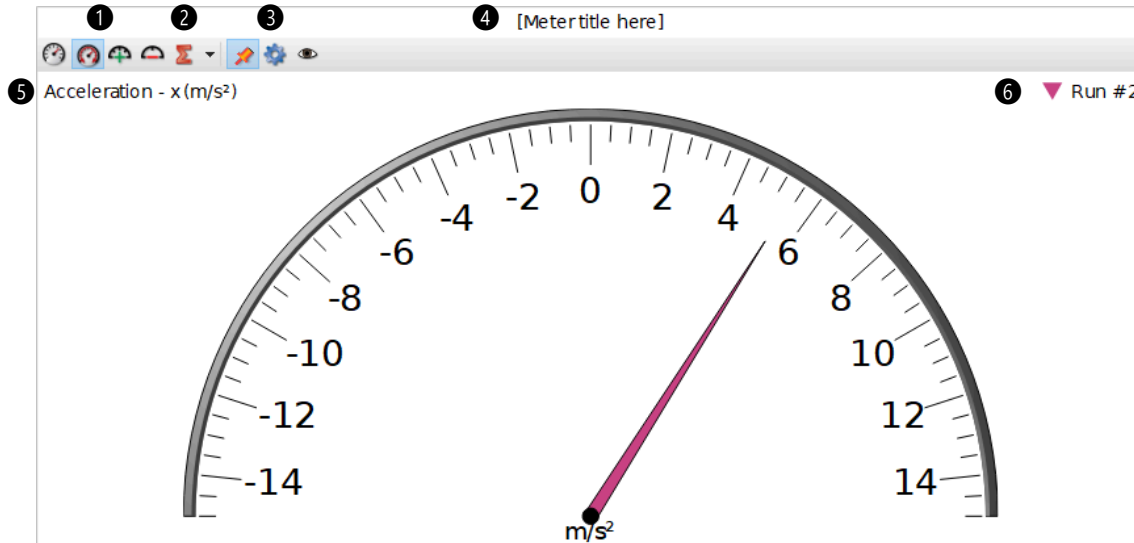
1   Scale Tools

- Click ⊙ to manually scale the meter to the best fit.
- Select ⊙ to have the meter automatically scale to the best fit.
- Click ⊕ to increase the number of ticks on the scale.
- Click ⊖ to decrease the number of ticks on the scale.

2   Statistics Tool

Select Σ to display visual statistics on the meter for the selected run. Click ▾ to select which statistics to make visible.

3   Display Tools

- Click 📌 to pin the toolbar to the display.
- Click ⚙ to access the display properties.
- Click 👁 to show or hide specific tools on the toolbar.

4   Display Title

Click then enter a custom title for the display.
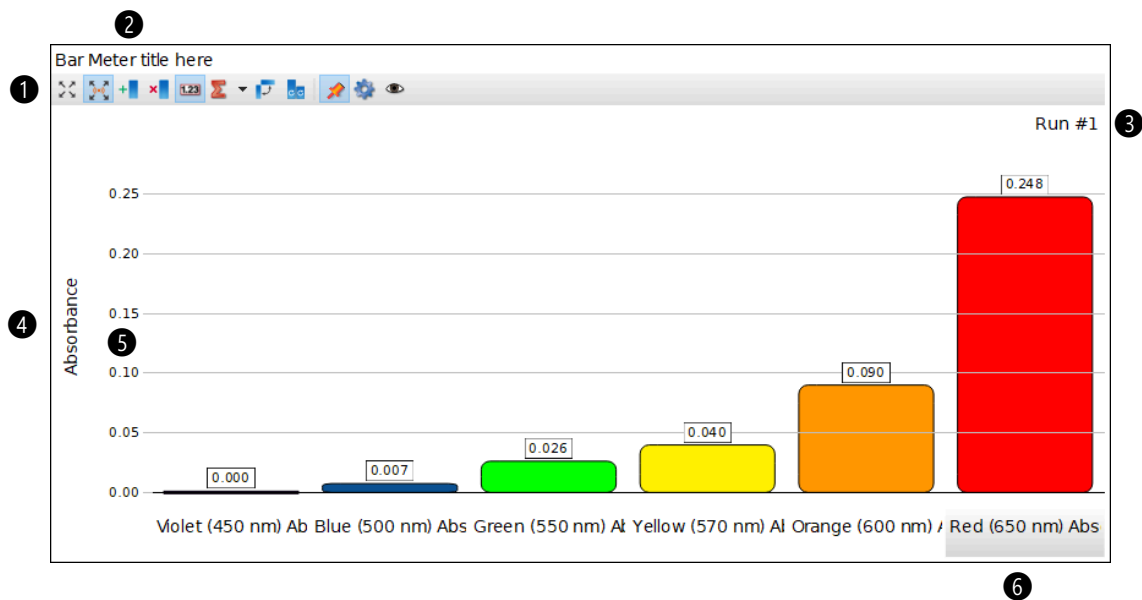
5   Measurement Selector

Click the measurement to select a different measurement to display. Click the unit to select a different unit for the current measurement.

6   Run Selector

Indicates the currently selected run. Click to select a different run to display.

Bar Meter Display

Visually compare the most recently recorded data values across similar measurements.

①　Display Tools

Scale to Fit ⛶

Click to scale the entire display to make all measurements visible.

Auto Scale ⛶

Select to continuously scale the entire display to make all measurements visible.

Add Bar +▮

Click to add an additional measurement at the far right of the display.

Remove Bar ×▮

Click to remove a bar from the display. First select the bar you want to remove before clicking the Remove Bar button.

Digits 1.23

Show or hide digital values on top of each bar.

Statistics Σ

Select the to display statistics of the data below the measurement. Click the menu ▼ to select the type of statistical data to display.

Change Layout 🗗

Select to change the bar layout between vertical and horizontal bars.

Clear Measurements 🔲

Click to reset all the measurements to select new measurements to display.

> ✏️ **Note:**
> This tool does *not* delete the data. If you wish to delete the data, see Delete Runs *(on page 88)*.

Pin Toolbar 📌

Click to pin the toolbar to the display.

Properties ⚙️

Click to access the display properties.

Tool Visibility 👁️

Click to show or hide specific tools from the toolbar.

②　Display Title

Click then enter a custom title for the display.

③　Run Selector

Click to change the displayed data run.

④　Common Measurement

Indicates the type of measurement common to all of the measurements on the horizontal axis.
Click to change the displayed unit (if available).

---

5   **Axis**

Click and drag to scale the axis.

6   **Measurement Selector**

Click to change the displayed measurement.

> **Note:**
> It is only possible to select a measurement that is of the same type as the vertical axis.

Circuit

Build a circuit and display measurements recorded by voltage and current sensors.

The Circuit display provides the ability to display sensor measurements that are integrated with a circuit simulation. When meters are added to the circuit drawing they can be configured to display live, quantitative sensor measurements. Additionally, the magnitude and direction of measured current corresponds with the speed and direction animated electrons (or arrows) within the circuit simulation.

Overview of the Display
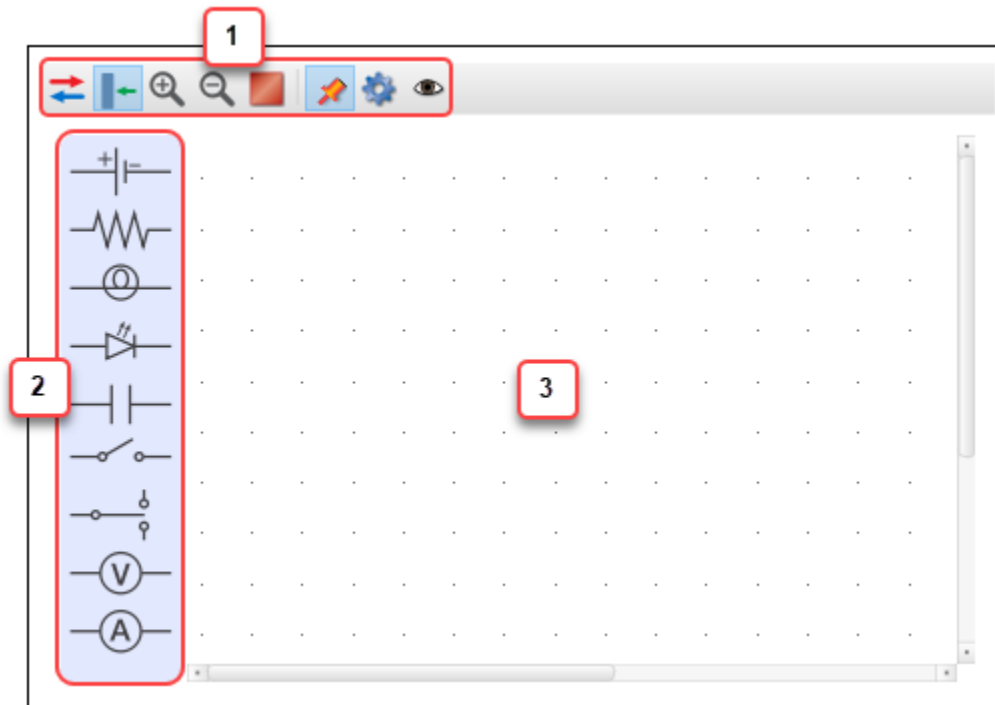
1 Circuit Toolbar

Icon	Description
	Change the current simulation direction from electron to conventional.
	Show or hide the components palette.
	Zoom in on the workspace.
	Zoom out of the workspace.
	Stop or start the animations.

2 Components Palette

Click and drag a component to add it to the workspace.

3 Workspace

Build your circuit here.

Build a Circuit

1. Click and drag components from the components palette onto the workspace. If desired, make the following changes to the component:

   - Click to rotate the component.
   - Click to change the magnitude of the component.
2. Connect components by clicking the end of a component and drawing a wire.

Display a Measurement

A voltage or current sensor must be connected to Capstone before performing these steps.

1. Add a voltmeter or ammeter to the workspace.
2. Click the meter then click to display a graph or to display digits.
3. Click the meter then click to select the sensor measurement to display.
4. Click to view the sensor measurements.

Controls Palette

Set the data collection mode and sample rate, define start and stop conditions, and delete data runs.

Controls Palette Overview

Learn what each tool is used for in the Controls palette.

> ⓘ **Tip:**
> Click 👁 to select which controls are visible. Click ✕ to hide the palette.

Recording Controls
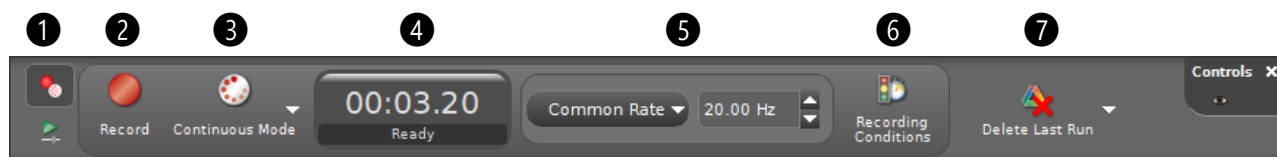
1   🔴 **Recording and** ▶ **Playback Controls**

Use to toggle between the recording and playback controls. Use the recording controls to record data. Use the playback controls to play back previously recorded data.

2   🔴 **Record,** ⭕ **Monitor, and** ▶ **Execute**

Click to Record data while in Continuous Mode. Click to Monitor data when in Keep or Fast Monitor Mode. Click to Execute code when no sensors are connected.

3   **Recording Mode**

Use to toggle between Continuous, Keep, and Fast Monitor Mode.

- 🔘 Continuous Mode: Set to record data at a specified sample rate.
- ✔ Keep Mode: Set to manually sample data *(on page 86)* by clicking the Keep Sample ✔ button.
- ⚡ Fast Monitor Mode: Set to monitor data without recording it. This mode is recommended for sampling rates greater than 1,000 Hz and is typically used with the Scope and FFT displays.

4   **Clock**

Displays the elapsed recording time.

5   **Sample Rate** *(on page 87)*

Use to set the sample rate of a single sensor or multiple sensors. Click the menu to select which sensor to set.

6   🚦 **Recording Conditions**

Use to set conditions when data recording starts or stops.

7   ❌ **Delete Runs** *(on page 88)*

Click to delete the most recent run. Click the down arrow to delete a specific run or all runs.

Playback Controls

Use the playback controls to perform an "instant replay" on data that has been recorded. The playback controls are particularly useful for video analysis.

1 Recording and Playback Controls

Use to toggle between the recording and playback controls. Use the recording controls to record data. Use the playback controls to play back previously recorded data.

2 Slider

Click and drag to move the time forward or backward.

3 Run Selector

Click and select which run to view.

4 Clock

Displays the elapsed recording time.

5 Beginning

Click to go to the start of data collection at time 0.00.

6 Previous Sample

Click to move to the previously recorded data sample.

7 Play

Click to play or pause the data recording.

8 Next Sample

Click to move to the next recorded data sample.

9 End

Click to move to the last data sample.

10 Playback Rate

Click and select the rate that data is played back.

11 Loop

Click to have the recording automatically start at the beginning after reaching the end of the recording.

Set Up and Use Manual Sampling

Manually select when data points are recorded instead of continuously recording data.

