



# Polygons and Angles: Teacher Guide

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## Overview

Students will use the Sphero robotic ball to draw polygons and learn the relationship between heading angles and the number of sides in a polygon where all sides are equal. They will also learn how to set the colors of the lights inside the Sphero.

Read through the student guide. At the start of the lesson, go over the concepts of heading and what angles are used to draw a square and a triangle.

## Objective

Students will:

- Learn about how the Sphero has a heading that goes from 0 degrees to 360 degrees, and it determines in which direction it will roll.
- Students will write a program to make the Sphero draw a square, where each side of the square is a different color.
- Students will write a program to make draw a triangle, determining the heading angles from clues.
- Students will write a program to make draw a pentagon, determining the heading angles from a formula.

## Common Core Math Standards

The following 4<sup>th</sup> and 5<sup>th</sup> grade Common Core Math Standards apply to this lesson:

- [CCSS.MATH.CONTENT.4.OA.C.5](#): Generate and analyze patterns
- [CCSS.MATH.CONTENT.4.NBT.B.6](#): Find whole-number quotients and remainders with up to four-digit dividends and one-digit divisors, using strategies based on place value, the properties of operations, and/or the relationship between multiplication and division.

- [CCSS.MATH.CONTENT.4.G.A.2](#): Classify two-dimensional figures based on the presence or absence of parallel or perpendicular lines, or the presence or absence of angles of a specified size.
- [CCSS.MATH.CONTENT.4.MD.C.5.A](#): An angle is measured with reference to a circle with its center at the common endpoint of the rays, by considering the fraction of the circular arc between the points where the two rays intersect the circle.
- [CCSS.MATH.CONTENT.4.MD.C.7](#): Recognize angle measure as additive.
- [CCSS.MATH.CONTENT.5.OA.B.3](#): Analyze patterns and relationships
- [CCSS.MATH.CONTENT.5.G.B.3](#): Understand that attributes belonging to a category of two-dimensional figures also belong to all subcategories of that category.
- [CCSS.MATH.CONTENT.5.G.B.4](#): Classify two-dimensional figures in a hierarchy based on properties.
- [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.)

## 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

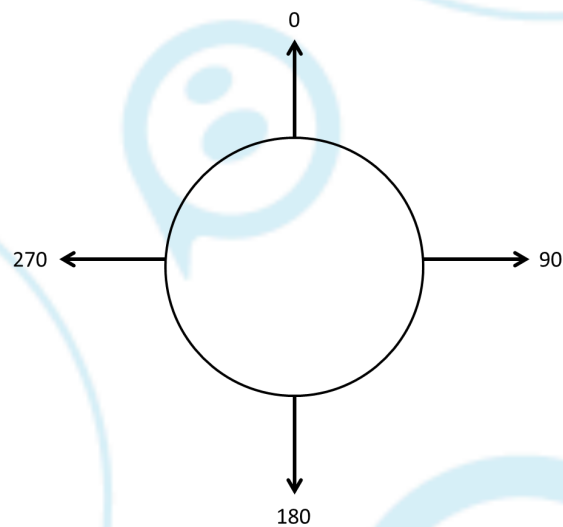
In part 2, students need to set the orientation, which is the direction of the 0 degrees heading for the Sphero. This is called "aiming" the Sphero. It's important that they get this right so that the Sphero will follow the path and not bump into anything. To do this, they need to adjust the blue "taillight" 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 an icon at the bottom of the screen and adjust the taillight so that it is pointing directly at them.

## Part 3: Square

In part 3, students will create a macro (computer program for the Sphero) and add steps to it to draw a square with each side a different color.

You may need to discuss the heading diagram for the Sphero.



This shows what heading values you should use to direct the Sphero to roll in a particular direction. Note that this diagram only shows 90-degree angle increments, but that you can have angles anywhere in between.

To create a macro to draw the square, they will:

1. Create a new macro.
2. Add a color (RGB) command and a Roll command.

3. Add another RGB command and a Roll command, this time with a 90-degree heading.
4. Figure out that they need to add another RGB command and a Roll command, this time with a 180-degree heading.
5. Figure out that they need to add another RGB command and a Roll command, this time with a 270-degree heading.

Note: they will try out the macro at various points as they are creating it so that they can see what each step does.

The final macro will look like this:



## Part 4: Triangle

For part 4, students will modify the macro to draw a triangle. You should discuss why there are 90-degree increments for the square: the 360 degrees in a circle is divided into 4 equal parts. Now, for a triangle, they will divide it into 3 equal parts, each with 120 degrees. The first heading angle is zero, the second one is 120 degrees, and the third one is 240 degrees (120 + 120).

The students will:

1. Create a new macro.
2. Add a color (RGB) command, a Roll command with a 0 heading.
3. Add another RGB command and a Roll command, this time with a 120-degree heading, and a Stop command with delay of 255.
4. Add another RGB command and a Roll command, this time with a 240 degree heading, and a Stop command with delay of 255.

The full macro is:



Then, to make the corners crisper, the students will put Stop and Delay commands at the end of each side of the triangle.

The full macro is:



## Part 5: Challenge

Part 5 is a challenge to see if the students have understood the concepts. For the challenge, students will have the Sphero draw a pentagon. To do this, they need to figure out that a pentagon has 5 sides, and therefore the heading directions will be spaced out by  $360 / 5 = 72$  degrees. Then they need to create the macro as follows:

1. Add an RGB command for red and a Roll with a heading of 0.
2. Add an RGB command for green and a Roll with a heading of 72.
3. Add an RGB command for blue and a Roll with a heading of 144. (72 + 72)
4. Add an RGB command for yellow and a Roll with a heading of 216. (144 + 72)
5. Add an RGB command for purple and a Roll with a heading of 288. (216 + 72)

Optionally, they can put Stop commands with delay after each Roll, which will make the corners crisper. The full macro is below:

