





## Polygons and Angles: Student Guide

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You are going to be using a Sphero to figure out what angle you need the Sphero to move at so that it can draw shapes with straight lines (also called polygons).

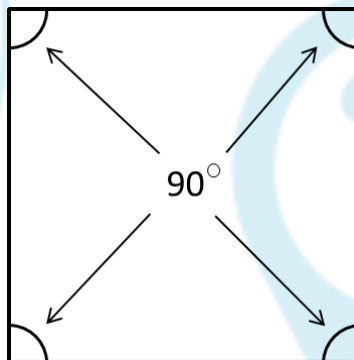
The MacroLab commands you are going to use in this lesson are:

-  Roll – Makes the Sphero roll at a given speed and heading.
-  RGB – Changes the color of the Sphero.
-  Stop – Makes the Sphero stop rolling immediately.
-  Delay – Waits for a while before doing the next step.

First you have to set up the Sphero (Part 1), and then there are two shapes to draw (Square for Part 2 and Triangle for Part 3), and then a challenge to see what you've learned (Part 4).

### How To Make Sphero Draw Shapes

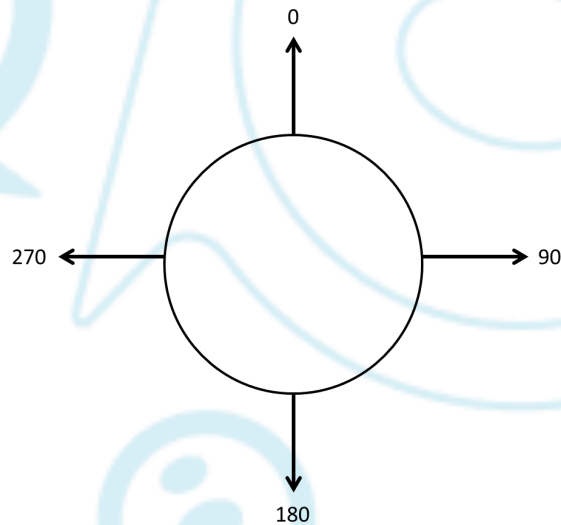
In this lesson, you're going to make Sphero trace the outline of shapes with straight sides, also known as polygons. Let's start with a simple shape, which is a square. A square has 4 equal sides, and the angle of each corner is 90 degrees.



So you might think that you should write a Sphero program like this:

1. Roll for 2 seconds
2. Turn 90 degrees right
3. Roll for 2 seconds
4. Turn 90 degrees right
5. Roll for 2 seconds
6. Turn 90 degrees right
7. Roll for 2 seconds

But this isn't how Sphero works. Sphero has a heading, which looks something like this:



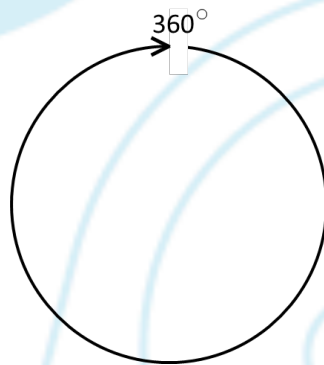
It will move directly away from you if the heading is zero degrees. To make it turn right, you need to set the heading to 90 degrees. To make it turn right again and head back towards you, you need to set the heading at 180 degrees. Don't think in terms of "turn right" or "turn left". Think instead about what degrees you want for the heading so that Sphero will move in the direction you want it to. For a square, those numbers are:

0  
90  
180  
270

If you think about it, each Roll step, the heading number went up by 90.

$90 = 0 + 90$   
 $180 = 90 + 90$   
 $270 = 180 + 90$

Why 90? Well, the heading circle has 360 degrees. We want the Sphero to go full circle and end up where it started.