While in Keep mode, data is continually *monitored* but not *recorded* until the Keep Sample button is clicked. This mode is used when recording a sensor measurement versus a non-sensor measurement, such as in a Boyle's Law or Beer's Law experiment. It is also useful to use this mode when recording a sensor measurement versus another sensor measurement.

Set Up Manual Sampling

> **i** **Tip:**
> Select **Manual Sampling** from the Sensor Data *(on page 5)* menu on the Entry Screen to automatically set up the experiment.

1. Build a page that includes a table and a graph display.
2. Add measurements to each display.
3. In the Controls palette *(on page 84)*, change the recording mode from Continuous Mode to Keep Mode .

> **✏** **Note:**
> The Recording button will change to Preview and a Keep Sample button will appear.

Use Manual Sampling

1. Click Preview to begin monitoring data. The current measurement is displayed in the table and graph but not recorded.
2. Click Keep Sample to record a data point. Repeat for each data you want to record.
3. Click Stop when finished collecting data.

Change the sample rate of a sensor

Change how many data points are collected per unit of time.

The default sample rate will work fine for most cases. It may be desirable to use a higher sample rate when trying to record an event that occurs very quickly to gather additional data points. For long-term data collection (over multiple hours), the sample rate should be lowered to conserve memory and prevent the data file from getting too large.

1. Go to the Controls palette at the bottom of the screen and select the sensor displayed next to the sample rate.
2. In the menu, select which sensor sample rate you want to change. Select **Common Rate** to set the sample rate for all connected sensors.

> ✏️ **Note:**
> Higher sampling rates may be limited for wireless sensors due to limitations in Bluetooth transfer rates. In general, avoid using a Common Sample Rate for high sample rates when using a wireless sensor that contains several sensors.

3. Change the sample rate by clicking the up and down arrows next to the sample rate.

Delete Data Runs

Permanently delete data runs from an experiment.

Delete the Most Recent Run

Go to the Controls palette at the bottom of the screen and click ![icon].

Delete a Specific Run

1. Go to the Controls palette at the bottom of the screen and click ![dropdown] next to ![icon].
2. Select the run you want to delete from the menu.

Delete All Runs

1. Go to the Controls palette at the bottom of the screen and click ![dropdown] next to ![icon].
2. Select **Delete All Runs** from the menu.

Workbook Tools

Open and save files, import and export data, and create a journal. Create a new workbook page, rename the page, and set the properties.

Export and open data in a spreadsheet

Export data as a comma separated values (CSV) file which can be opened with a spreadsheet application such as Excel or Google Sheets. You can also copy data directly from a table and paste it into a spreadsheet or word processing application.

Export All Data

1. In the main menu, go to **File > Export Data...** .
2. Select which data you want to export.
3. Click **Alignment Options** then select how you want the data to be aligned.
4. Click **Export Format** then select **Comma separated values** .
5. Click **Export to file...** .
6. Save the CSV file on your computer.
7. Open the CSV file in a spreadsheet program.

Copy and Paste Data from a Table

This feature requires a Table *(on page 57)* display with data visible on the screen.

1. Click and drag over the data you want to copy.
2. Right-click then select Copy Values.
3. Open a spreadsheet or word processing application and paste the values.

Blockly Coding

Create programs with the Code Tool using Blockly. Use sensor measurements to report data and control output devices.

Code Tool

The Code Tool interface consists of a workspace to build a program using blocks from the Blockly Toolbox.

To access the Code tool, click on the Tools palette on the left side of the screen.
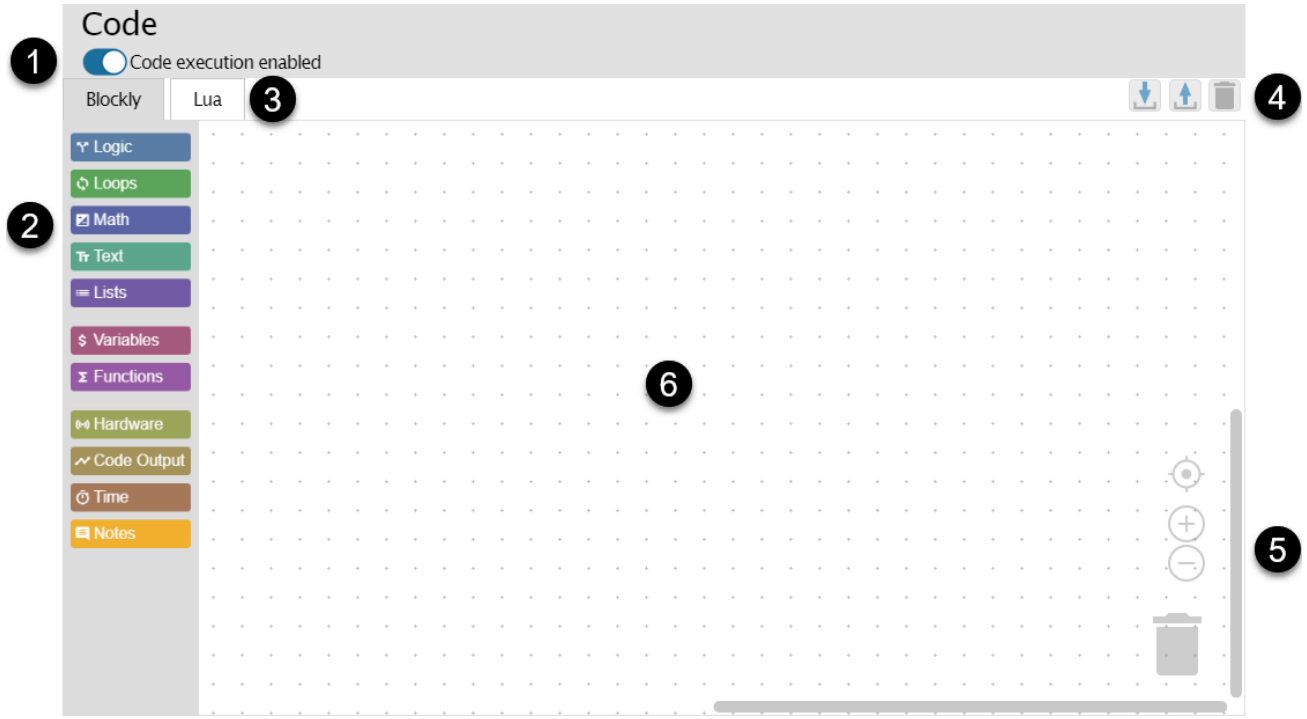
1 **Code Execution Switch** ⬤

Toggle to enable or disable code to run a program *(on page 134)* during data collection.

2 **Blockly Toolbox**

Click a category to add a block to the workspace to build a program *(on page 132)*.

Logic *(on page 96)*

Use the Logic blocks to create if-then statements and comparison operations.

Loops *(on page 99)*

Use the loop blocks to control the number of times lines of code are executed.

Math *(on page 102)*

Use the Math blocks to include numbers in code and perform mathematical operations.

Text *(on page 106)*

Use the Text blocks to create and perform operations on strings of text.

Lists *(on page 110)*

Use the List block to create an ordered collection of strings (text) or numbers.

Variables *(on page 113)*

Use the Variable blocks to store a value that can be referred to later.

Functions *(on page 116)*

Use the Function blocks to create functions that are used to structure specific tasks.

Hardware *(on page 120)*

Use the Hardware blocks to interact with PASCO sensors and accessories.

Code Output *(on page 123)*

Use the Code Output blocks to provide text or numeric output in a Digits *(on page 61)* or Table *(on page 57)* display.

Time *(on page 126)*

Use the Time blocks to pause code or get a timestamp from when the program was started.

Notes *(on page 130)*

Use the Notes blocks to add comments to your code that are ignored by your program. Insert a single note between blocks or associate a note with a group of blocks.

3 **Lua Code Viewer**

The editor provides a graphical interface for creating programs using the Lua programming language. Click the Lua tab to view (but not edit) what the program looks like in text-based code to help with debugging.

4　**Code Tools**

- [Import](#) *(on page 137)* code from a .pcbx file.

- [Export](#) *(on page 136)* all code as a .pcbx file for importing into other SPARKvue or Capstone files.

- Delete all code on the workspace.

5　**Workspace Tools**

- Center the code on the workspace.

- Zoom in on the workspace.

- Zoom out of the workspace.

- Delete blocks by dragging them to the trash can. Click the trash can to retrieve deleted blocks.

6　**Workspace**

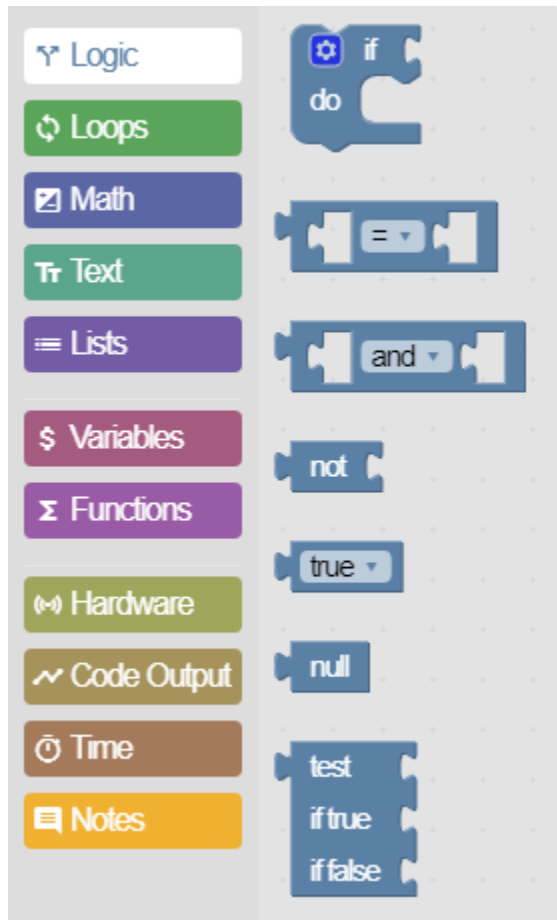Drag blocks to the workspace to create a program.

Blockly Toolbox

Learn how to use the blocks available in each Blockly Toolbox category.

Logic

Use the Logic blocks to create if-then statements and comparison operations.


If Statement Block

An **if** statement will do some statements if a value is true. An **else if** and **else** statement can be added to the **if** block by clicking .

The **else if** statement gets checked if the first **if** statement fails. If all the **else if** statements fail, then the else statement is performed.
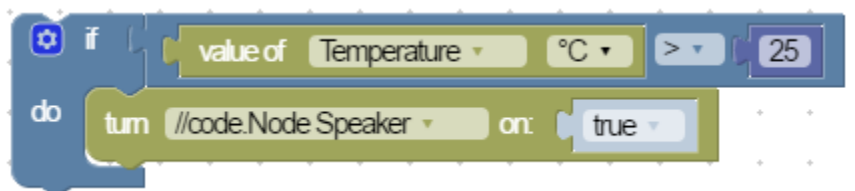
If Statement with the Comparator Block

The comparator block returns true or false based on the comparison being done.
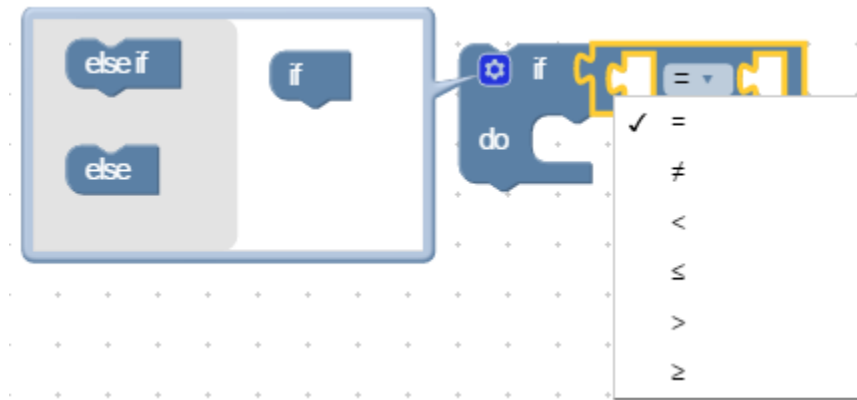
Possible comparisons include:
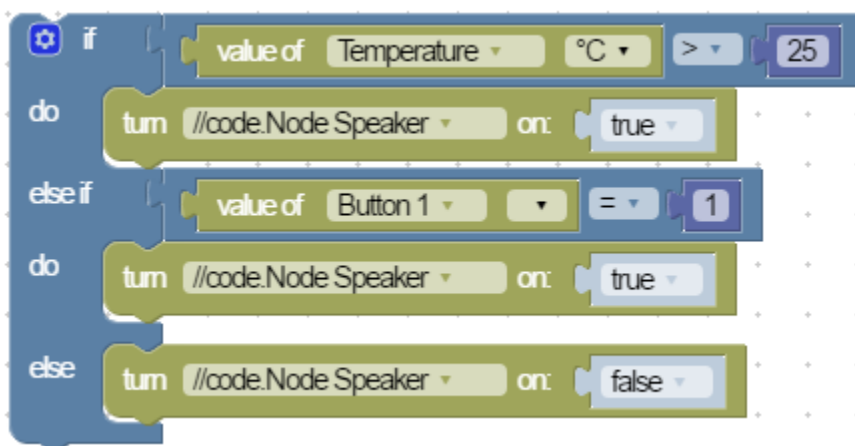
- Equal to (=)
- Not equal to (≠)
- Less than (<)
- Less than or equal to (≤)
- Greater than (>)
- Greater than or equal to (≥)

