GEOMETRY AND ART

Mandalas

Big Ideas
Unit of Instruction Circles Mandala Project
Geometry Concept • Visualize and reason spatially using various attributes of circles such as concentric circles and arcs.
Rationale This lesson will allow students to represent how they see themselves through the use of geometry and symbols. They will experiment with the use of a compass, identifying parts of a circle and different types of symmetry. Creativity in mathematics will be exhibited in many ways, including the identification of historical and cultural uses of symbols and circles.
NCTM Standards • Use visualization, spatial reasoning and geometric modeling. • Use geometric ideas to gain insights into other disciplines and other areas of interest such as art and architecture.
Idaho Content Standards • G.4.1.1 Analyze properties and determine attributes of two- and three-dimensional objects. • G.4.1.2 Explore congruence and similarity among classes of two-dimensional objects and solve problems involving them. • 9-12.VA.1.1.1 Identify representative visual works of art from a variety of cultures and historical time periods.

Background	
Vocabulary	
Arc	Daisy Design
Balance: Symmetrical/Asymmetrical	Intersection Point
Center Point	Mandala
Circumference	Radii
Clockwise	Reflectional Symmetry
Concentric Circle	Rotational Symmetry
Counter-clockwise	
Math Instruction (pre- or post-project)	
Students practice making circles with different radii using a variety of types of compasses. Rotational/reflectional symmetry.	

Driving Question

Project Objective

- Students will become proficient with the use of a compass
- Students will work with different types of circles (tangent, concentric, etc.) while using symbols to define themselves
- Students will think logically to create designs with rotational and/or reflectional symmetry.

Questions to be Answered

How do you create different types of circles (concentric, tangent, etc.)?

How do you construct arcs that intersect in the center of a circle?

What symbols can be used to illustrate aspects of your life?

How are mandalas used to represent other cultures?

What types of attributes could a design have to exhibit rotational symmetry?

What types of attributes could a design have to exhibit reflectional symmetry?

Materials

Materials Required

- Different types of compasses
- Various sizes and colors of paper
- Colored Pencils / Markers
- Scissors
- Hot glue gun / Glue Sticks

Optional Extras: glitter pens, decorative scissors, old magazines for pictures, transparency sheet, colored tissue paper, etc.

Reference Materials

Mathematics: Teaching in the Middle School. Focus Issue: "Mathematics and the Arts." NCTM. April 2007/
Serra, Michael. *Discovering Geometry: An Inductive Approach*, 2nd Edition, Key Curriculum Press, Emeryville, California, 2003.
The Last Mimzy. Film. New Line Cinema. 2007.

www.artglassmosaics.com

www.mathopenref.com/constructions.html

www.nusantara.com/2007/01/manhole-mandalas-in-new-york.html

www.free-mandala.com/cn/start.html (gives background and descriptions)

Lesson Outline
Description of Activity
Create a circular design incorporating concentric circles, a 6 or 12 petal daisy design, partial petals, symbols representing your life, and a written expression of the meaning of symbols used.
Day One
10 min. Drawing practice: draw circles, using different compasses.
15 min. Create a daisy design of 6 or 12 petals. See handout for illustrated directions.
10 min. Create a second daisy design with reflectional symmetry but without rotational symmetry. See handout.
10 min. Create a third daisy design with rotational symmetry but not reflectional symmetry. See handout.
Day Two
Begin mandala design. See handout for illustrated directions.
Day Three
Finish mandala project.

Ideas for Further Independent Student Project
Create a three-dimensional mandala.
Create a mandala with 4 or 8 petals.
Research the history of mandalas in various cultures and locate examples.

<table>
<tr><td colspan="1">Assessment</td></tr>
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Rubric

Projects can be worth any amount of points. A possible rubric is listed below.

Creativity: 20%
- Use of symbols
- Title
- Background/framing
- Creativity in written component including possible references to ethnic/cultural connections of mandalas.

Neatness: 20%
- Typed written component
- Lack of correction marks
- Legible symbols
- Lack of glue stick/glue marks

Accuracy: 60%
- 6 or 12 petal daisy is accurately constructed
- Partial petals are accurately constructed
- Concentric circles are accurately constructed
- Written component explains symbols
- Written component is written using appropriate grammar, etc.
- Name and title appear on the front of the project

SYMMETRY

Reflection symmetry, **line symmetry**, **mirror symmetry**, **mirror-image symmetry**, or **bilateral symmetry** is symmetry with respect to reflection.