A square has 4 sides. Since each of those sides gets an equal share of the 360 degrees, each side gets an angle of:

$$360 / 4 = 90.$$

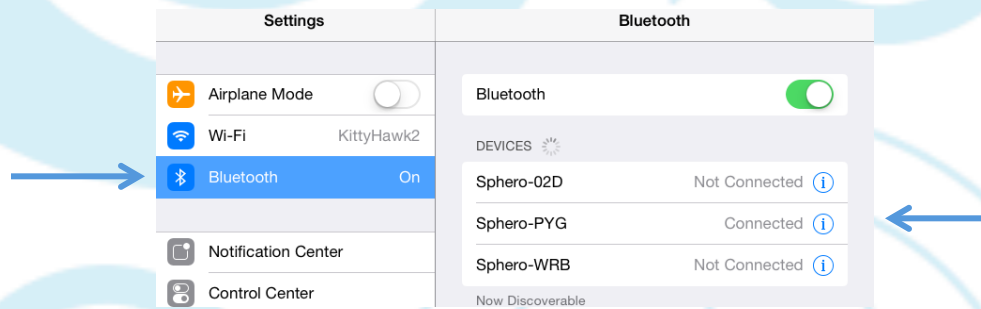
What if you wanted to draw a triangle instead? Then the heading angles would change by  $360 / 3$ , which is 120 degrees. The first angle would be 0 and the second angle would be 120 degrees. What would the third angle be?

You're going to be figuring this out, and more complicated shapes, too.

## Part 1: Connect Sphero

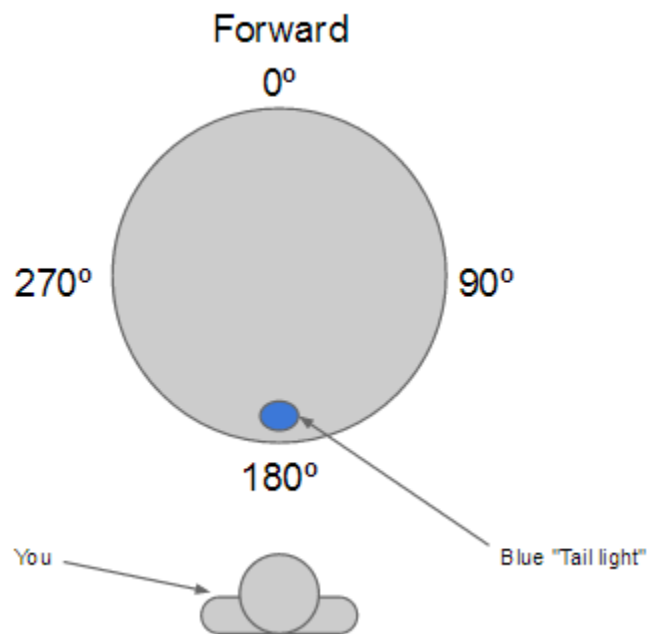
First thing you need to do is to connect the iPad to the Sphero. Here's how:

1. Pick up the 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: Aim Sphero

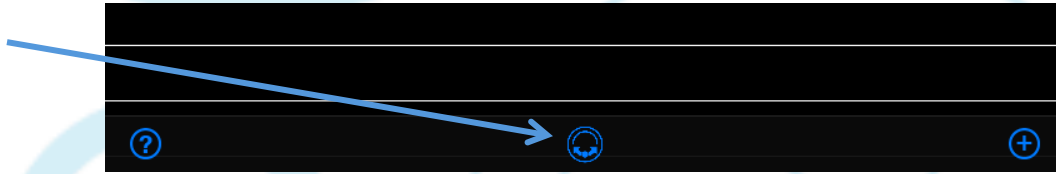
The Sphero has a direction built into it that it thinks of as “straight ahead”. This is called the orientation. The first thing we want to do is to aim the Sphero so that the orientation is on the path we want it to go. Each Sphero has a blue light inside of it called the “taillight”, which is always 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 the Sphero to go.



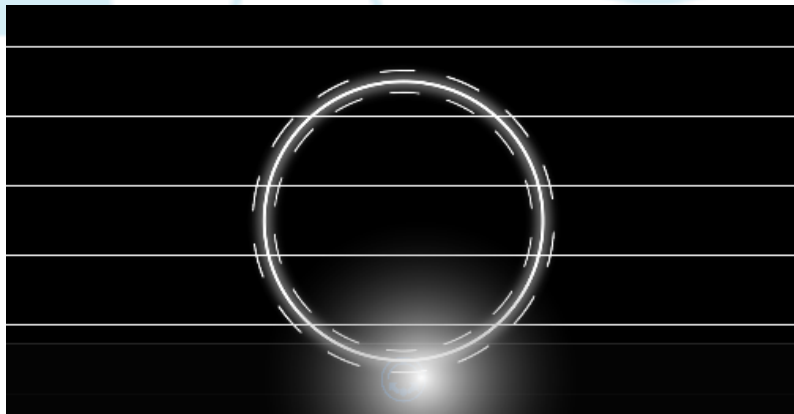
Follow these steps to aim the Sphero:

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.



