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Introduction to learning with Sphero

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 an 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.

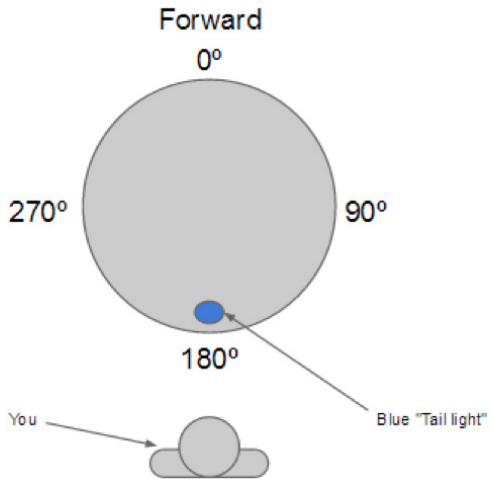
Help and support

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.

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OrbBasic Lesson 2
Circles and if/then/else: Teacher Guide

Overview

Students will use Sphero to explore the computer science concepts of variables and conditionals (if statements). They will use OrbBasic, which is a text-based programming language for the Sphero. They will write a simple program that rolls Sphero in a circle until it gets an error. Then they will fix the error by adding an if/then statement. They will learn about if/then/else statements to light up Sphero under certain conditions. For the challenge, they will make the circle increase its radius each time it goes around a circle.

Read through the student guide to learn about what the if/then, if/then/else, and LEDC commands do. At the start of the lesson, discuss with the students how to program Sphero to roll in a circle, and how if/then and if/then/else statements works.

Objective

Students will:

- Create an OrbBasic program to roll Sphero in a circle once, using a variable to store the heading
- Modify the program with an if/then statement to fix an error and make it go in a circle indefinitely
- Modify the program with an if/then/else statement to light up one color half the circle, and another color the other half
- Modify the program to increase the size of the circle at the end of each cycle.

Common Core Math Standards

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

- CCSS.MATH.CONTENT.4.OA.C.5: Generate and analyze patterns
- CCSS.MATH.CONTENT.5.OA.B.3: Analyze patterns and relationships
- 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 via Bluetooth on either Apple (iPod, IPhone, or iPad) or Android devices. 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 iPads, but other devices could be used. Here is what each group would need:

Materials Needed (continued)

- iPad with Sphero OrbBasic loaded. You can get Sphero OrbBasic for free from the iTunes app store.
- Sphero that has been fully charged
- Print-out of the worksheet (last page of teacher's guide)
- A flat clear area of at least 10 x 10 feet. (Preferably not very slippery.)

Part 1: Connect the Sphero

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

- Wake up the Sphero
- Turn on Bluetooth
- 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 OrbBasic 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: Making the Sphero roll in a circle

In part 3, students will create an OrbBasic program that rolls Sphero in a circle by having it roll a very short distance and then increase the heading by 5 degrees. It uses a variable called h that starts at zero and is increased each time by 5. See the student guide for the code.

The first version of the code lets the variable h start at 0 and keep getting larger. When it hits 360, then the roll command gets an error because heading values need to be between 0 and 359. You can see the error at the bottom part of the screen. At this point, the Sphero stops running the program and keeps doing whatever the last step was, which is to roll. So the program makes the Sphero roll in a circle and then keeps rolling in a straight line. They will need to tap Stop to make the Sphero stop.

They will fix the error by adding a new line with an if/then statement which checks to see if h has a value of 360, and if it does, it sets it back to 0. With this line, Sphero will roll in circles indefinitely.

Part 4: Adding Color

Students will learn about the if/then/else statement, which will do one command if something is true, and a different one if it is not. In this case, it checks to see if h < 180 (the heading is in the first half of the circle), and if it does, it lights it up in one color; if it is not, then it lights it up in another.

Part 4: Adding Color (continued)

Although you could use OrbBasic's RBG command for the colors, OrbBasic has a simpler command called LEDC. (LED refers to the light emitting diodes that are used to light up the Sphero.) LEDC is followed by one number, which corresponds to a color. The student guide has a table that shows which color has which number.

