Hello there, and thanks for taking a look at Sphero and Education!

The lessons in the SPRK program teach math, physics, and computer science concepts using hands-on, engaging activities with Sphero, a robot ball. Students work in small groups to write computer programs that control how the Sphero rolls and appears. They are designed as lessons primarily for 4th and 5th graders that will take approximately one hour.

These lessons start with an introduction and then list the Common Core Math Standards that are relevant to the lessons. They contain a teacher guide, a worksheet for the students to fill out, and a student guide.

The CORE lessons cover:
• Math: Percentages, division, geometry, and patterns
• Physics: Speed, time, and distance
• Computer Science: Program flow, variables, conditionals, and reading sensors

What is Sphero?

Sphero is a robot ball with several features that can be controlled through mobile apps, including computer programs that the students build. The main features are:
• Rolling. The Sphero can roll at a given speed and heading for a given amount of time.
• Colors. The Sphero can light up in any color.
• Bluetooth. Sphero connects to devices such as iPads, iPhones, and Android phones and tablets through wireless Bluetooth connections. This allows the Sphero to be controlled by a number of apps.

There are 4 education related apps available to control Sphero. Each of these is available for free from app stores such as iTunes and Google Play.
• Sphero. This is the main Sphero app used for firmware updates and general driving.
• Draw and Drive. Allows you to draw a shape with multiple colors and have Sphero roll in that shape and color.
• MacroLab. Creates simple programs (“macros”) that are a series of instructions for the Sphero through an easy-to-use graphical user interface.
• OrbBasic. Creates more complex programs using a text-based programming language.

The CORE & STEM lessons in the SPRK program use MacroLab and OrbBasic.

Help and support

We're here for you! If you have questions, comments, suggestions, or just want to chat please contact us!

• General Support Email: support@gosphero.com
• General Support Phone: 1 (303) 502-9466
• Education: education@orbotix.com
• Volume Purchase: vpp@orbotix.com
• Twitter: @SpheroEdu
Heading and Aiming

One of the things that makes Sphero so unique is that its heading is relative to the user, not relative to the ball. This makes the Sphero much easier to get to go where you want it to go. The diagram shows how the heading works. Note that only 90 degree increments are shown in the diagram, but you can specify the heading down to 1 degree.

Each time the Sphero is turned on, it needs to be "aimed," which means setting the direction that will be used for a heading of 0 degrees. This is accomplished with Sphero’s "taillight". The taillight is a blue, light inside the Sphero. Each Sphero app has a button that lets you set the taillight, which looks like this:

To use this button, tap and hold on it, and then slowly move your finger around the circle. You will see the blue taillight rotate. When it is pointing directly at you (in other words, directly away from the direction you want the Sphero to roll for heading of 0 degrees), remove your finger. The student guides for all of the MacroLab lessons lead you through how to do this.

For an interactive introduction on how to aiming, use the Sphero app.
Overview

Students will use Sphero to conduct an experiment. They will identify how long they need Sphero to move at 10% speed to reach and knock over a target object (such as a whiteboard marker). Using this information, they will then calculate how long Sphero will need to move at higher speeds to reach the same target. Finally, they will be given a bowling challenge where they can use any speed they like to knock over as many “pins” (whiteboard markers) as they can. In the challenge, they will record their results and then they will determine the mean, median, and mode of the results from the entire class.

Read through the student guide. At the start of the lesson, review the relationship between time, speed, and distance. Also introduce mean, median, and mode.

Objective

Students will:

• Students will solve an open ended problem with guess and check.
• Students will use division and the relationship between rate, distance, and time to determine the time needed to reach a target
• Students will calculate mean, median, and mode from a data set that they helped generate

Common Core Math Standards

The following Common Core Math Standards for 4th, 5th and 6th grade apply to this lesson:

• CCSS.MATH.CONTENT.6.SP.A: Develop understanding of statistical variability
• CCSS.MATH.CONTENT.6.SP.B: Summarize and describe distributions
• CCSS.MATH.CONTENT.4.OA.A: Use the four operations with whole numbers to solve problems.
• CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them.
• CCSS.MATH.PRACTICE.MP2: Reason abstractly and quantitatively.
• CCSS.MATH.PRACTICE.MP4: Model with mathematics.
• CCSS.MATH.PRACTICE.MP8: Look for and express regularity in repeated reasoning.