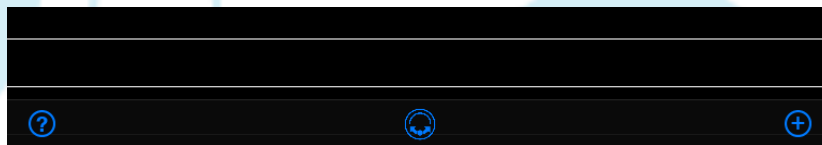
4. A white circle will appear. Move your finger slightly to rotate the insides of the Sphero. You will see a blue light inside the ball. Move it around until the blue light is directly facing the person holding the Sphero. This is the "taillight", and shows the direction opposite where the Sphero will move when moving straight ahead.



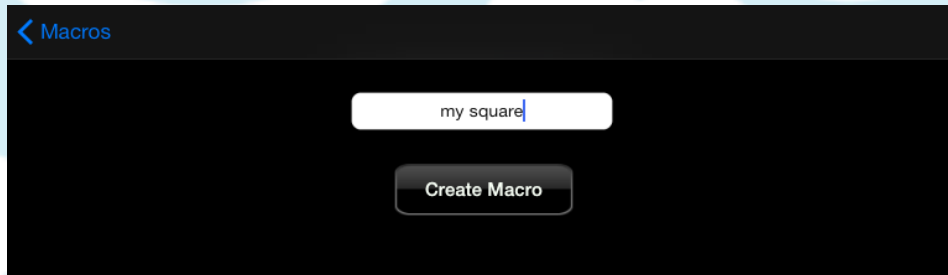
### Part 3: Square

Now that we have the Sphero going in the right direction, follow these steps to make the Sphero draw a square.

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



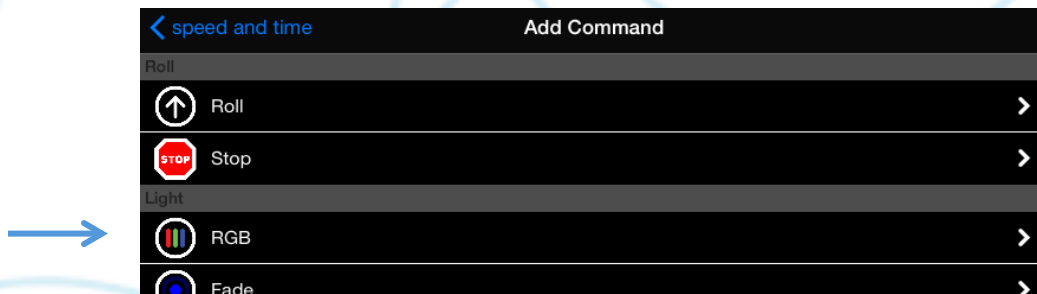
2. Where it says Macro Name, call it my square. Click Create Macro.



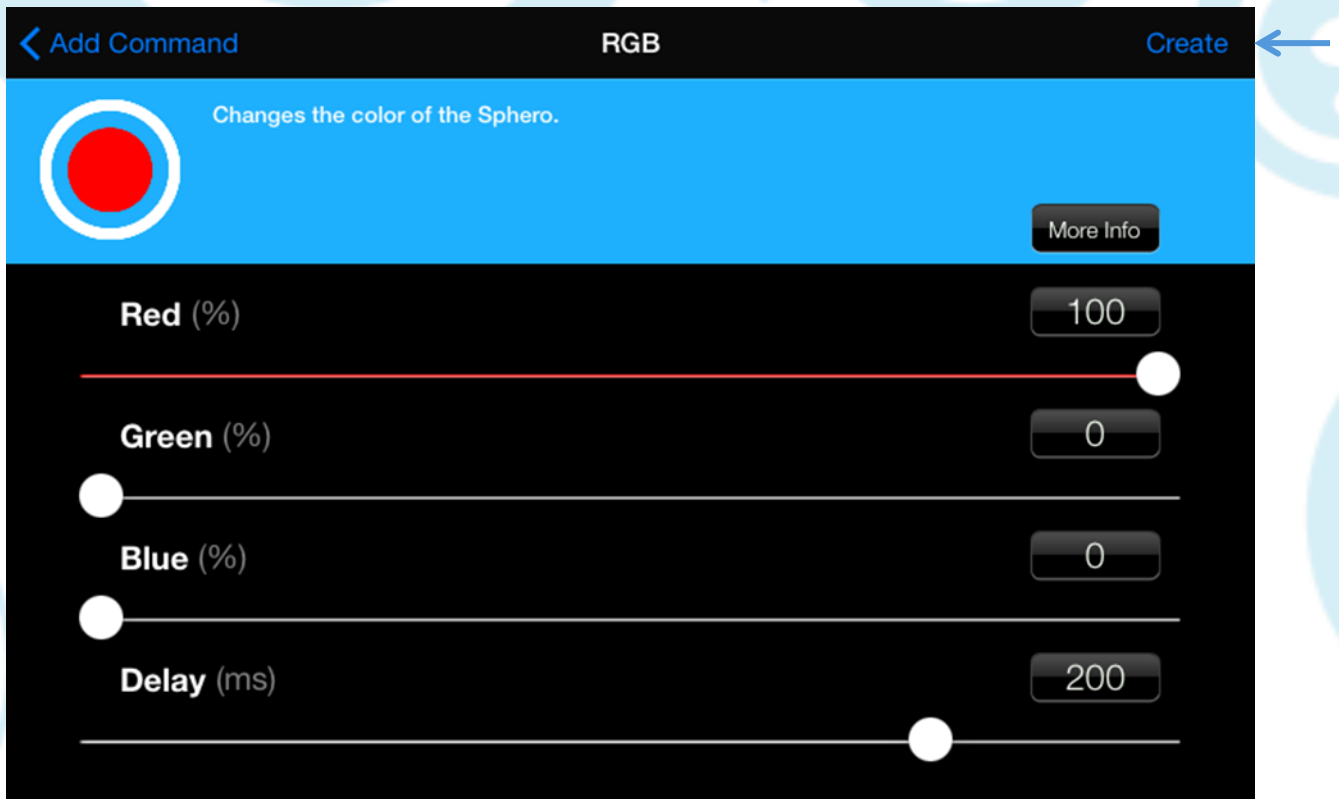
3. Add a command by tapping the + button at the bottom.



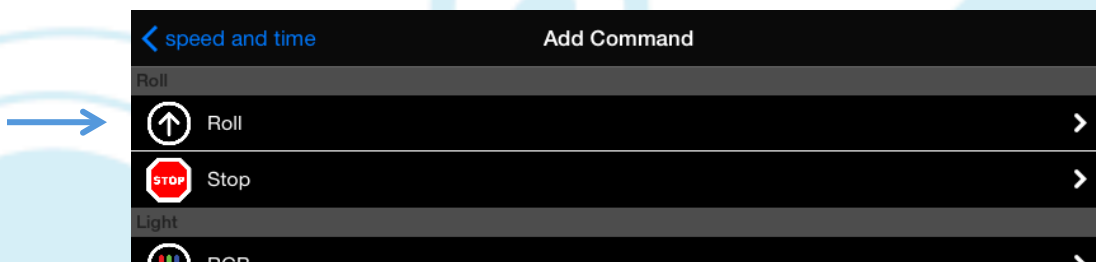
4. For the fun of it, let's make every side of the square light up as a new color. So tap on RGB (which stands for "Red, Green, Blue"), the third command in the list.



5. Drag the slider for Red to the right for 100% in order to make a red color. Slide the Green and Blue sliders to the left for zero. Leave the Delay at 200. Click Create.

