



Title: Geometry in Nature

Topics: geometry, geometry in nature, biomimicry, native plants, seed dispersal

Related Disciplines: mathematics, geometry, biology, ecology

Objectives:

- A. Learn about geometry in nature.
- B. Work in teams to build a sculpture.

Lesson:

A. Introduction (20 minutes)

The demands of nature have driven many organisms to coopt patterns of growth that we might not immediately associate with the natural world, instead resembling patterns we might expect to see in a geometry textbook or design magazine. A problem common to organisms across the tree of life is how to fit as much of something into as small a place as possible – for example, bees packing honey in a hive, flowers packing seeds in a seed head, mammalian intestines packing as much surface area as possible into an abdomen. This often results in geometric patterns that might be described by a mathematician; bees use repeating hexagons to pack as many larval chambers as possible into one hive and the pattern of seeds in a sunflower can be described using the Fibonacci sequence.

We can observe another geometric pattern in a plant species that you might find in your backyard. Bee balm is a fragrant member of the mint family indigenous to much of North America where it can be found in relatively dry, open areas like prairies, old fields, roadsides, and forest margins. Its purple flowers are pollinated by bees, butterflies, moths, and other flying insects, and the plant can be made into tea which was used by Native Americans to treat cold and flu symptoms.

When it's done flowering, the seed head persists on the plant and its complex geometry can be observed first hand. The seed head is shaped like a sphere, but is made up of many truncated cones. (Imagine cutting an ice cream cone in half; we're talking about the half with two holes.) Each cone contains four seeds so the inherent design of the seed head serves both to pack as many seeds as possible into a small space, while also aiding in moving seeds afield to sprout. As the seed head is tossed about by winter winds, the seeds are rattled in the seed head and scattered around the plant. If the seed head breaks off, it may roll away like a tumble weed, scattering the seeds far and wide to germinate in the absence of competition with their parents for light and nutrients.

Our art project today will guide you through how to make a biomimetic model of the bee balm seed head which can be used to explore the idea of geometry in nature and get you thinking about the plants in your own backyard.

B. Class Project (60 minutes)

Here are step-by-step instructions on how to build a sculpture from truncated cones, one that will ultimately resemble a sphere. It is modeled after the seed head of bee balm (Monarda fistulosa), a species of flowering plant that is native to much of North America (see Figure 2 and 3).

These instructions do not need to be read aloud to the class. They can be summarized verbally or printed for groups of older students to read and follow in small groups. The project will require cooperation and 3-dimensional thinking and will introduce students to the concept of native plants and geometry found in nature.

Materials: construction paper, scissors, glue, paper clips or tape, pens/pencils/markers

Steps:

1. Print templates (see Figure 1) for each student. You do not necessarily need to follow the measurements on the template; feel free to make them as large or small as you like, but the size needs to be consistent for a single sphere. The templates can be printed on standard paper as they will just be traced and won't be incorporated into the final sculpture where sturdier paper is necessary.
2. Have your students use the template to trace truncated cones onto their construction paper. Only trace the solid blue line, though the dotted lines can be used to discuss the geometry of the shape.
3. Next, cut out between 1 and 10 traced, truncated cones depending on class size and time allotted. The more cones the better because extra cones can be used to build multiple sculptures, but you will need at least four cones for a single spherical structure.
4. For each cut shape, pull the two narrow ends together to form half of a truncated cone (like a crown) and glue the overlapping edges. Once glue has dried you can move onto the next step.
5. Take two truncated cones, put them side by side so that one full edge is in contact between the two (the bottoms will be at a bit of an angle). Then use two paperclips or two pieces of tape to fasten the top and bottom of the truncated tubes together.
6. Next, add another truncated cone so that it is in contact with both of the previous cones. Two edges will be shared between this cone and the previous two. Fasten the top and bottom of both edges with paperclips or tape.
7. Continue adding truncated cones to the shape until you achieve a spherical shape.
8. Final product may be put on a desk or stand or can be hung from the ceiling.
9. Try making spheres of different sizes by changing the size of the template. Groups of students could each be assigned a different size template (though all templates used to make a particular sphere should all be the same size).