Example 1

In this example, if the temperature of a sensor is greater than 25 °C, the speaker will turn on.
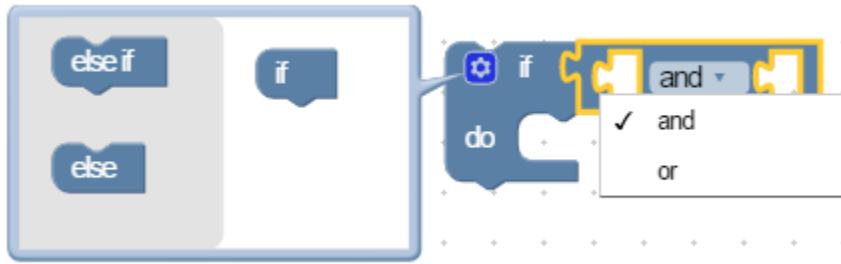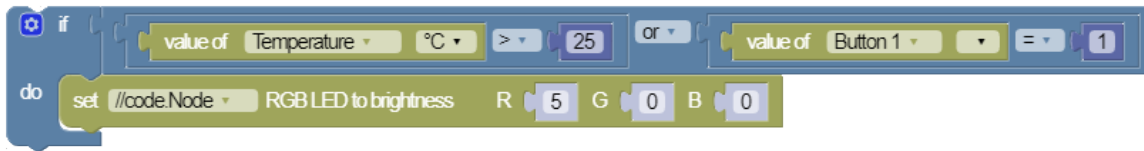
Example 2

This example uses **else if** and **else** statements. If the temperature is less than 25 °C but Button 1 is pressed, the speaker will still turn on. If neither scenario is true then the speaker will be turned off.

If Statement with the Comparator and Bitwise Block

The bitwise block returns true or false based on whether two statements are both true (and) or if at least one of the statements is true (or).

Example 3

In this example, if the temperature of a sensor is greater than 25 °C *or* Button 1 is pressed, the red (R) LED will turn on.
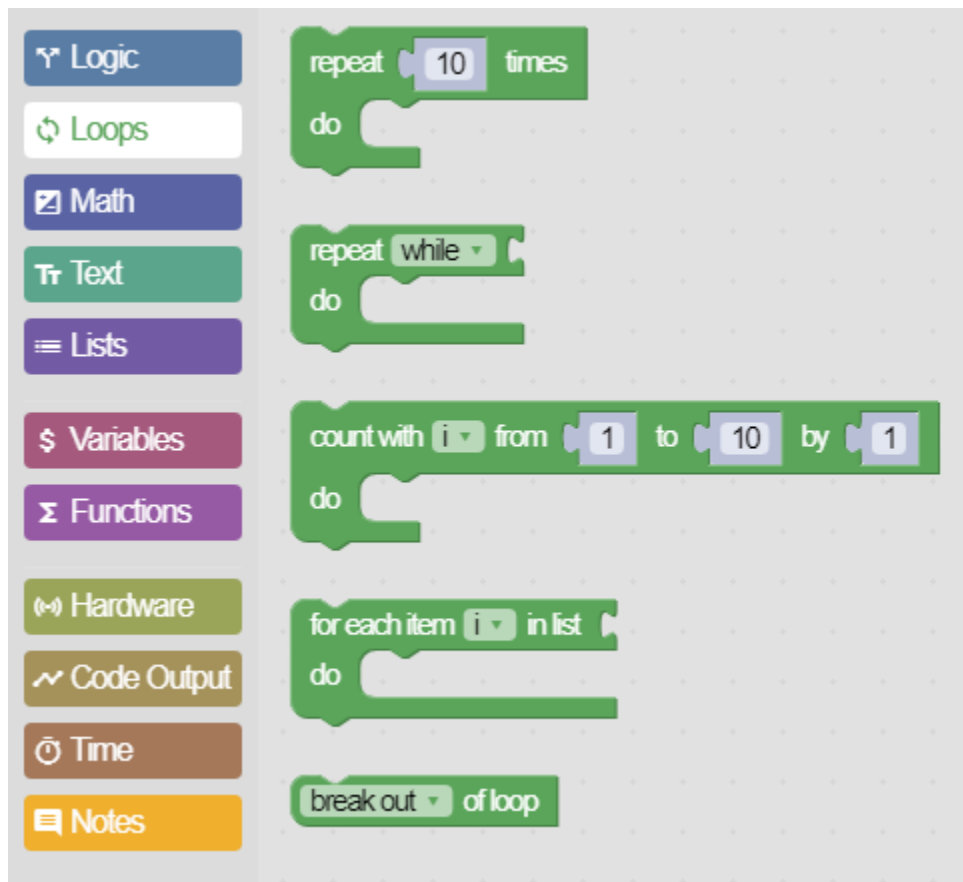
Example 4

Adding to Example 3, if the temperature is less than 20 °C *or* Button 2 is pressed, the blue (B) LED will turn on. Otherwise, all the LEDs will turn off.
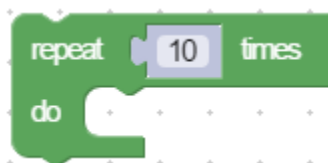
Loops

Use the loop blocks to control the number of times lines of code are executed.

Repeat [number of] times

This block repeats code a specified number of times.

Example 1

In this example, the //code.Node speaker is set to play 16 random frequencies for 0.5 seconds each.

Conditional Repeat

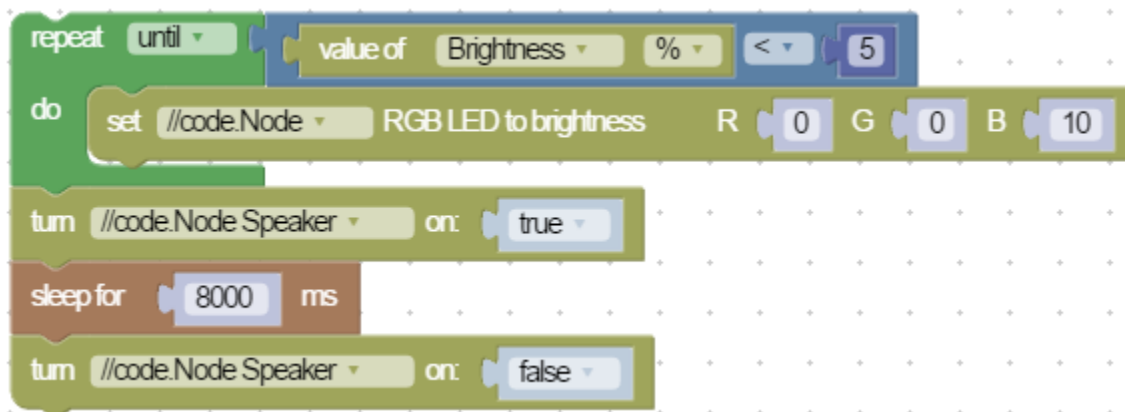The block repeats a task *while* a condition is valid or *until* a condition is met.

Example 2: *While* Loop

A while loop continues as long as a condition is valid. In this example we will keep the LED set to cyan until the program is stopped.

Example 3: *Until* Loop

The until statement keeps looping until a condition is met. In this example the loop is keeping the blue LED on. If the light sensor detects darkness, the loop will stop and turn the speaker on for 8 seconds.
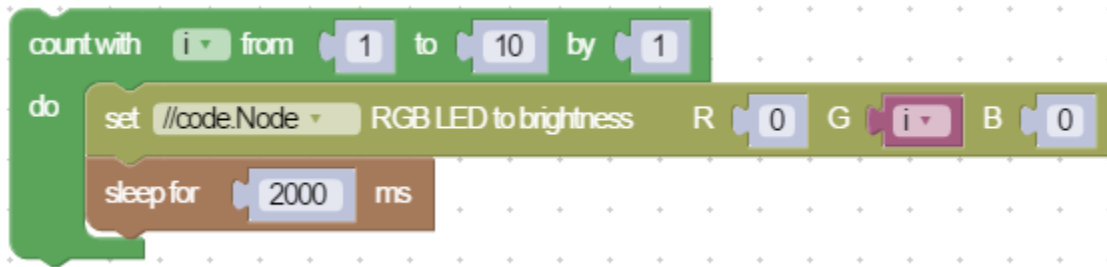
Counting Loop

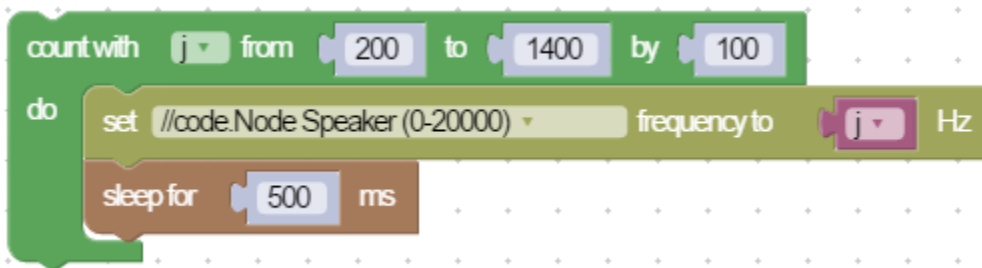This block counts up at a specified integer until the range limit is reached.

Example 4

This loop will initially set the green LED's brightness to 1 and increment by 1 until 10 is reached. The LED will stay at each brightness level for 2 seconds.
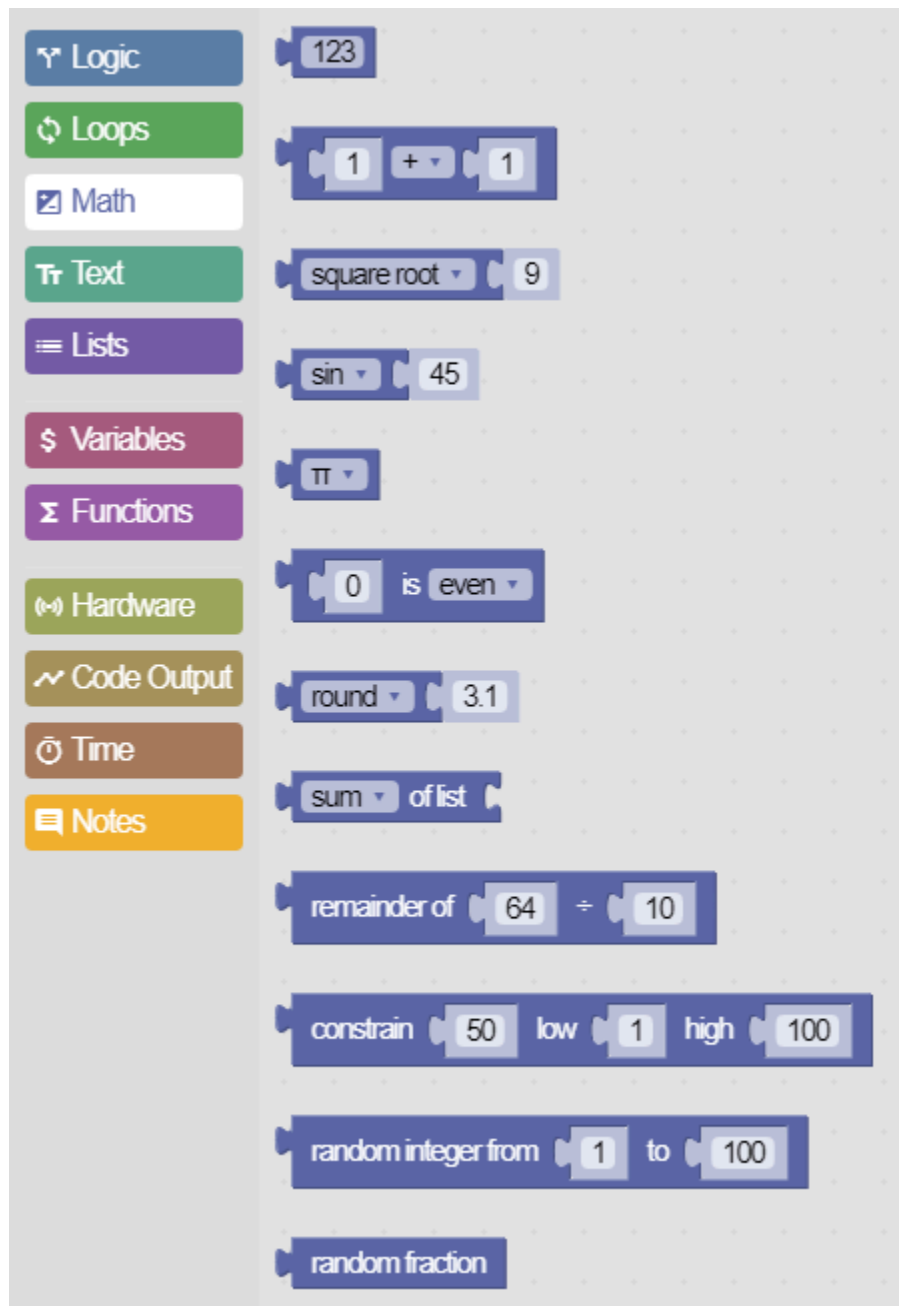
Example 5

This loop will start the speaker at a frequency of 200 Hz and in increase by 100 Hz until the loop reaches 1400 Hz. Each frequency will be played for 0.5 seconds.
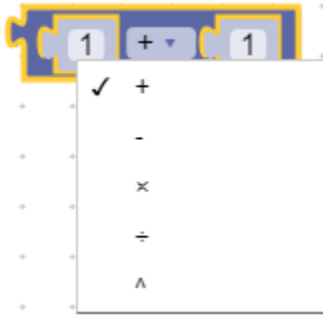
Math

Use the Math blocks to include numbers in code and perform mathematical operations.