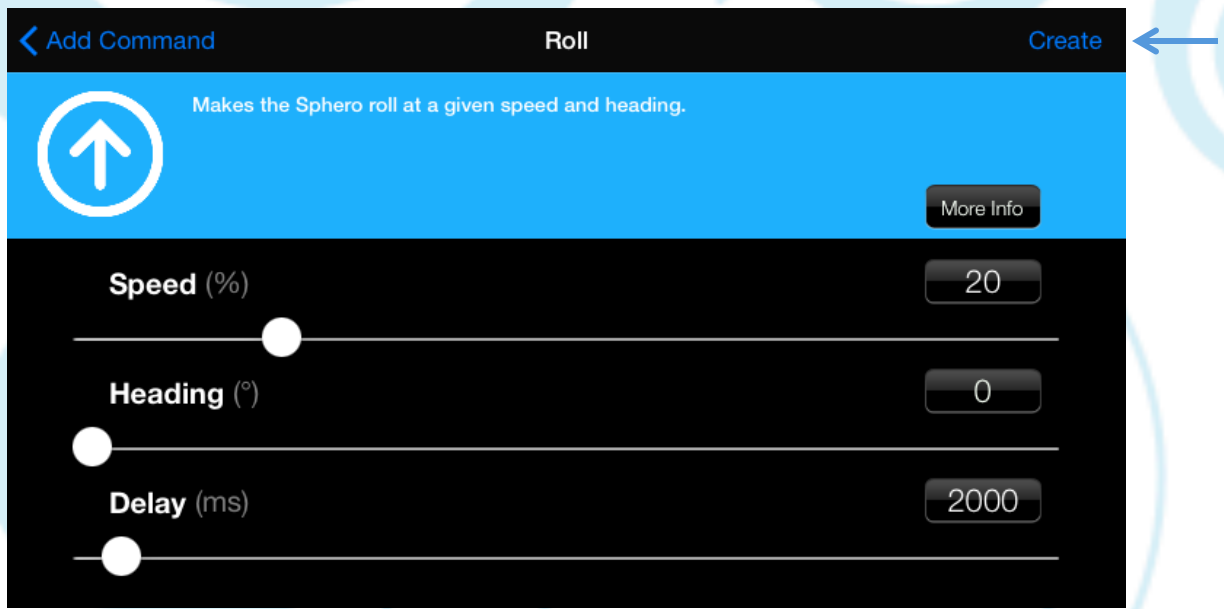


- Now let's add a Roll to create the first side of the square. Tap on Add to add a new command. Tap on Roll, the first command in the list.



- Set the Speed to 20 and the Delay to 2000 (2 seconds). It may be easier to use the keyboard than try to get the right values with the slider. Leave the Heading at zero. Click the Create button up top.



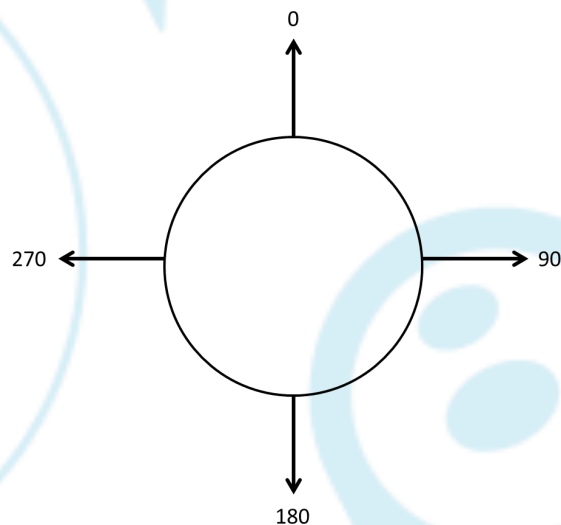


8. Tap Play. You will see the Sphero turn red and go a short distance.

That's the first side of our square. Now, we want the Sphero to glow another color and make a right turn to make the second side. The color is easy:

9. Add a third command by tapping the Add button. Tap RGB again, and this time bring the Green bar to 100% and the Red and Blue bar to 0%, making the color green. Click the Create button.