Part 5: Challenges

For the challenge, students will see if they can modify the program to increase the size of the circle each time the Sphero goes around. This is a fairly difficult challenge, so several hints are given. If they look back at their previous lesson's program, they should be able to figure out that they need a variable (for example, d) that holds the delay. They need to add a line to start it at 50, then modify the delay commands to use it, and then add an if/then statement to increase by 10, but only if h=0. The answer is below (the line numbers and LEDC values don't have to be exactly the same):

```
10 h=0
15 d=0
20 goroll h,50,2
30 delay d
40 h=h+5
45 if h=360 then h=0
47 if h > 180 then LEDC 1 else LEDC 2
48 if h=0 then d=d+10
50 goto 20
```

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OrbBasic Lesson 2
Circles and if/then/else: Student Guide

In this lesson, you're going to create a new program with OrbBasic that makes the Sphero go in a circle. You'll be using variables again, and you'll also learn about the if/then statement, where Sphero will do something, but only if a statement is true.

Here are the Sphero commands you'll be using for this lesson:

- goroll –Makes Sphero roll at a given speed and heading. Also makes it stop.
- delay – Makes Sphero wait an amount of time before doing the next command
- goto – Makes Sphero go to a certain place in the program
- variables – Used to store a number
- if/then – Used to make the Sphero do something if a statement is true
- if/then/else – Like if/then, but also does something else if the statement is false
- LEDC – Makes the Sphero light up a color

First you have to connect Sphero to the iPad (Part 1), then you'll aim Sphero (Part 2), then you'll write an OrbBasic program to make Sphero roll in a circle (Part 3). Next, you'll make it light up with two different colors (Part 4), and then you'll control the distance it rolls with a variable (Part 4). Finally, you'll have a challenge to use the variable to make Sphero roll in bigger and bigger circles (Part 5).

How can we make the Sphero roll in a circle?

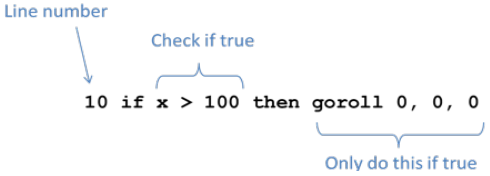
There's no "roll in a circle" command in OrbBasic. Instead, we have to create the circle out of small line segments. We'll start with a goroll command to roll the Sphero forward just a little bit at heading 0 degrees. Then we'll do another short goroll, but this time increase the heading just a tiny bit to 5 degrees. You can see in the diagram below that the top arrow is just slightly bent to the right of the bottom arrow, which is totally straight up and down.

Next, we increase it to 10 degrees and roll a little more. Then 15 degrees. Then 20 degrees. We add 5 degrees to the heading each time.

Once the heading goes all the way to 360 degrees, the Sphero will have moved in a full circle.

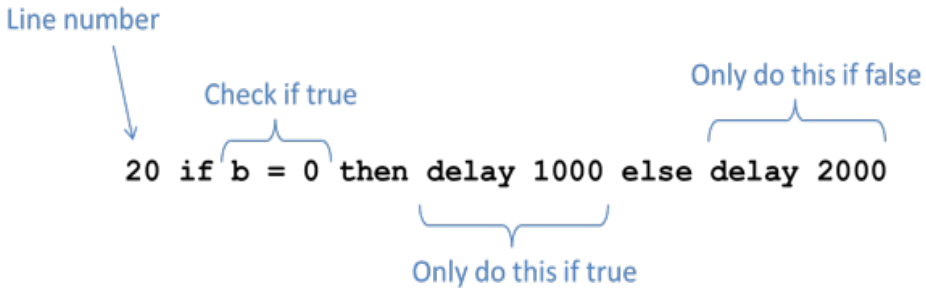
If/then and if/then/else statements

Sometimes you'll want to make Sphero do something, but only when certain conditions happen. For this, Sphero has an if/then statement. The if/then statement looks like this:



This line is saying that if the variable x is greater than 100, then Sphero should stop. (A goroll command with all zeros will stop the Sphero.) The part after if usually involves a variable. The part after then can be anything you want Sphero to do.

You can also add an else to an if/then statement. This will allow you to tell Sphero to do something if a statement is true, but to do something else if it is not true. The if/then/else statement looks like this:



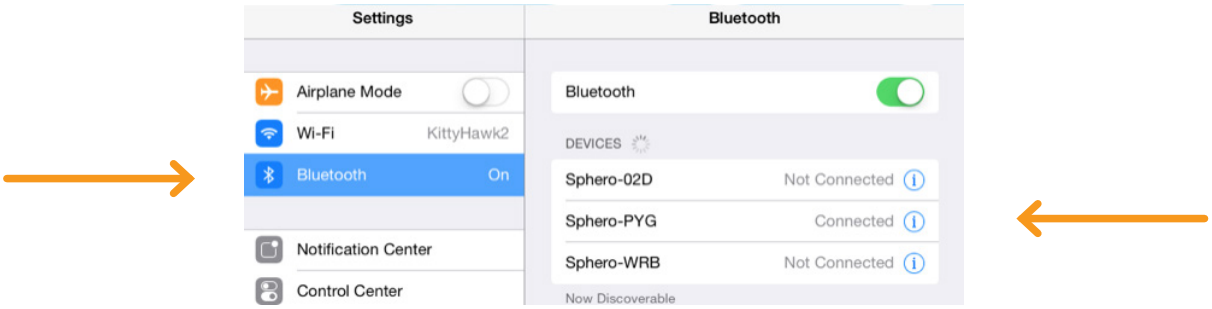
This line is saying that if the variable b is 0, then the Sphero should delay for 1000 milliseconds (1 second), but if b is not 0, then it should delay for 2000 milliseconds (2 seconds).

Let's try these out!

Part 1: Connect the Sphero

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

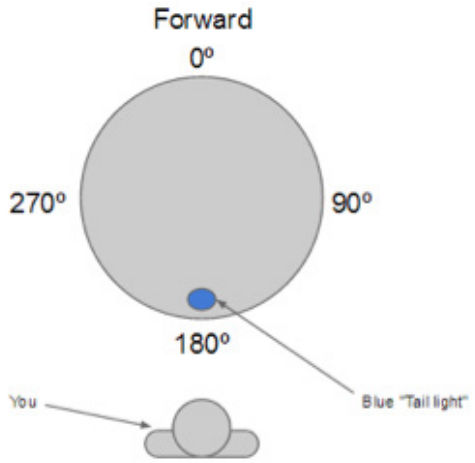
1. Pick up Sphero from its charging station and tap it twice on the logo to wake it up. You may have to tap it hard. It will start flashing colors when it is awakened out of its "sleep" state.
2. On your device, make sure Bluetooth is enabled. From the home page, click on Settings at the bottom. Then 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".



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.

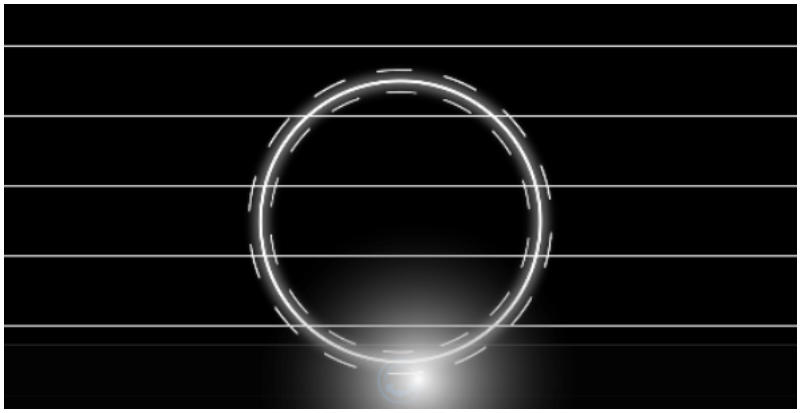
Part 2: Aiming Sphero (continued)



Follow these steps to aim the Sphero:

1. Go to the home screen and open OrbBasic.
2. Have one of you hold the Sphero and stand at the beginning of the path you will use for your experiments.
3. Now, you will aim the Sphero in that direction. Have a second member of the group use the iPad. In OrbBasic, 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.



Important: For these experiments, the Sphero will travel a long distance, so be sure to aim the Sphero as accurately as you can to keep it on track. You can also re-aim Sphero anytime!

Part 3: Making Sphero roll in a circle

Now that we have the Sphero going in the right direction, let's get it going in a circle. As explained above, we want to increase the heading by 5 degrees each time. We'll need a variable called h (for heading) that starts at 0, and then we'll add 5 to it after each small roll. Follow these steps:

Part 3: Making Sphero roll in a circle (continued)