Basic Math

Basic Operators

Use this block to perform basic mathematical operations on two numbers and return the result. Available operations include addition, subtraction, multiplication, division, and exponents.

Remainder

This block returns the remainder from dividing two numbers. For example, the block shown above would return a value of 4.
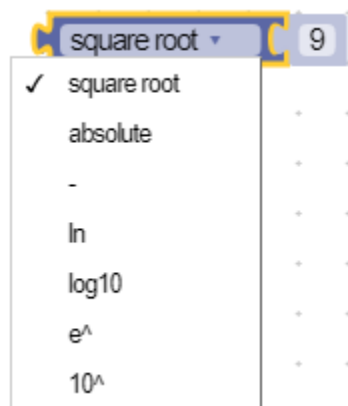
Common Constants
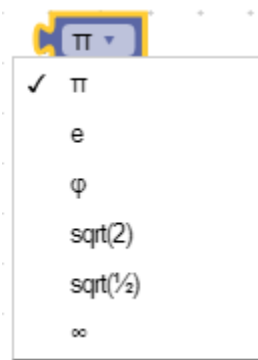
Use this block to return the value of a common constant including pi, natural exponent, golden ratio, square root of 2, square root of ½, and infinity.
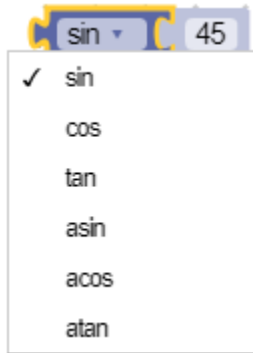
# Functions

Scientific Functions

Use this block to performs a function on a single number and return the result. Available function include square root, absolute value, inverse, natural logarithm, base 10 logarithm, exponential, and power of 10.

Trigonometric Functions

Use this block perform a trigonometric function on a single number in *degrees* and return the result. Available functions include sine, cosine, tangent, arcsine, arccosine, and arctangent.

Rounding Functions
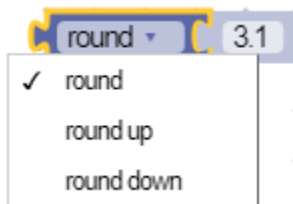
Use this block to round numbers to the nearest integer and return the result. Available options include:

- `round`: Round down for decimals less than 0.5, round up for decimals greater than 0.5.
- `round up`: Always round up the number regardless of the decimal value.
- `round down`: Always round down the number regardless of the decimal value.

Statistical Functions
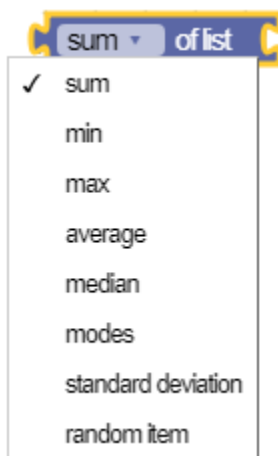
Use this block to calculate statistics on two or more numbers and return the result. Unlike the other blocks in the Math group, this block requires a list *(on page 110)* of numbers instead of a single number. Available options include:

- `sum`: Add together all numbers in the list.
- `min`: Return the smallest number in the list.
- `max`: Return the largest number in the list.
- `average`: Return the mean of the numbers in the list.
- `median`: Return "the middle" value in the list.
- `mode`: Return the value(s) that appears most often in the list.
- `standard deviation`: Return the standard deviation of the numbers in the list.
- `random item`: Return a random number in the list.
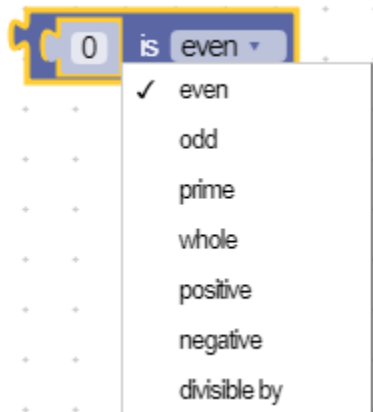
Random Numbers

Random Integer

This block returns an random integer between the two specified numbers.

Random Fraction

This block returns a random decimal between 0 and 1.0.

Check a Number

Use this block to check the type of number and return a value of `true` or `false`. The block can check if a number is even, odd, prime, whole, positive, negative, or divisible by a given number.
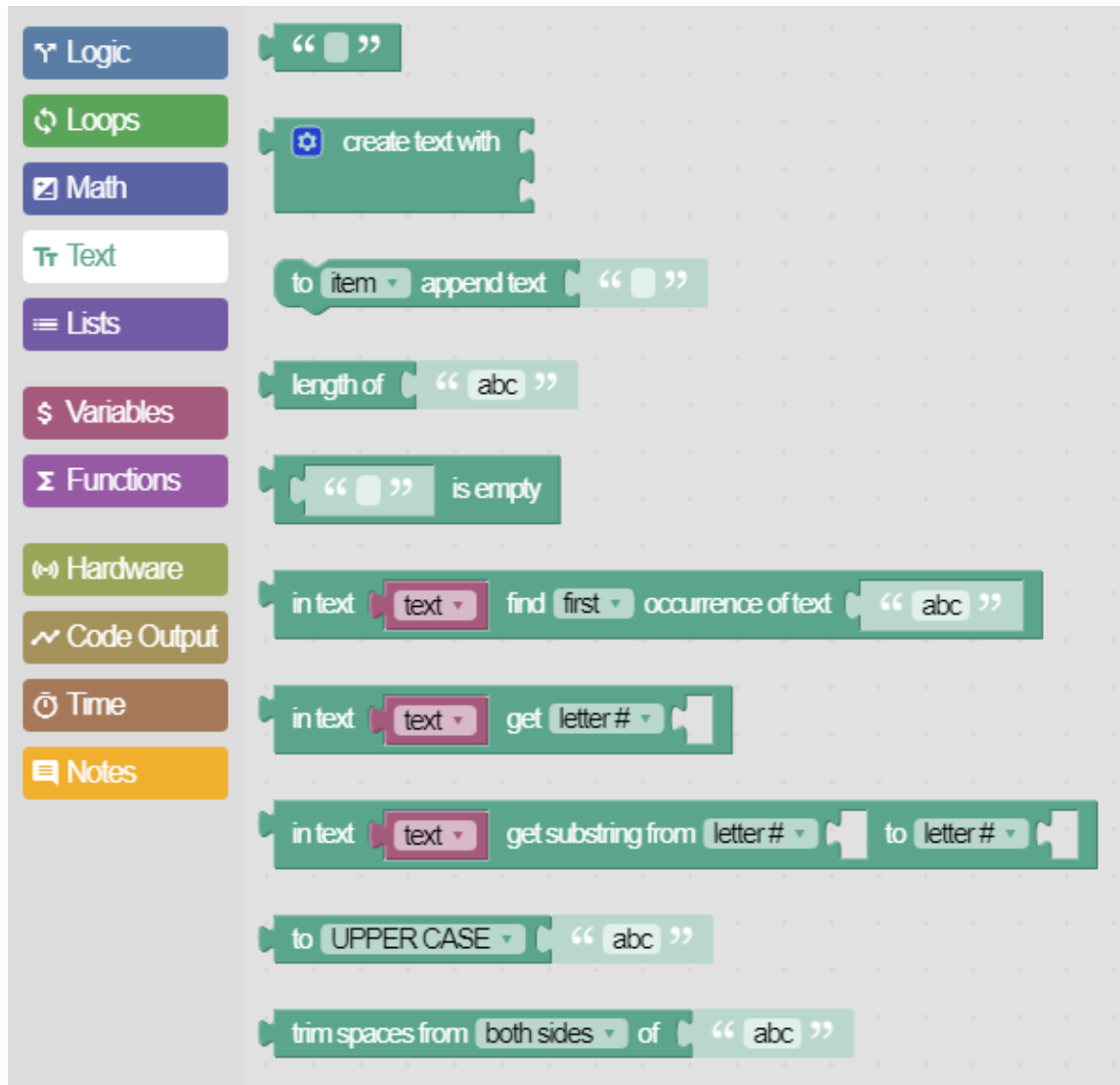
Constrain a Number

This block returns a number that is constrained between two specified values. If the number is higher than the specified high number, the block will return the high number. If the number is lower than the specified low number, the block will return the low number.

Text

Use the Text blocks to create and perform operations on strings of text.

Example 1

In this example, the first line sets the variable *(on page 113)* `myName` to the string "Paul". The second line displays a text output *(on page 123)* as the first letter of `myName` in a digits display.
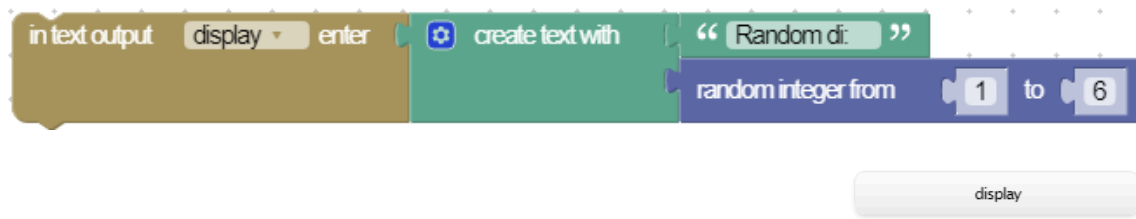
Example 2

This example uses an append block that adds text onto an existing text variable. We set our initial variable `myName` to "Paul" and later appended " Stokstad" (note the space added at the beginning of the string). We then display the full name into our `fullName` Text Output block.
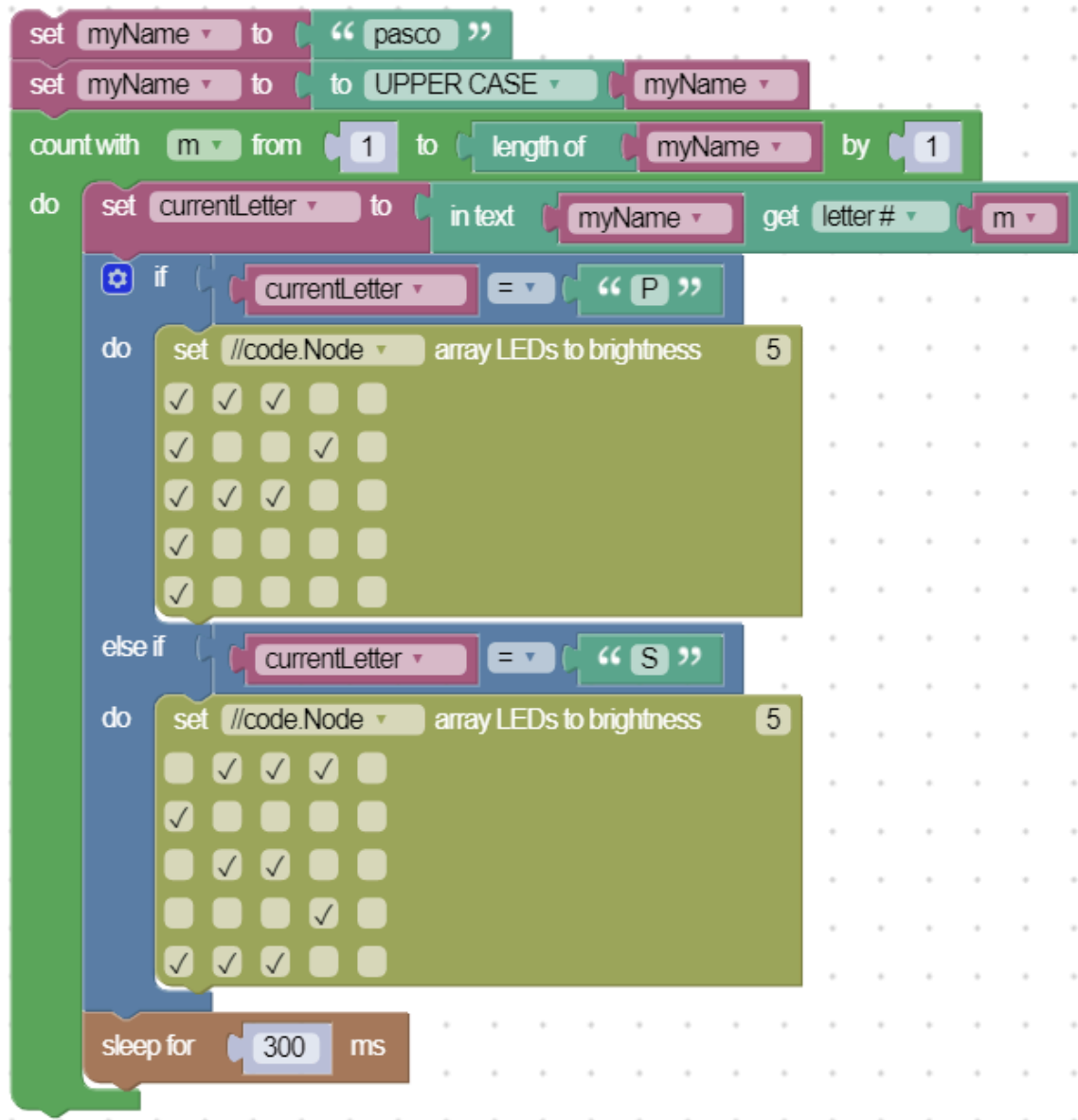
Example 3