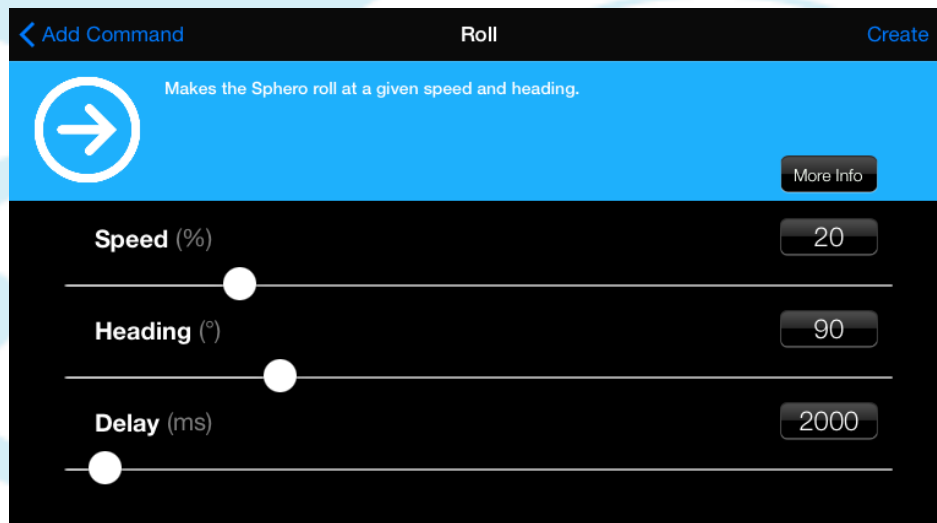
How do we get Sphero to turn? Remember, Sphero has a heading, which looks like this:



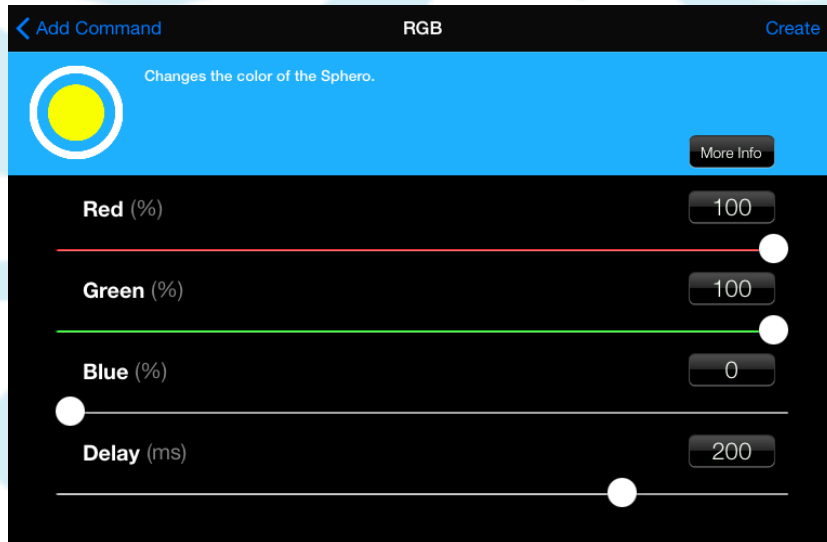
It will move directly away from you if the heading is zero degrees. To make it turn right, we need to set the heading to 90 degrees.



10. Add a fourth command by tapping the Add button. Chose Roll. Set the speed to 20%, the heading to 90, and the delay to 2000 (2 seconds). Tap Create.



11. Bring the Sphero back to the starting point and tap Play. The Sphero should create two sides of the square: red and green.
12. Add another command to turn the Sphero to blue. You should be able to figure out how to do this now.
13. Add a sixth command to have it create the third leg of the square. The speed and delay should be the same as the others, but the heading will be different. Take a look at the heading diagram to figure out what value it should be.
14. Move the Sphero back to the starting point and try it again. Do you have three sides of the square?
15. Lastly, let's add the color yellow. We can do this by mixing red and green together. (If you mix red and green paint, you'll get brown, but if you mix red and green light, you'll get yellow.) Create a new RGB command, and move the red and green bars to 100%, and the blue bar to 0%.



16. Now, add the last Roll command. Looking at the heading diagram, you should be able to figure out the heading.
17. Tap Play. Did you get a full square? If you did, congratulations!

