

**Curriculum topics:**

- Patterns & Relationships
- Symmetry
- Volume of Spheres & Cylinders
- Transformations on the plane
- Japanese Culture
- Artistic Exploration

**Subject: Math**

**Grade range: 6 – 9**

**Who we are:**

Resource Area for Teaching (RAFT) helps educators transform the learning experience through affordable “hands-on” activities that engage students and inspire the joy and discovery of learning.

For more ideas and to see RAFT Locations

[www.raft.net/visit-raft-location](http://www.raft.net/visit-raft-location)


# Mathematical Japanese Kokeshi Figures

Explore Japanese culture, properties of 3-dimensional shapes, and transformations on the plane while creating a figure based on a traditional Japanese Kokeshi doll!



# Materials required

For each student:

- Copy of Mathematical Japanese Kokeshi Figures Chart, 1
- Cylindrical tube, 1; approximately 4cm wide by 18cm high
- Paper square, 1; 5cm by 5cm
- Sphere, 1; approximate 11.5 cm diameter (made of Styrofoam or other material)
- Color paper strip, 1; approximately 5 cm by 20 cm.
- One side length of Velcro or other material, black; approximately 15.5cm by 20cm
- Square base, 1; approximately 10 cm by 10 cm(cardboard or other material)
- Markers, pens, pencils
- Assorted stickers, 6. Three different identical pairs of stickers → 
- Compass, protractor, ruler
- Scissors, tape or glue
- Optional: Calculators

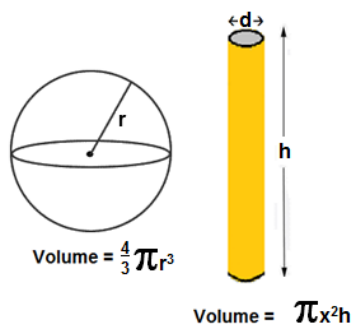
## To do and notice

1

Measure and record the following on the *Mathematical Japanese Kokeshi Figures Chart*:

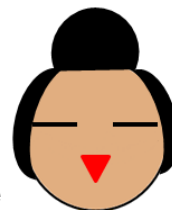
- The estimated radius of the sphere.
- The circumference of the sphere
- The diameter, radius, and height of the tube.
- The volume of the sphere.
- Notice if the tube were sealed at both ends, it would be a solid cylinder. Calculate and record the volume of the tube if it were a solid cylinder.

$r$  = sphere radius,  $c$  = sphere circumference,  $d$  = tube diameter,  
 $x$  = tube radius, and  $h$  = height of the tube



2

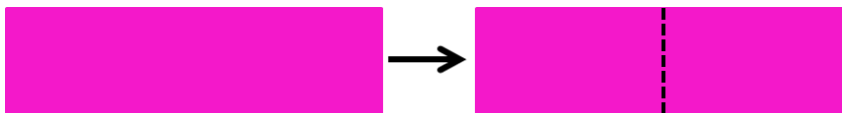
Glue the sphere onto the top end of the tube. Draw or glue eyes and a mouth onto the face of the sphere. Add “hair” by gluing the Velcro onto the top and sides of the head. Optional: add a black pom-pom to top of head or other features.




3

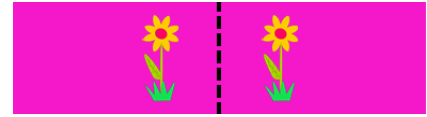
Create an Obi (Japanese Kimono sash) with the paper strip as follows:

- Fold the paper strip in half widthwise, crease along the fold, then unfold:

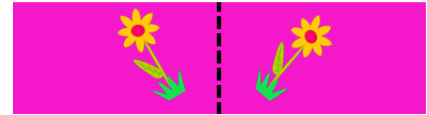


- Using two identical stickers, orientate one sticker on the left side of the fold. Position the other sticker onto the right side of the fold to make a transformation on the “plane.” Stick both stickers in place on the Obi sash. Choose one or more of the following types of transformations on the plane for each matching sticker pair:

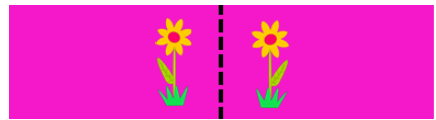
○ a GLIDE translation:  on the Obi :



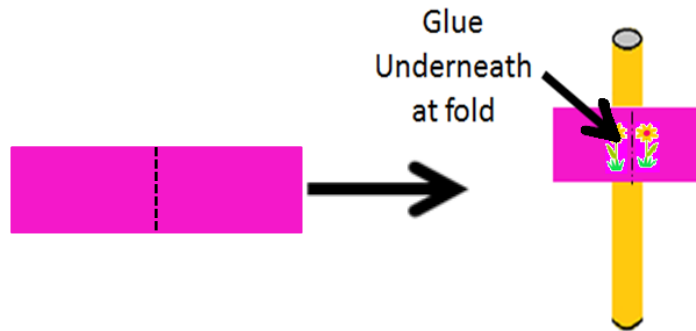
○ a ROTATION:  on the Obi :



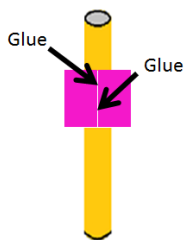
○ a REFLECTION:  on the Obi:



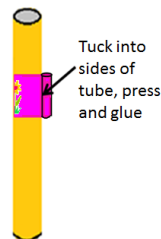
- 4** Align center fold of the Obi vertically onto the front of the tube. Glue the inside fold of the Obi to the tube →



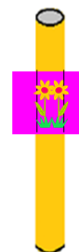
- 5** Wrap each end of the Obi around to the backside of the tube. Bring both ends of the Obi together. Glue the ends to the center of the backside of the tube. Tuck the inner folds of the Obi into the sides of the tube. Press and secure with glue:



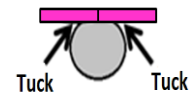
Back View



Side View

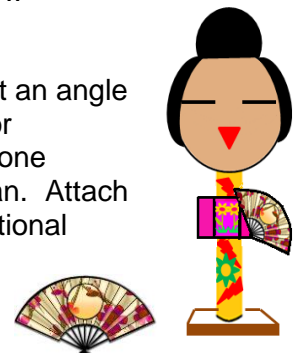


Front View



Top View

- 6** Start at one corner of the square piece of paper. Use the compass to sweep out an angle measuring between 90 and 120 degrees. Check the angle with the protractor for accuracy. Cut out the resulting arched wedge. Make small folds starting along one straight edge until reaching the other straight edge. Unfold slightly to make a fan. Attach fan to front of Kokeshi. Glue bottom of tube to square base. Optional: add additional décor.



## Curriculum Standards:

Geometry:  
Volumes,  
Transformations  
(Common Core  
Math Standards:  
Geometry, Grade  
6, 1,3,4; Grade 7,  
4,6;  
Grade 8, 1, 2,  
3,4,9)

Area and  
Circumference  
of a circle  
(Common Core  
Math  
Standards  
: Grade 6,  
Geometry, 6)

Problems involving  
angles & area  
(Common Core  
Math  
Standards:  
Geometry,  
Grade 6, 1;  
Grade 7

Creative art,  
materials,  
and making  
(National  
Visual Arts  
Standards:  
Creating: Grades  
6-9,1.1, 2.1)

Art, society, and  
culture  
(National Visual  
Arts  
Standards:  
Connecting:  
Grades 6-9, 11.1)

Problem Solving  
and  
Reasoning,  
Modeling with  
Math  
(Common Core  
Math  
Standards:  
Mathematical  
Practices  
Grades 6 – 9

# The content behind the activity

**The math behind the activity:** Mathematics comes alive in the making of these Japanese Kokeshi figures! Volume formulas for both the cylinder and the spherical “head” lead to interesting discoveries with the Kokeshi model (“what would you discover about the volume formulas if the height and radii of both the cylinder and the sphere were the same?”). Transformations of stickers on a flat rectangle “plane” could easily lead to further investigations of tessellations on a 2-dimensional coordinate graph. Creating a fan for the Kokeshi leads to mathematical investigations of angular measurement and sectors of circles!

**Historical Background Information:** Originally from northern Japan, Kokeshi are Japanese dolls made of wood, having a simple body, an enlarged head painted with thin, delicate lines to define the face and hair. Interestingly, Kokeshi dolls do not have arms or legs! It is thought these dolls were originally made during the 1600-1868 (Edo Period) to be sold to people who visited the hot springs in the north-east of the country. Some say the Kokeshi were used as massage tools by spa bathers. Modern Kokeshi dolls come in different styles; with hair, arms, kimono, etc.! Today Kokeshi are highly collectible.

## Learn more

- Describe symmetry and where examples of symmetry appear on the Kokeshi.
- Explain how to find the surface area of the tube? Of the Head? Of the Obi sash?
- Research and describe how transformations on the plane are used in tessellations.

### Related Activities:

***Kumihimo*** -- <http://www.raftbayarea.org/ideas/Kumihimo.pdf>

***Zen Rock Garden*** -- <http://www.raftbayarea.org/ideas/Zen%20Rock%20Garden.pdf>

***Mathematical Russian Matryoshka Figures*** –

<http://www.raftbayarea.org/ideas/Mathematical%20Russian%20Matryoshka%20Figures.pdf>

***Mathematical African Akuaba Figures*** –

<http://www.raftbayarea.org/ideas/Mathematical%20African%20Akuaba%20Figures.pdf>

***Mathematical Hopi Kachina Figures*** –

<http://www.raftbayarea.org/ideas/Mathematical%20Hopi%20Kachina%20Figures.pdf>

## Resources

Visit [www.raft.net/more](http://www.raft.net/more) for “how-to” video demos and more ideas!  
See these websites for more information on the following topics:

- Watch a Kokeshi doll being made:  
<http://www.thisiscoossal.com/2014/10/watch-a-japanese-kokeshi-doll-emerge-from-a-spinning-block-of-wood/>
- More information about Kokeshi dolls:  
<http://www.japanya.co.uk/kokeshi.aspx>
- More on transformations on a coordinate plane:  
<http://www.virtualnerd.com/middle-math/integers-coordinate-plane/transformations>
- Scroll down this site to see more on how transformations are used in tessellations:  
<https://www.mathsisfun.com/geometry/plane-geometry.html>