The **create text with** block joins together text from two or more blocks. In this example, the string "Random di: " is joined with the **random integer** math *(on page 102)* block which displays a random number between 1 and 6.
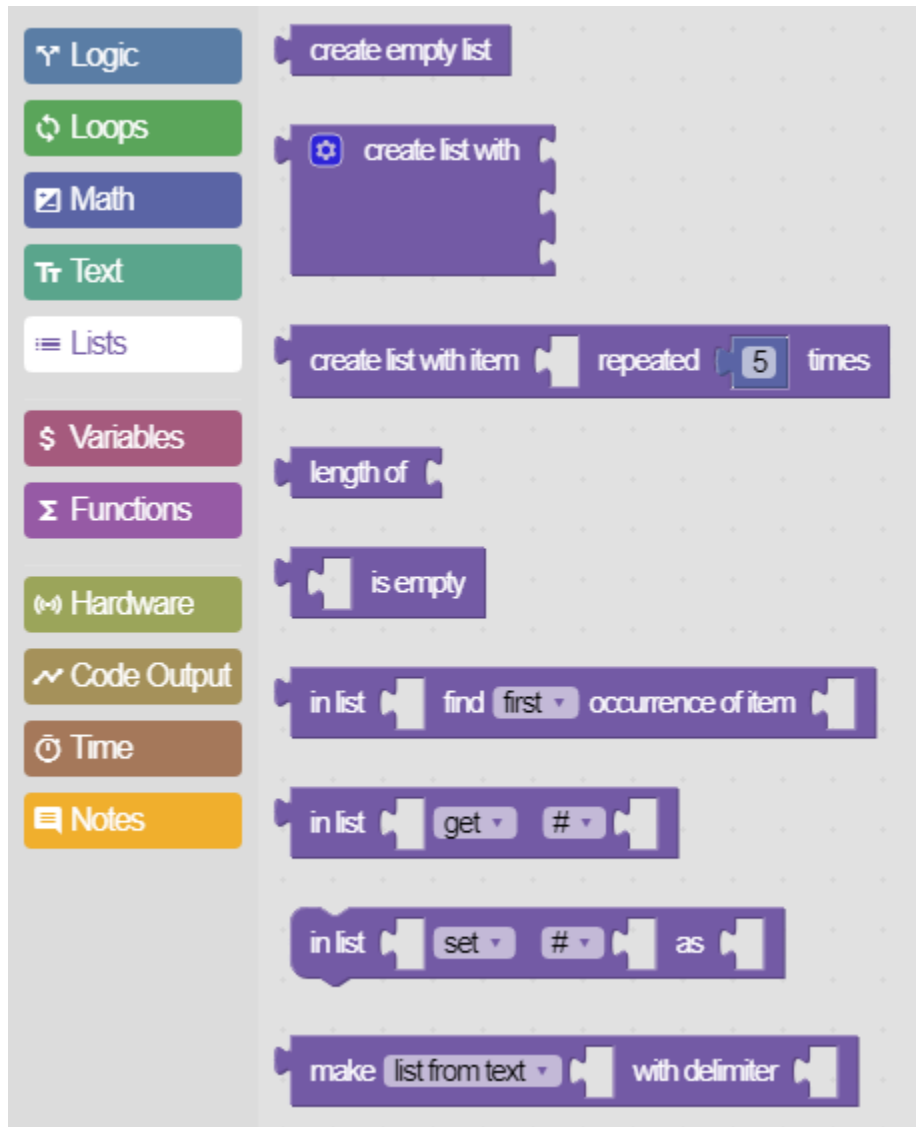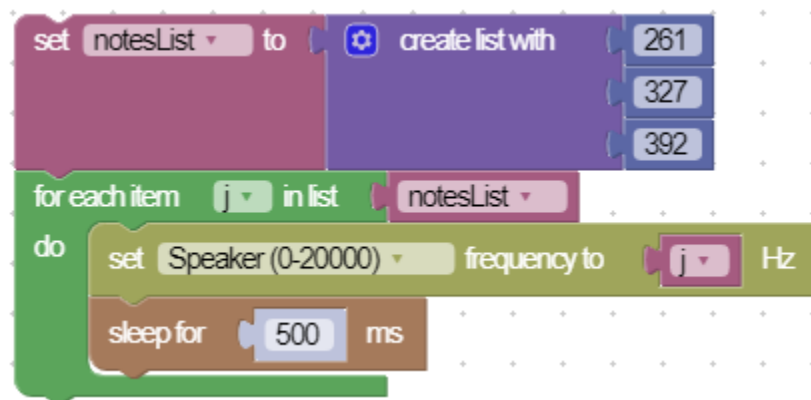
Example 4

In this example the string "pasco" is changed to uppercase and displays the letters "P" and "S" on the //code.Node LED array.

Lists

Use the List block to create an ordered collection of strings (text) or numbers.

Example 1

A variable called `notesList` is set to a list of three different numbers. These numbers are then used to set the speaker frequency of the //code.Node where they are played one at a time every 0.5 seconds.

Example 2

Lists can be created from a string. In this example, a list of numbers is created by separating them with a comma, which acts as the delimiter. The end result is that the //code.Node speaker outputs the frequencies of 261, 327, 418, and 192.
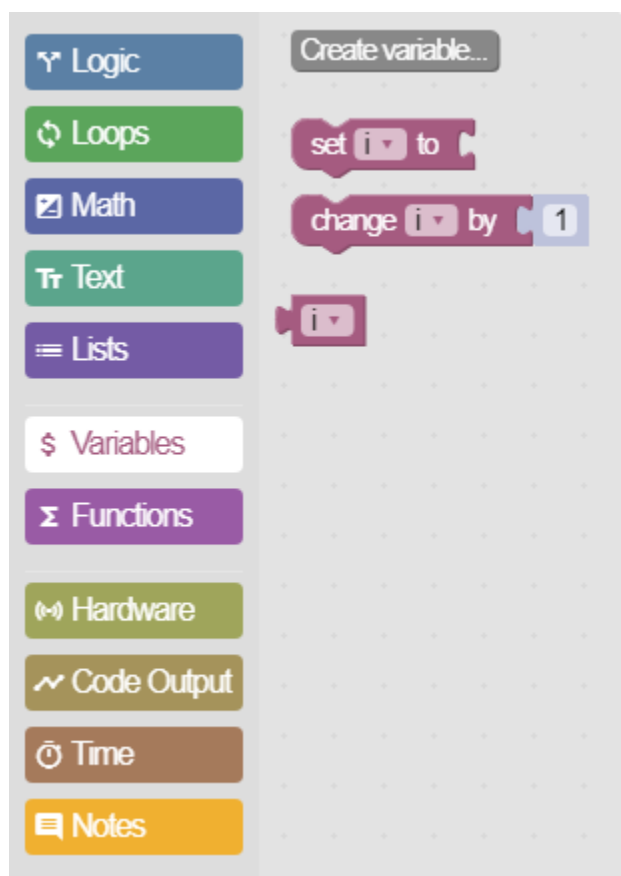
Example 3

A variable can be set from a list of numbers one value at a time. In this example, a variable is set to a list containing three different integers. In the loop, the //code.Node speaker is set to play the frequencies of the #1 and #3 values in the list, change the first and last values of the list (which happen to be #1 and 3), and play those values again. The speaker output will sound different than the first round because we changed the frequencies after going through the loop one time.

The end result is that the //code.Node speaker outputs the frequencies 261, 418, 491, and 182, each for 0.1 seconds.
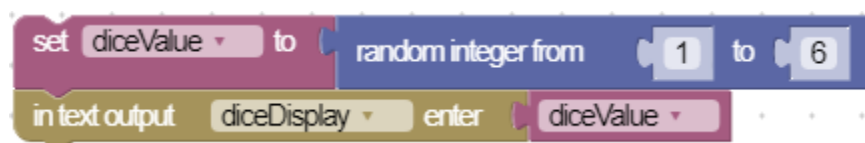
Variables

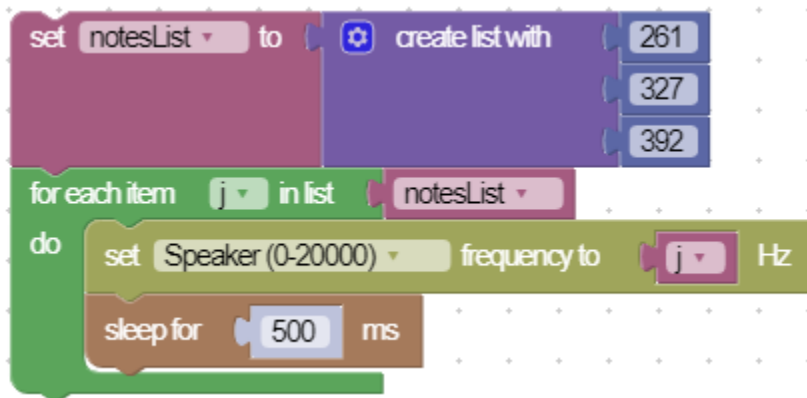Use the Variable blocks to store a value that can be referred to later.
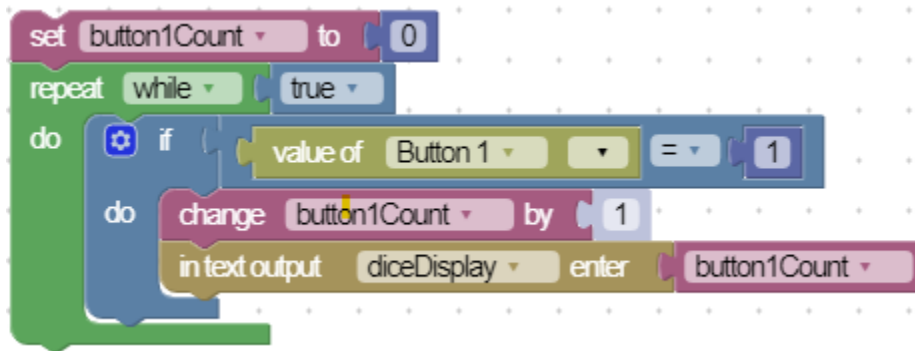

Example 1

4

In this example, the variable called `diceValue` is created and is set to a random number between 1 and 6. The value of `diceValue` is then displayed in a text output called `diceDisplay`. The text output is viewed using a Digits display.

Example 2

This example contains two variables. The first variable is called `notesList` which stores a list of numbers. The second variable is called `j` which is defined as the item in each list. The first time the loop circles through, `j` is 261, the second time it is 327 and the third it is 392.