Materials Needed

Spheros are controlled by mobile devices, either Apple (iPhone or iPad) or Android. Ideally, you would do this lesson in groups of 3 or 4 students, each with their own Sphero and device. This lesson is designed for iPad, but other devices could be used. Here is what each group would need:

• iPad with Sphero MacroLab loaded. You can get Sphero MacroLab for free from the iTunes app store.
• Sphero that has been fully charged
• A flat clear area of at least 8 feet by 8 feet. (Preferably not very slippery.)
• Masking tape
• 5-7 Whiteboard Markers or other object students can knock over with Sphero
Part 1: Connect the Sphero

In part 1, students need to connect each iPad with a Sphero. They will:

1. Wake up the Sphero
2. Turn on Bluetooth
3. Connect the correct Sphero to the iPad, using the colors that it flashes as a way to tell which Sphero has which name

Part 2: Aim the Sphero

In part 2, students need to set the orientation, which is the direction of 0 degrees heading for Sphero. This is called “aiming”. It’s important that they get this right so that the Sphero will follow the path and not bump into anything. To do this, they need to adjust the blue “taillight” so that it is pointing directly at them. If they do this correctly, then the Sphero will roll directly away from them. Students will:

1. Open up MacroLab on the iPad
2. Hold the Sphero in front of them as they look down the path
3. Tap and hold the aim icon at the bottom of the screen and adjust the taillight so that it is pointing directly at them.

Part 3: Reaching the target

Set up the target object 7 feet away from a starting line. You can use masking tape on the floor to mark the starting line.

To begin this portion, let the students have a few practice rounds to ensure Sphero is heading straight towards the target.

Now that the students have Sphero moving straight, they need to figure out when Sphero is set to 10% speed how long of a delay they need to knock over the target object and stop within 6 inches of it.

Part 4: Calculations

Once they have determined the correct delay to knock over the target, then they need to figure out how long of a delay to use for Sphero being driven at 30%, 50%, 80%, and 100% speeds. Students may need to use the calculator on the I-pad, otherwise they should be able to complete all of the calculations using long division. Students then should fill in the table on their worksheet.

<table>
<thead>
<tr>
<th>% speed</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>delay (ms)</td>
<td>10,000</td>
<td>5,000</td>
<td>3,333</td>
<td>2,500</td>
<td>2,000</td>
<td>1,667</td>
<td>1,429</td>
<td>1,250</td>
<td>1,111</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Example of solution (note: for your reference this table includes all delays, not just the 30,50,80, and 100% speeds):
Part 4: Calculations (continued)

Here is a simple approach for students to solve for the delays of different speeds:

If 10% of speed needs 10,000 ms to reach the target:

Distance = Speed * Delay
Distance = 10 * 10,000
Distance = 100,000

For 20%, we still need to go the same distance (this one is straight forward because the speed has doubled but just to outline the process):

Distance = Speed * Delay
100,000 = 20 * delay
100,000 / 20 = delay
5,000

While not included in the student guide, you may find it may be interesting to have students plot the Delay vs. Speed relationship and speak about the shape of the graph.

![Sphero: Delay vs. Speed Relationship](image)

At the end of this section, there is time for students to test their math and see how close they can get to the target at each speed. They are prompted to take a few trials at 30%, 50%, 80%, and 100% to see if they can successfully knock over the target using the delay value they calculated.

Part 5: Challenge

For this challenge, set up 5 whiteboard markers at the same target location used earlier in the lesson. This challenge is a fun game of Sphero bowling where students determine which speed and delay they would like to use to knock over as many of the whiteboard markers over as they can. They need to record how many markers they knock over each of their 5 tries. Then, as a class compile the results of all trials and students will determine the mean, median, and mode of this data set.
This lesson builds on the previous 2 in a more open-ended, experiment-based way. You are going to be using Sphero to knock over an object that your teacher has set up a few feet away. In this lesson you will use division to see how much delay is needed for sphero to reach a target at different speeds. At the end of the lesson you will use Sphero to knock over whiteboard markers, or other objects in a bowling challenge that explores Mean, Median, and Mode. The Macrolab commands you are going to use in this lesson are:

- Roll – Makes the Sphero roll at a given speed and heading.

First you have to connect Sphero to the iPad (Part 1), then aim it (Part 2), and then there are two activities (Part 3 and Part 4), and finally a challenge to see if you can apply what you’ve learned (Part 5).

**Review of Milliseconds, Rate, Distance, and Time:**

Remember from MacroLab Lesson 1 that Sphero delays are programmed in milliseconds, or 1/1000 of a second, so to roll for 1 second you will use delay of 1000 ms. Also from MacroLab Lesson 1, rate, time and distance are all related and you can calculate any one of them using the other two.