It is the most common type of symmetry. In 2D there is an axis of symmetry, in 3D a plane of symmetry. An object or figure which is indistinguishable from its transformed image is called mirror symmetric (see mirror image). Also see pattern.

The **axis of symmetry** of a two-dimensional figure is a line such that, if a perpendicular is constructed, any two points lying on the perpendicular at equal distances from the axis of symmetry are identical. Another way to think about it is that if the shape were to be folded in half over the axis, the two halves would be identical: the two halves are each other's mirror image. Thus a square has four axes of symmetry, because there are four different ways to fold it and have the edges all match. A circle has infinitely many axes of symmetry, for the same reason.
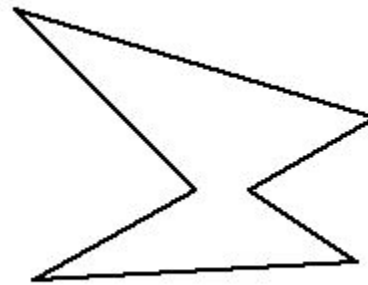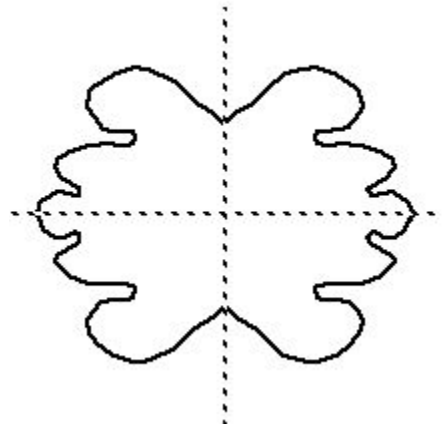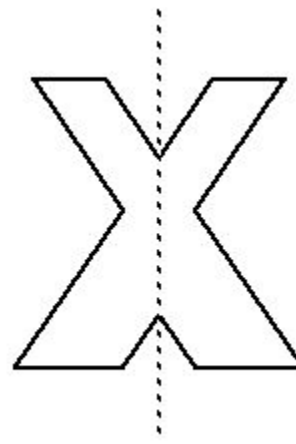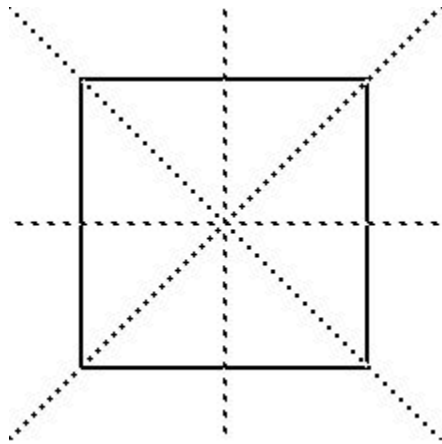
An image has **Rotational Symmetry** if there is a centre point around
which the object is turned a certain number of degrees and the object
still looks the same, e.g., it matches itself a number of times while it is being rotated.
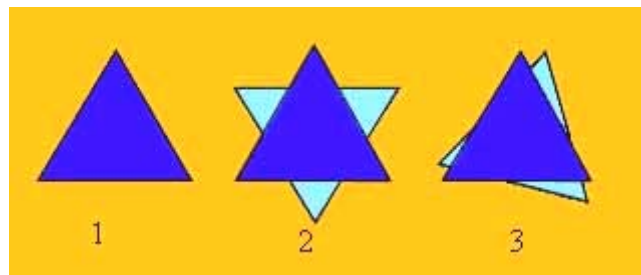
Since this triangle will match itself **3 times** as it is
rotated it is said to have rotational symmetry of **Order 3**
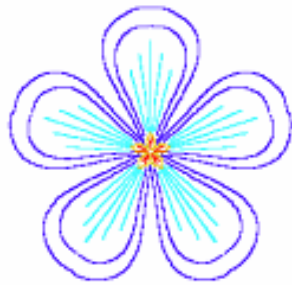
This flower has rotational symmetry of **Order 5** since it matches itself **5 times.**