Example 3

If a variable is a number, the **change by** block can be used to increase or decrease the value of the variable. In this example, the variable `button1Count` increases by 1 each time Button 1 on the //code.Node is pressed.
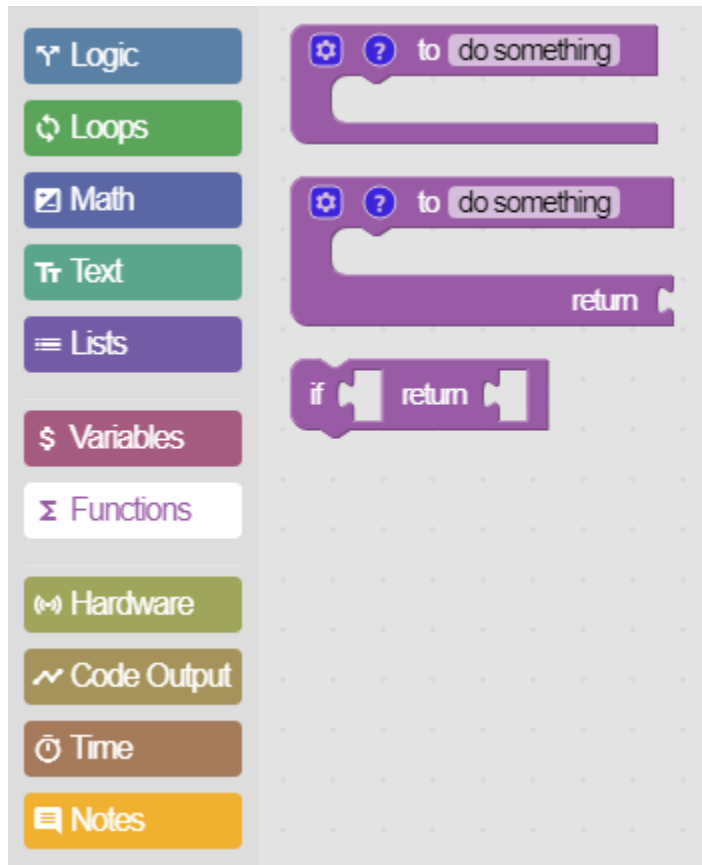
> **Note:**
> The value of `button1Count` is set to 0 at the beginning of the code. Blockly does not assume that a variable starts at 0.
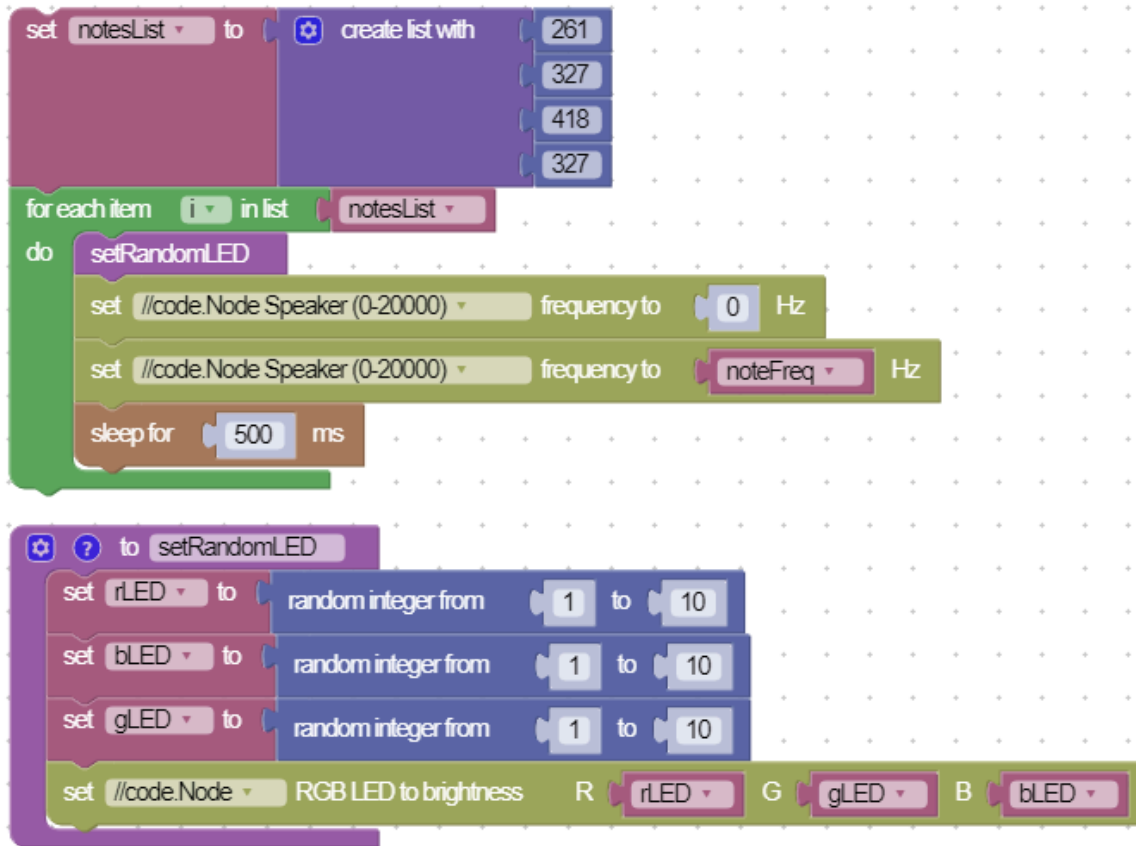
Functions

Use the Function blocks to create functions that are used to structure specific tasks.
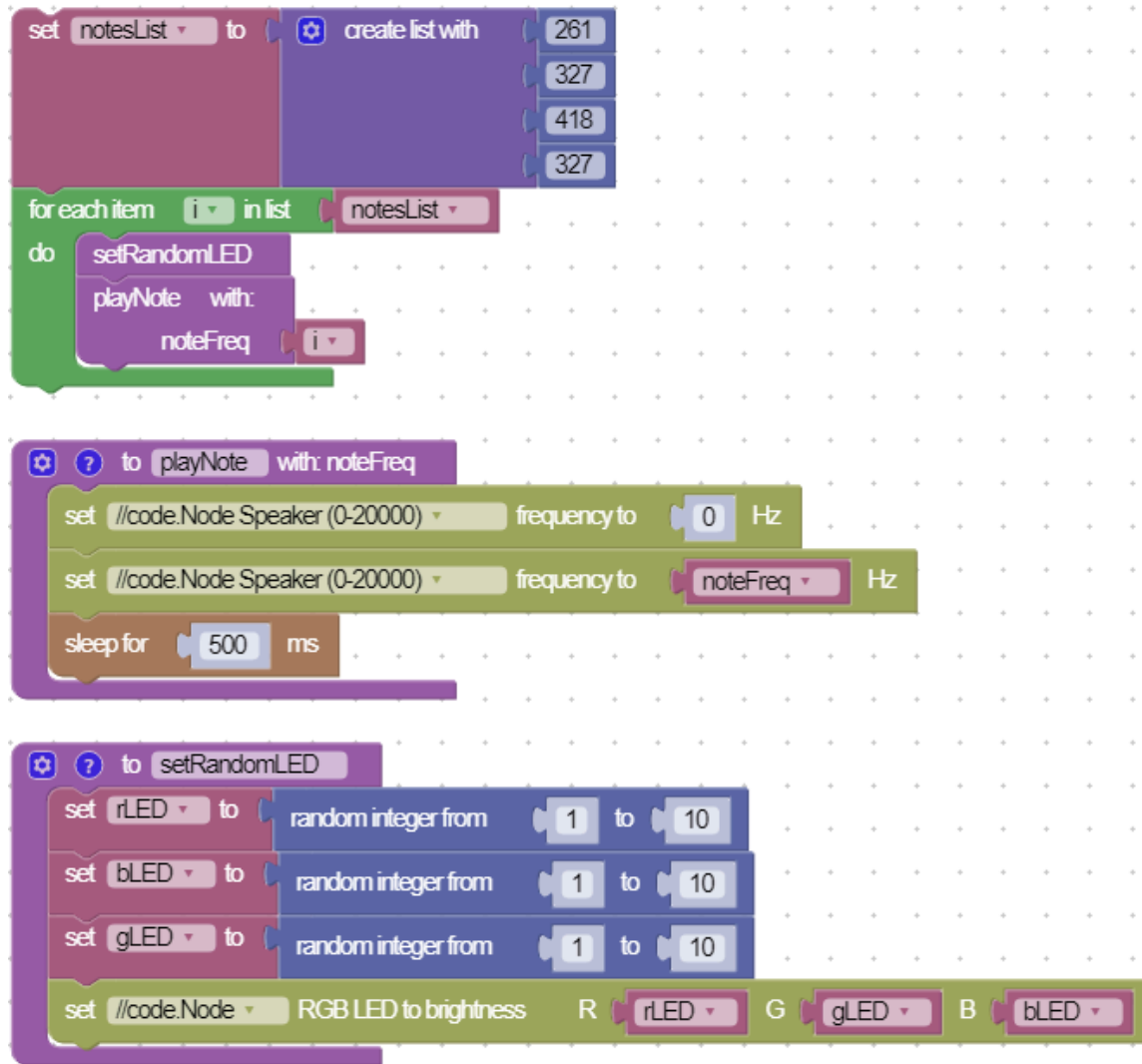
Example 1: Simple function

Functions are used to store repeatable tasks and make code easier to read. In this example, we have a function named `setRandomLED` that sets the //code.Node RGB LED to a random color. By putting this code in a separate function our main code block is easier to read.

Example 2: Passing variables into a function

Example 1 can be taken a step further by also creating a function to play a musical note. In order to play a note, a value needs to be placed in the function so the program knows which note to play. This is accomplished by selecting properties ⚙ on the function block and adding the **input name** block to the function.

In the loop, the note that is to be played is stored in the `i` variable which gets its value from the `notesList` variable. A function called `playNote` is created which takes an input called `noteFreq`. The `i` variable is passed into this function. The function turns off the speaker (if it is running) and plays each note in the list for 0.5 seconds.

Example 3: Returning values from a function

Functions can also return a value. In this example, a function called `getNoteFrequency` looks up a character `i` from the `notesList` list and returns the note letter's frequency. This value is then set to `noteFreq`, which is passed into the `playNote` function to play the note.

Hardware

Use the Hardware blocks to interact with PASCO sensors and accessories.

Reading Sensor Values

The **value of** block is used to read a measurement from a sensor. In this example a //code.Node is connected providing the option to select any of its measurements from the list.

//code.Node Speaker

Two blocks are available to control the speaker on a //code.Node. One block sets the speaker frequency and the other simply turns it on (`true`) or off (`false`). You can also turn off the speaker by setting the frequency to 0.
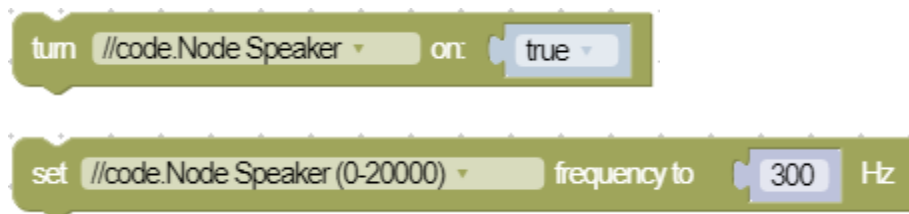
Signal Generator

The same blocks used to control the //code.Node speaker can be used to control the signal generator on the 850 Universal Interface, 550 Universal Interface, and the Wireless AC/DC Module. Two additional blocks allow you to set the signal generator waveform and voltage.

In this example, the Wireless AC/DC Module is set to output a square wave with an amplitude of 2 V and a frequency of 1000 Hz.
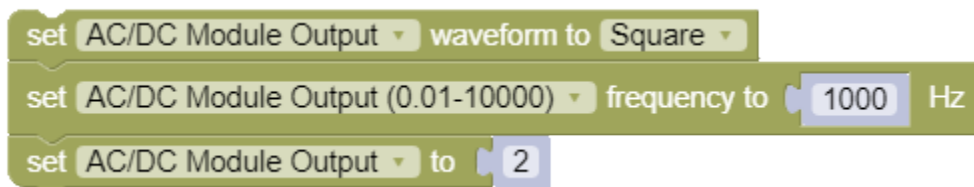
Zero Measurements

The **zero sensor** block is used to zero a measurement of a sensor.

//code.Node LED Array

Three blocks are available to set the brightness of each LED in of the //code.Node LED array. The brightness of each LED set on a scale from 0 to 10. An LED in the array is identified by its x and y coordinate. The top left of the array is defined as the origin (0,0). The x coordinate corresponds to the horizontal direction and the y coordinate corresponds to the vertical direction.

The following block sets the brightness of a single LED on the array.

The next block sets the brightness of a group of LEDs. The coordinate of each LED is defined by two consecutive numbers, where the first number is the x coordinate and the second number is the y coordinate. Each LED listed is separated by a space. In the following example, a diagonal line is formed in the center of the array from the top left to bottom right.