1. Tap the + button at the bottom to create a new program

2. In the space where it says Program Name, give your program a name, then click the '+ New Program' button under it.

3. Tap in the big white space. A keyboard will appear at the bottom of the screen.

4. Start typing code. You'll first need to set the variable h to zero.

```
10 h=0
```

5. Next, you'll want to roll at that heading (variable h) at speed 50, type 2 (turns quickly).

```
20 goroll h,50,2
```

6. Then, you'll want a very short delay so that it only rolls a little bit. Use 50 milliseconds.

```
30 delay 50
```

7. The next line will increase the heading variable h by 5 degrees.

```
40 h=h+5
```

8. The next line will increase the heading variable h by 5 degrees.

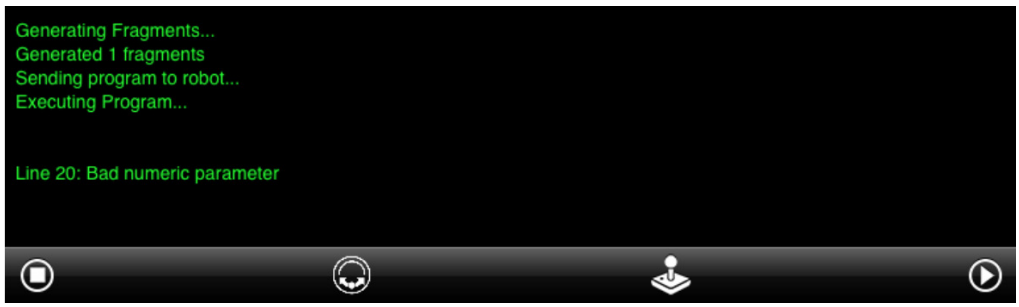
```
50 goto 20
```

Your full program should look like this:

```
10 h=0
20 goroll h,50,2
30 delay 50
40 h=h+5
50 goto 20
```

9. Tap the Done button and then the Play button to see what happens. But be ready to tap the Stop button.

Did it go in a circle? What happened when it came back to where it started? You probably had to tap the Stop button. Clearly something went wrong, and if you look in the black area, you'll see an error:



What could be going wrong at line 20? Well, h started at zero, and then went to 5, 10, 15, etc. When it got back to the starting point, h had a value of 360. The first number in the goroll command can only be between 0 and 359. So Sphero stopped the program and just kept doing the last command, which was to roll forward.

How can we fix this? We need to check if h is 360, and if it is, set it back to 0 so that it can keep going in circles. That's where the if/then statement comes in.

10. Add this line between 40 and 50:

```
45 if h=360 then h=0
```

11. Tap the Done button and then the Play button to see what happens. Is Sphero going in circles?

Part 4: Adding Color

Let's make your program a little fancier. It needs some color. OrbBasic has an RGB command, similar to what MacroLab has, but it also has an LEDC command that lets you choose a color from a table. (The type of lights that Sphero uses are called LEDs, for light emitting diodes. That's why the command has that name.)

Part 4: Adding Color (continued)

Here are the colors that you can use with LEDC:

Number	Color
0	No light
1	Red
2	Green
3	Blue
4	Orange
5	Purple
6	White
7	Yellow

For example, a command to light the Sphero orange would be:

```
45 if h=360 then h=0
```

Let's add a line to our program that makes the Sphero one color when the heading is 0 to 180 degrees (the first half of the circle) and another color when it's 180 to 360 degrees (the second half of the circle). This is a great place to use the if/then/else command.

1. Add a line in between lines 45 and 50 to check if the heading is less than 180 degrees. If it is, then light up one color. If it's not, light up another color. You get to choose the colors. (Use the table to figure out what numbers to use.) In the example below, it will be red for the first half, and green for the second half.

   Important: OrbBasic is a case-sensitive programming language. This means that whether a letter is capital or not is important. LEDC must be made with all capital letters.

   ```
   47 if h<180 then LEDC 1 else LEDC 2
   ```

2. Tap the Done button and then the Play button to see what happens. Tap the Stop button when you've seen enough.

Part 5: Challenge

Let's take what we learned in OrbBasic lesson 1 and apply it here. Remember how we had the Sphero going farther and farther each time? Now you'll modify your program so that it makes bigger and bigger circles. Each time it makes a circle; it should increase the size of the circle by a little bit.

Here are some hints:

1. The way to make the circle bigger is to make the delay bigger.
2. You'll need a variable to use for the delay. Take a look at your OrbBasic 1 program to see how you did this before.
3. You'll only want to increase the delay when the Sphero has gone around a full circle. That means the line to increase it should be an if/then statement, where you are checking to see if the heading (the variable h) is at zero.
4. You'll only want to increase the delay a little bit each time. Try starting at 50 and then increasing by 10 each time it has gone full circle.

Good luck and have fun!

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OrbBasic Lesson 2
Circles and if/then/else: Worksheet

Names:

Part 4 - Challenge:
Write down your program that draws circles that show two different colors and that has a bigger circle each time it goes around.