Rate (speed) = Distance / Time (delay)

**Part 1: Connect the Sphero**

First thing you need to do is to connect the iPad to Sphero. Here’s how:

1. Pick up Sphero from its charging station and tap it twice on the logo to wake it up. You may have to tap it hard. It will start flashing colors when it is awakened out of its “sleep” state.

2. On your device, make sure Bluetooth is enabled. From the home page, click on Settings at the bottom. Then choose Bluetooth.

3. You will be shown a list of Spheros. Connect to the appropriate Sphero by tapping it. You can tell which Sphero is which by the names, which relate to the colors the ball is flashing. For example, if it flashes purple, then yellow, then green, then that is ball PYG. Select the one you want. Once successfully connected, it will say “Connected”.

![Sphero Bluetooth Connection](image)
Part 2: Aiming Sphero

Sphero has a direction built into it that it thinks of as “straight ahead”. This is called the orientation. The first thing we want to do is to aim the Sphero so that the orientation is on the path we want it to go. Each Sphero has a blue light inside of it called the “taillight”, which is always on the exact opposite side of the straight ahead direction. You are going to set the taillight so that it’s pointing right at you when you look down the path you want Sphero to go. Then, when it goes straight ahead, it will be on that path.

Follow these steps to aim the Sphero:

1. Go to the home screen and open MacroLab.
2. Have one of you hold the Sphero and stand at the beginning of the path you will use for your experiments. Have them face the direction the Sphero should roll, and hold the Sphero directly in front of them.
3. Now, you will aim the Sphero in that direction. Have a second member of the group use the iPad. In MacroLab, you will see a circle with two arrows at the bottom center of the screen. Tap on it and hold it.
4. A white circle will appear. Move your finger slightly to rotate the insides of the Sphero. You will see a blue light inside the ball. Move it around until the blue light is directly facing the person holding the Sphero. This is the “taillight”, and shows the direction opposite where the Sphero will move when moving straight ahead.

Part 3: Reaching the Target

1. Now that we have the Sphero going in the right direction, follow these steps to reach the object that your teacher set up for you to knock over such a whiteboard marker. Tap the + button at the bottom to create a new macro.
2. Where it says Macro Name, call it Bowling. Click Create Macro.
Part 3: Reaching the Target (Continued)

3. Add a new command by clicking the + button.
4. Choose Roll

Using only 10% speed, test different delays to see what the delay should be so that Sphero knocks over the target object and stops within 6 inches of that object.

5. To do this set the speed to 10% and the delay to a value of your choice, keep the heading at 0 degrees. Click Create.
6. Record on your worksheet each delay value that you try.
7. Record on your worksheet the delay value that was successful in knocking over the object.

Part 4: Calculations

Once you have identified the right amount of delay it is time to make some calculations to figure out how long of a delay will be needed to reach the same target when moving at higher speeds.

1. Now that you know the delay needed at 10% speed, use math to figure out how much delay is needed to reach the object when moving at higher speeds.
2. Fill in the table in your worksheet, there is an example calculation already done for you for 20% speed
3. Test out your math and run trials to see if you can knock over the object at 30%, 50%, 80%, and 100% speeds. Only do 3 trials for each speed and see if you can be successful at all speeds.

Part 5: Challenge

As a group you will have 5 tries to knock over all 5 whiteboard markers (or other object used for pins).

1. As a team, determine what speed and delay you want to use to knock over as many objects as possible
2. Once you are ready, let the teacher know you want to run your tests. You will have 5 minutes to run your trials; you can make adjustments after each run.
3. Keep track of how many markers you knock down for each trial on your worksheet.
4. Once you have these trials complete and have recorded your results add them to the master list for the class
5. Once the master list is complete, on your worksheet record all the trial results in order from lowest to highest.
6. Determine the Mean, Median, and Mode of this data set.
Part 3:
List the delays are you trying to just reach the target at 10% speed: What delay worked best to reach the target?

<table>
<thead>
<tr>
<th>Delay</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Example 20,000 ms)</td>
<td>(Moved too far past target)</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Part 4:
Using the delay value you found and the fact that Sphero is moving at 10% speed can you figure out what the delay should be at 30%, 50%, 80% and 100% to reach the same target.

Remember: Delay x speed = distance

<table>
<thead>
<tr>
<th>% speed</th>
<th>10</th>
<th>30</th>
<th>50</th>
<th>80</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>delay (ms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>delay that knocked over object (ms)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Part 5:
What speed and delay will you use to knock over the pins?

<table>
<thead>
<tr>
<th>Trial #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pins knocked over</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

List all bowling results from the class, from lowest to highest:

What is the median? What is the mode? What is the mean?