The third block sets each LED by selecting a box. This example draws a happy face.
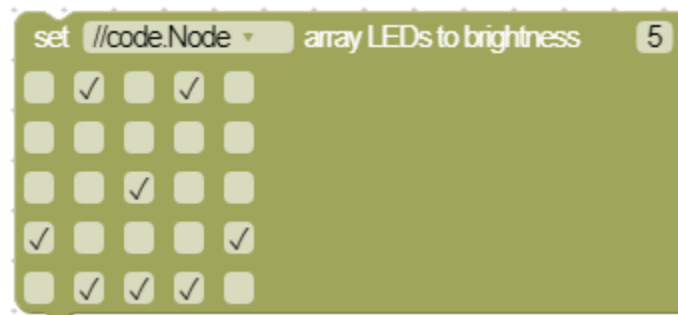
//code.Node RGB LED

The color of the //code.Node RGB LED can be controlled by setting the brightness of the red (R), green (G), and blue (B) LEDs.
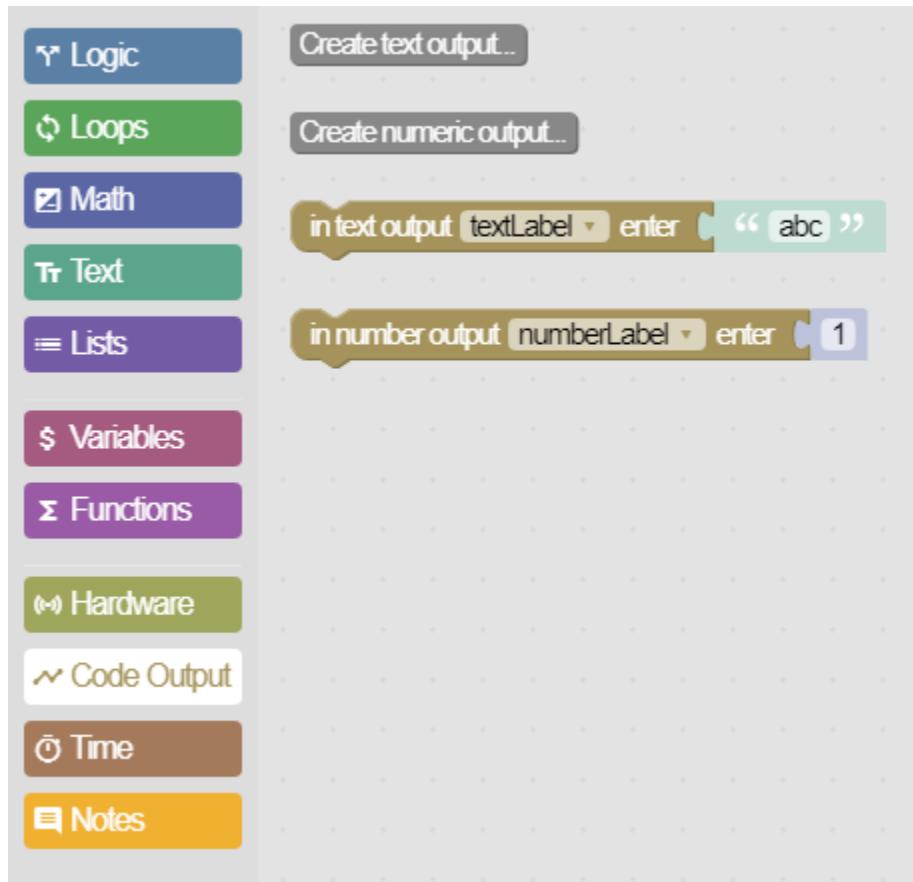

Smart Cart Ballistic Cart Accessory

The release of a projectile from the Smart Ballistic Cart Accessory can be controlled using the **release projectile** block.

Code Output

Use the Code Output blocks to provide text or numeric output in a Digits *(on page 61)* or Table *(on page 57)* display.

Text Output

This block outputs a string of text.

Numeric Output

This block outputs a numeric value, such as a sensor measurement.

Create a Text Output

1. Click the **Create text output...** button, enter a name for the output, and click **OK**.
2. Close the Code tool.
3. Double click **1.23** to add a Digits display to the screen.
4. Click **Select Measurement** then select the name of the text output under **Code Output Data.**

Example 1: Displaying Text Versus Numbers

This example contains two Digits displays with one showing text output and the other shown numeric output.
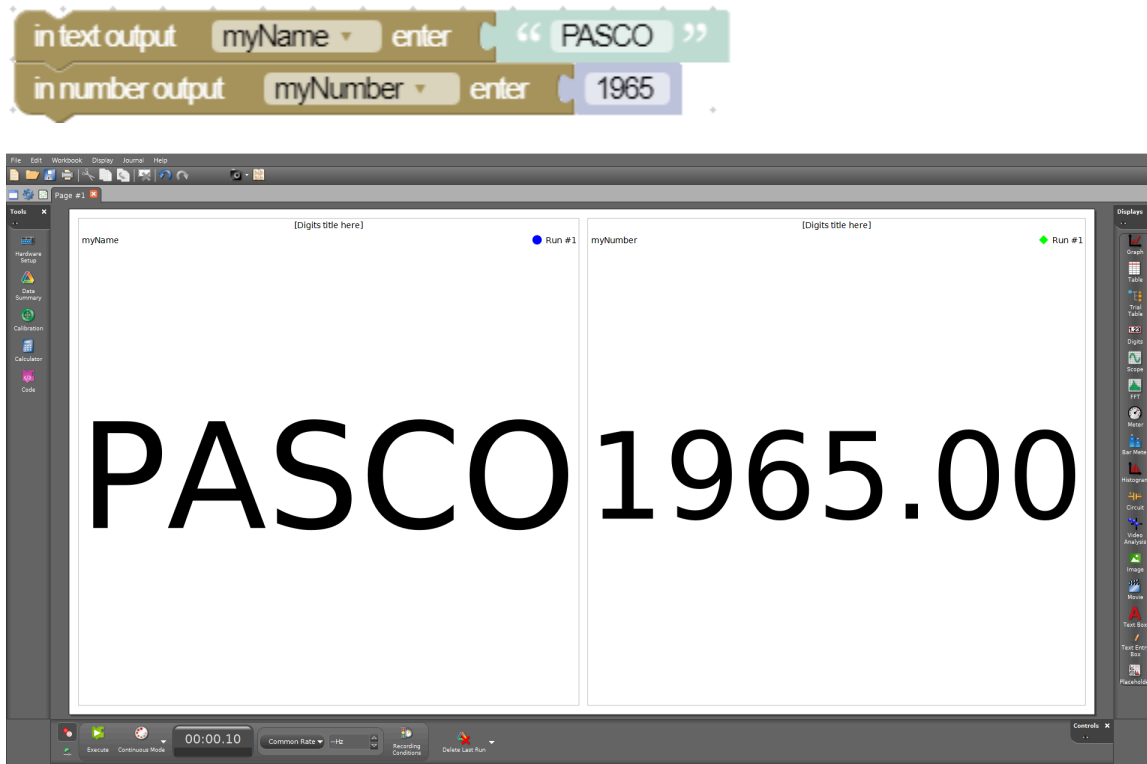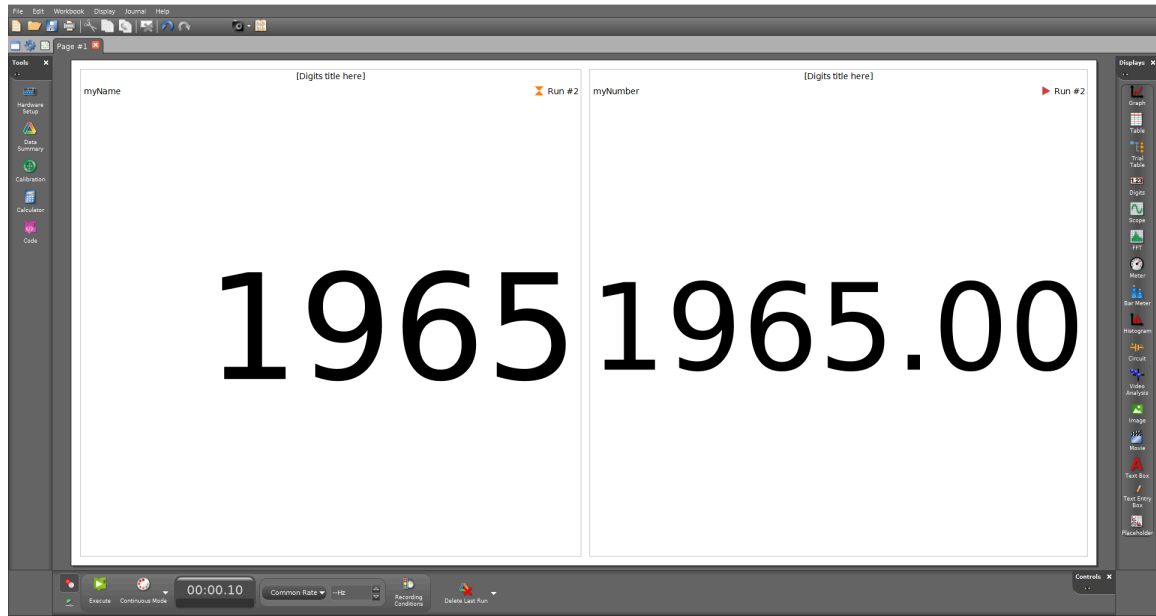

Example 2: Displaying Numbers in Text Output

It is possible to display numbers in text output. However, the numbers will be interpreted as a string of text instead of a quantity of measurement, which means that mathematical operations cannot be applied on the output. When showing a number, you can see the difference between a text and number display.
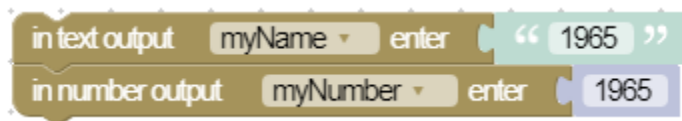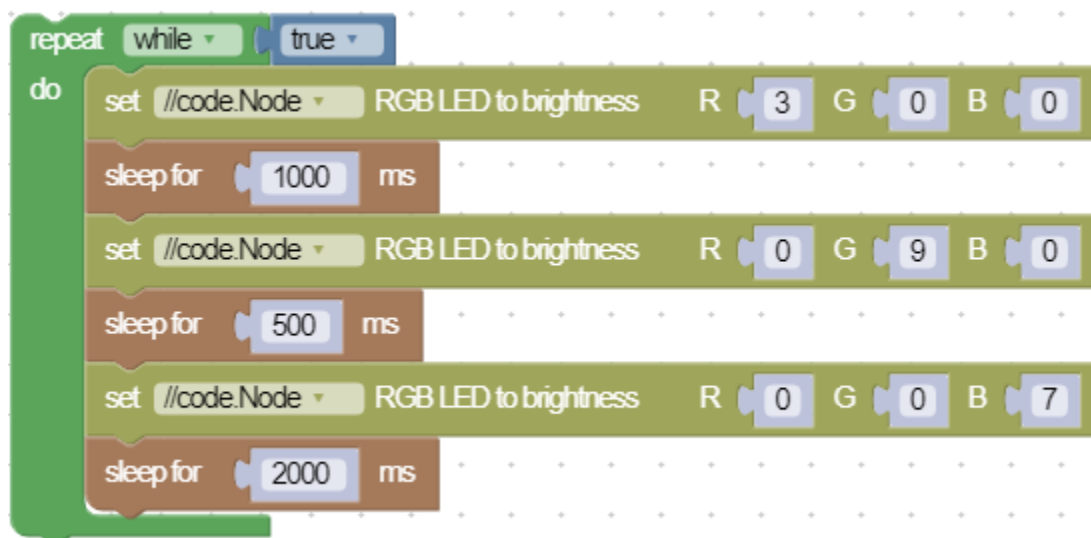
Time

Use the Time blocks to pause code or get a timestamp from when the program was started.

Example 1: Using Sleep Blocks

Sleep blocks pause the code for a designated amount of time. In this example, the red LED is turned on for one second, then the blue LED is turned on for a half second, and finally the green LED is turned on for two seconds. Note that when a program is sleeping it is not performing any other task.

Example 2: Sleep Block Causing an Error
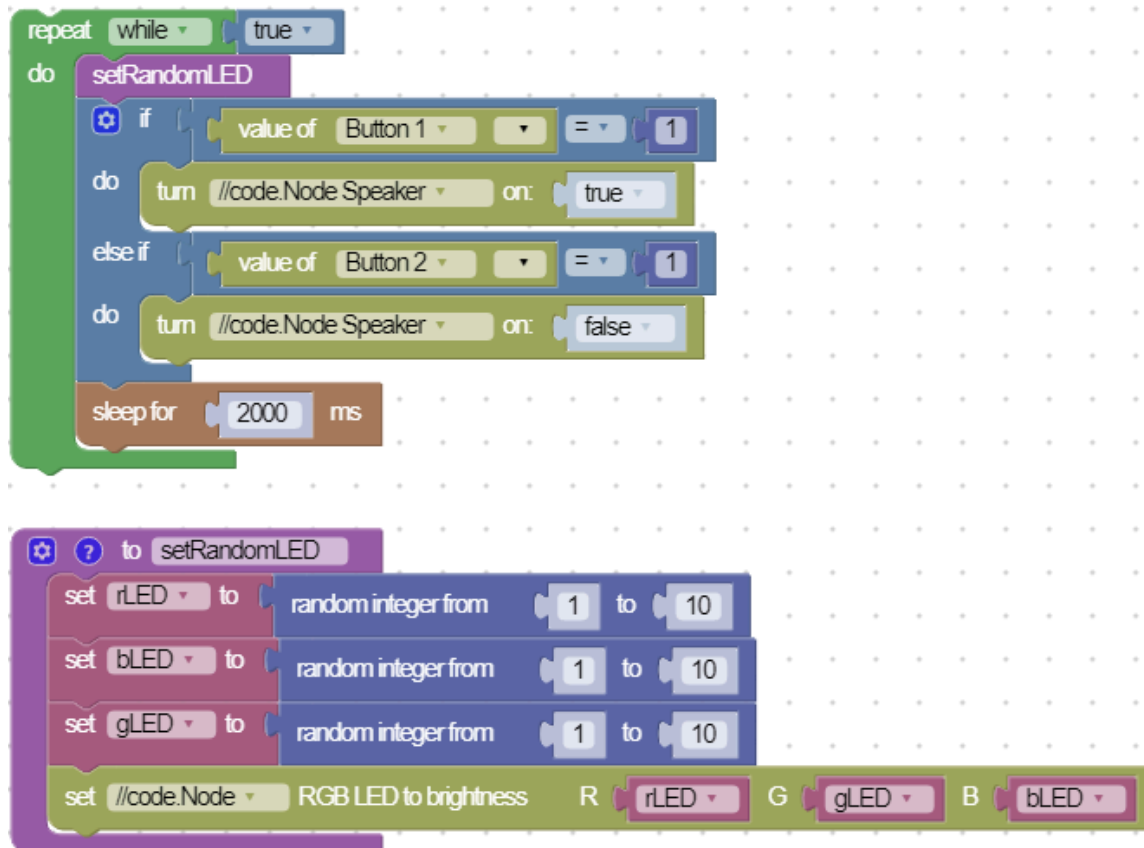
Say we want to change the //code.Node RGB LED color every two seconds and also turn the //code.Node speaker on or off by using the //code.Node buttons. In this example, if Button 1 is pressed, the speaker may or may not turn on. This is because the code only checks the button state *after* every two seconds (when the LED changes). If the button is not pressed down during that check then the code will not turn on the speaker. To get the speaker to turn on Button 1 must be pressed and *held* so that when the LED changes the state of Button 1 state will be `true`. To turn the speaker off, we must press and hold Button 2 so that it is held down the same time the LED changes.