C. Conclusion (10 minutes)

Ask students to discuss how the form of the model seed head supports the function it serves for the plant. How is the shape used to pack many seeds into a small area, and to help those seeds spread?

Homework:

- Find a plant outside or online that shows a geometric pattern.
- Find another example of the Fibonacci numbers in nature.
- Research a plant that is native to your state. Where does it like to grow?

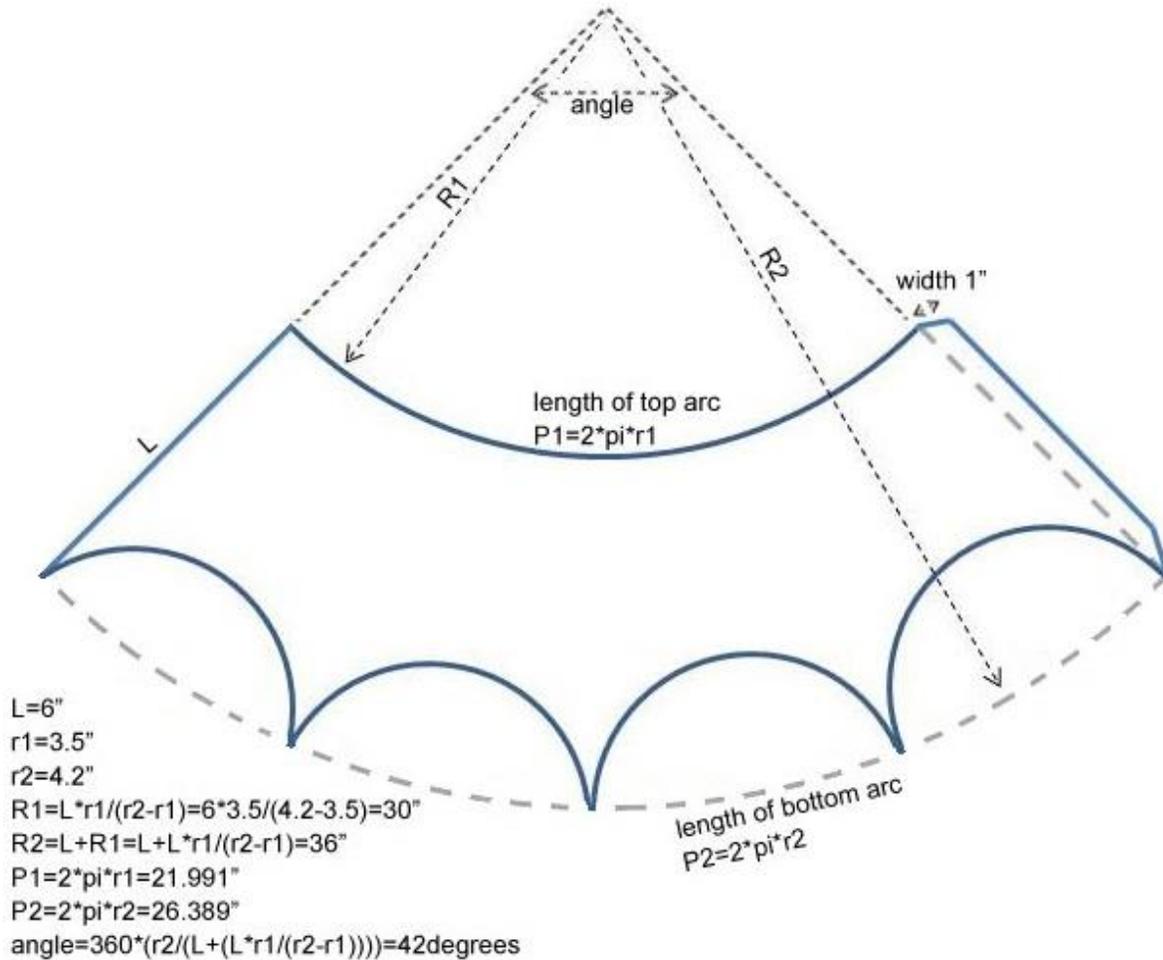


Figure 1. Template for individual truncated cones



Figure 2. Bee balm in its natural environment



Figure 3. Close-up of flower head