### Part 3: Triangle

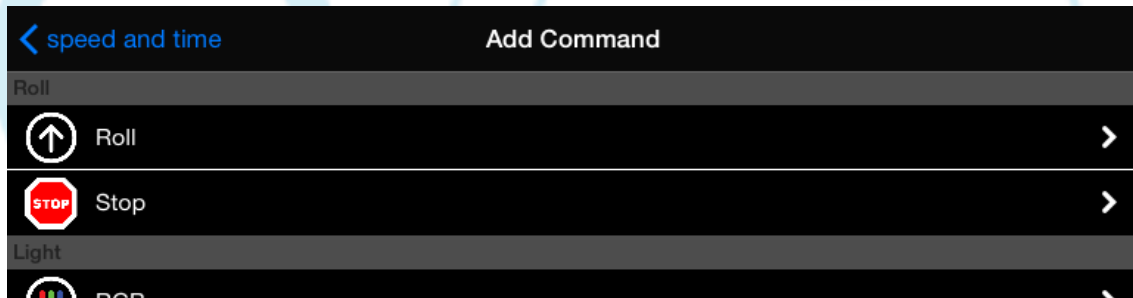
In this section, you'll have the Sphero draw a triangle. How will you do this? If you remember back to the introduction, the heading angles for a triangle change by  $360 / 3$ , which is 120 degrees. Let's test this theory out and make a new macro that draws a triangle.

Follow these steps:

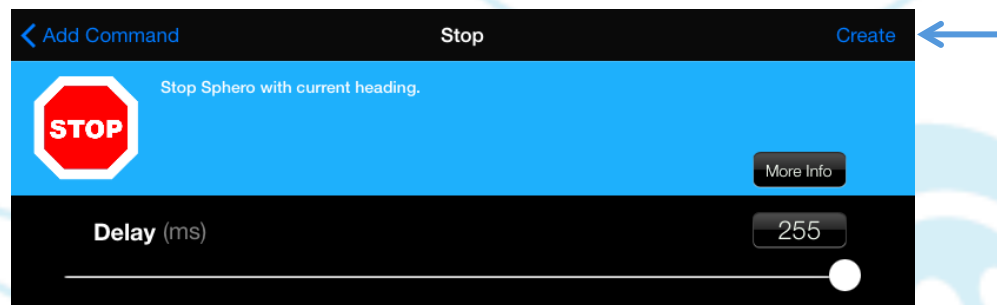
1. Return to the Macro screen by tapping on Macros in the top left corner.
2. Tap the + button at the bottom to create a new Macro
3. Name the Macro triangle.
4. Like before, add an RGB step for the color red.
5. Like before, add a Roll step that rolls at 20% speed, at 0 heading, and delay of 2000 milliseconds (2 seconds).
6. Again, add an RGB step for the color green.
7. Add another Roll step like the one you just did, but now we want the heading to be 120, since that's  $360/3$ .
8. Add an RGB step for the color blue.
9. Add one last Roll step with the same speed and delay. We want this step's heading to be 120 higher than the last one, or in other words, be  $120 + 120$ .
10. Put the Sphero at the starting point and tap Play to run the program. Did you get a triangle?

You may have noticed that the triangle's corners are a little rounded. That's because the Sphero has momentum when it comes to each corner. In other words, it had a little speed in the direction it was going in, and it doesn't change that speed right away. Let's fix that by adding two new commands between each of the Roll commands. These commands will stop the Sphero and make it wait before drawing the next leg of the triangle. Follow these steps:

1. Tap the + button at the bottom to add a new step.
2. Tap the Stop button.



3. Drag the delay to the maximum, which is 255. Click Create.



4. This will stop the Sphero, but we need it to sit for half a second more to give it time to find its new heading. Tap the + button again to add a new step.
5. Tap the Delay button. Change the value to 500 milliseconds (half a second). Tap Create.
6. Now we need to move these two steps into place under the first Roll command. Tap the Edit button in the top right corner.
7. Tap the three lines on the right side of the Stop step, and slide the step up until it is under the first Roll command.
8. Do the same for the Delay step, bringing it up under the Stop step. Then click Done in the top right. Your macro should look like this:



9. Tap Play. Does the first corner seem tighter than the second one?
10. Add another Stop step and Delay step with the same values as before. Tap the Edit button and slide them under the second roll. Tap Play and you should have tight corners for both your triangles.

### Part 4: Challenge

For the challenge, see if you can create a new macro to draw a pentagon, which is a 5 sided shape. Call the macro "pentagon". Have the sides of the pentagon be red, green, blue, yellow, and purple. You don't need to put in Stop and Delay steps. Think about:

1. How many steps do you need?
2. What is the amount you will add to each heading to figure out the next heading?
3. What two colors will you mix to get purple?