> **ⓘ Tip:**
> See Example 4 *(on page 128)* for a method to fix this problem.

Example 3: Getting the Instantaneous Time

We can use the **get time in ms** block to get a timestamp of when an event happens. In our example we can use the block to determine how long it takes for the temperature to reach 25 °C. The time can be displayed using the **number output** block from the Code Output *(on page 123)* group.

Example 4: Perform Synchronous Functions

We can use the **get time in ms** block if we want tasks to happen every *x* amount of seconds . In this example, we set a variable `timeCheck` to the time stamp at the start of the program. We then use an if statement that has a

condition where `timeCheck` will be set to the current time stamp every two seconds and also run the `setRandomLED` function . At the same time, a separate conditional statement is set so that the //code.Node speaker will turn on by pressing Button 1 or turn it off by pressing Button 2. The loop does not have to stop before turning the speaker on or off. This does not work with the sleep blocks as see in .

Notes

Use the Notes blocks to add comments to your code that are ignored by your program. Insert a single note between blocks or associate a note with a group of blocks.
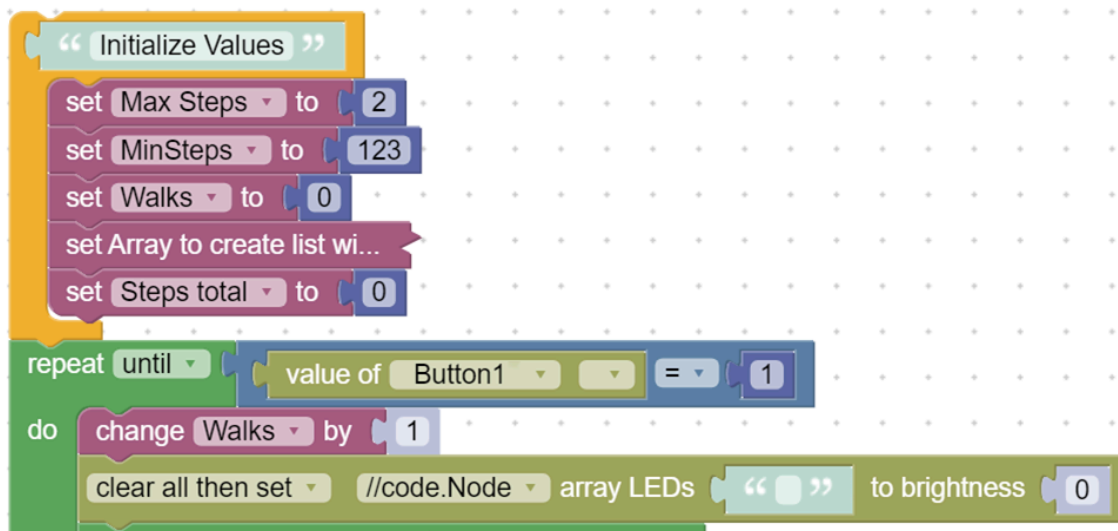

Single Line Notes
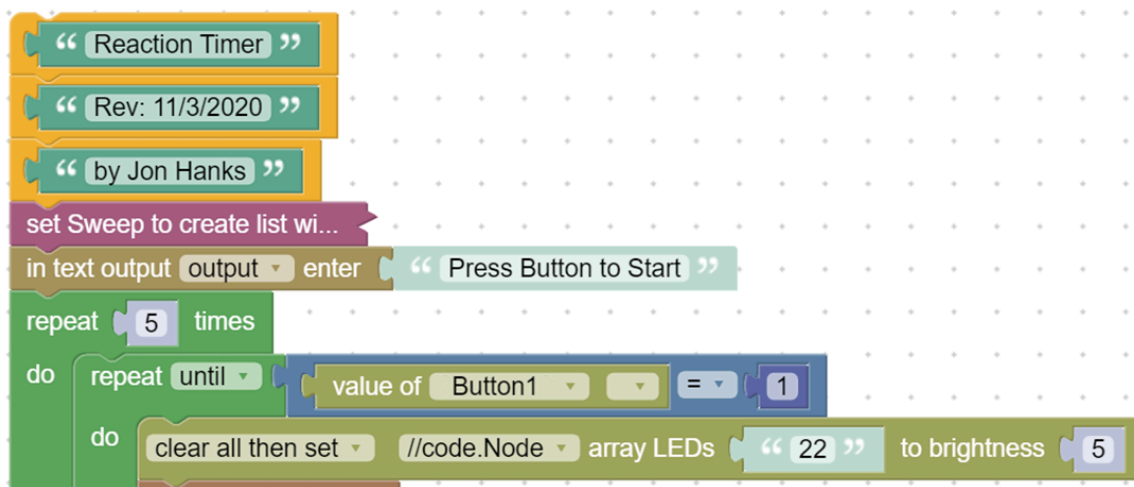
Single line notes are useful for adding comments to your code to help others understand how the code works. These blocks are also useful for adding metadata to your code such as the author name and revision date. You can add a single line note above or below a block.
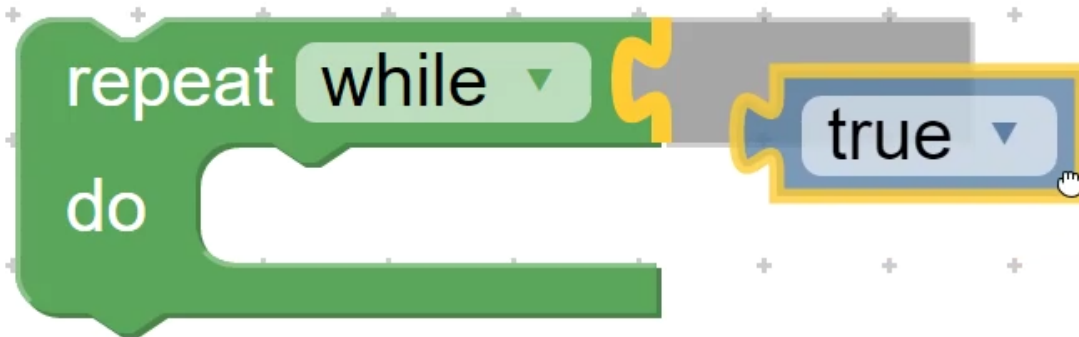
Block Group Notes

Block Group notes work like single line notes, except that you can associate multiple blocks with a note. Another useful feature of the block group note is being able to move a group of blocks by clicking and dragging the note block.

Build Code Using Blockly

Create programs by dragging and dropping blocks onto the Code tool workspace.

Build Code

The blocks are shaped like puzzle pieces to provide hints on how the blocks fit together. However, the blocks will only join together if the code is valid. To build a program:

1. Select a Block category from the menu.
2. Click and drag a block onto the workspace.
3. Click and drag a second block near an existing block until you silhouette of the block connecting to the existing block, then release.
4. Repeat this process for multiple blocks to build your program.

Modify Blocks

Some blocks contain features which allow you to modify the parameters of the block.

Properties

Allows you to modify the properties of a block. Click the icon to see the options.

Comments

Allows you to add a comment or note to a block. In order to get this to appear, right-click (or press and hold) on the block and select Add Comment.

Drop-down Menu

Some blocks have a drop down menu to change the behavior of the block. Click the down arrow to see the list of selections.
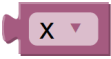
Enter a Numeric Value

Blocks that look like this allow you to enter numeric values. Click on the block and enter the desired value.

Enter a Text String

These blocks are used for text strings. Click the blank space and enter in any alphanumeric character.

Variables X ▾

A magenta block with a drop down menu represents variables. Click the menu to select a different variable, rename the variable, or define a new variable.

Delete Blocks

Delete a single block or a group of blocks by dragging and dropping the blocks to the workspace trash �. Click the trash to retrieve previously deleted blocks.

Delete all the blocks on the screen by clicking the trash button 🗑 .

Disable Blocks

Disabling blocks can be useful when you want to test your code by removing blocks from the code without permanently deleting them. To disable blocks, right-click on the block then select Disable Block.

Run a Program

Execute a Blockly program created in the Code tool.

To run a program, click ⬤ .

When sensors are connected to Capstone, code is executed while recording data. Data recording will automatically stop once Capstone reaches the end of the program code. You can also stop the code by clicking ◻ .

> **Note:**
> If sensors are not connected, the Record ⬤ button changes to Execute ▶. This provides the ability to run code without having sensors connected.

> **Tip:**
> If you do not want code to be executed during data collection, disable code execution by toggling the switch ⬤● at the top of the Code tool.

Import and Export Code

Import and export Blockly code to share between other SPARKvue or Capstone files.

A program created in the Code tool *(on page 92)* can be copied into another file by using the import ⬇ and export ⬆ tools at the top of the workspace. The Blockly code is exported as a .pcbx file which can be imported into a SPARKvue or Capstone file.
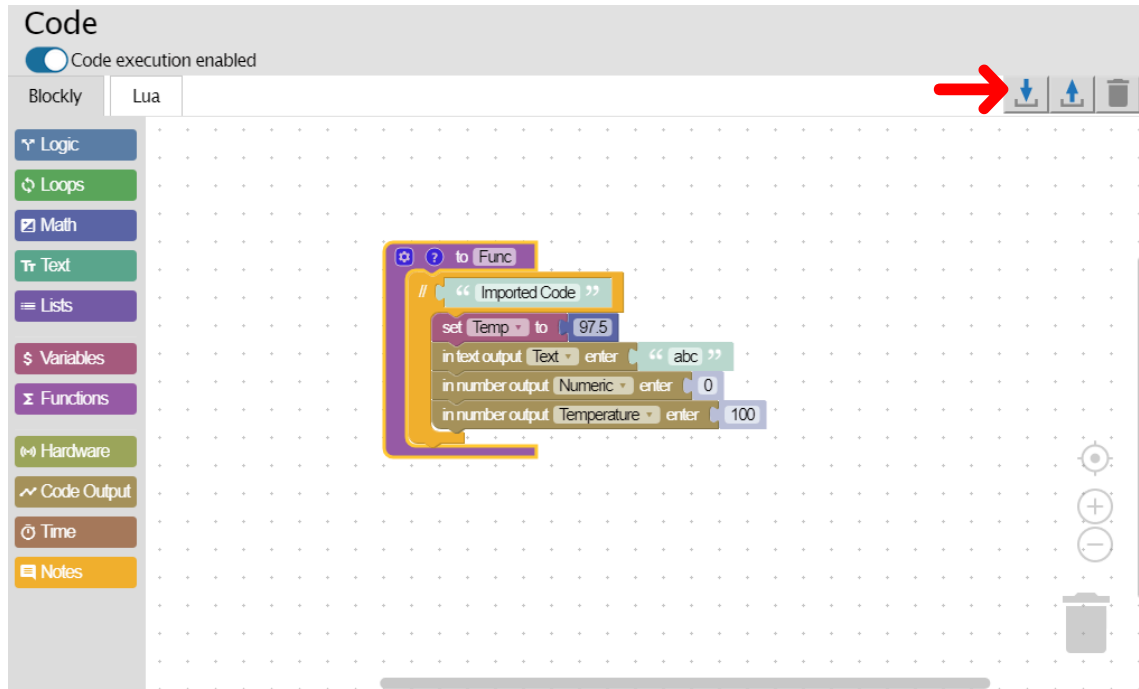
Export Code

1. Click the export tool at the top of the Blockly workspace.
2. Select the location where you want to save the file then click **Save**.

> **Note:**
> It is not possible to export the following types of measurements:
>
> - User-Entered Data
> - Calculation Data
> - Timer Data from Photogates
> - Video Analysis Data
> - Snapshot Data from Scope, FFT, and Histogram displays

Import Code

You can import code to a new file or to a file which already contains existing code. If the file contains existing code, the imported code will be added to the workspace as a separate group of code.

1. Click the import tool at the top of the Blockly workspace.
2. Navigate to the location of the .pcbx file you want to import and click **Open**.

> ✏️ **Note:**
> If you are importing code that contains a block with a name identical to a block in the existing file, the imported block will be renamed.