Since all the toppings are placed so evenly, this pizza has rotational symmetry of **Order 6**
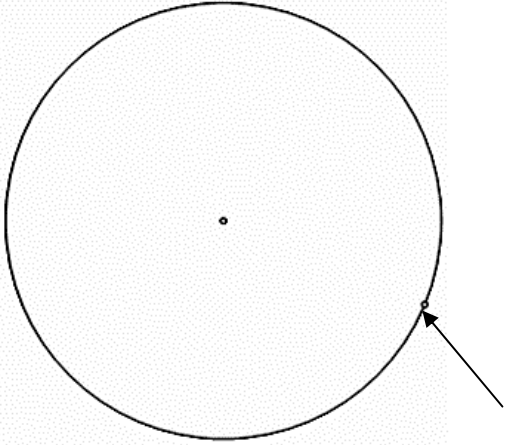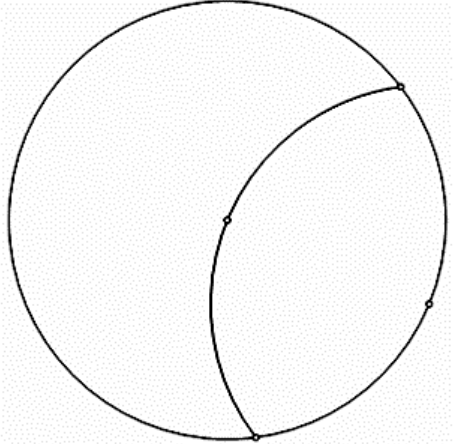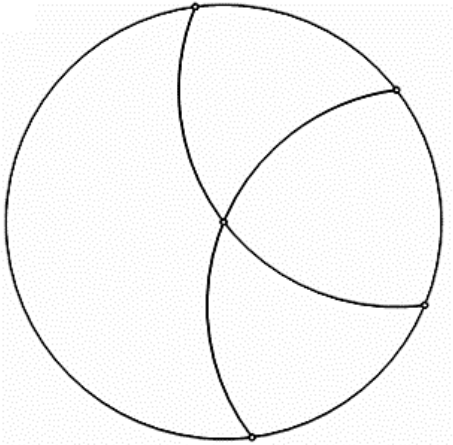
Look carefully at the image on the left. Where is it from?

Notice that it has rotational symmetry of order 2?

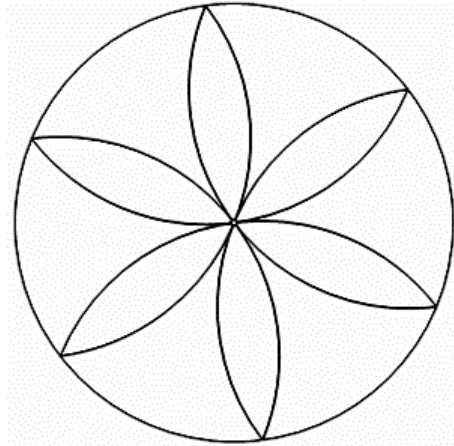Where could you look to see if you have any images that have rotational symmetry?

NB According to the New South Wales Mathematics Syllabus,
'... if an object only matches itself once, it is **NOT** considered to have rotational symmetry.'

Daisy Design Directions

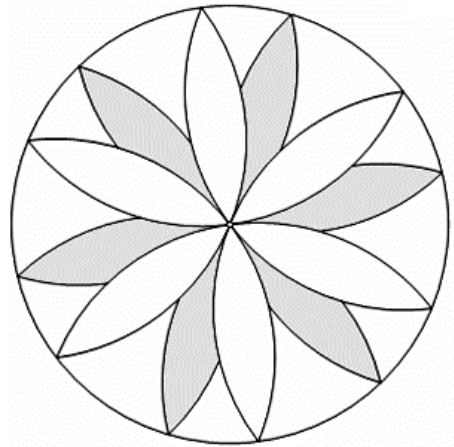|	
1) Use a compass to draw a circle.	
2) Place a random point on the circumference of the circle.	
3) Using the same radius as the circle, place the point of your compass on the point created.	
4) Make an arc from one side of the circumference to the other through the center of the circle.	
5) Place the point of your compass on the intersection of your arc and the circumference.	
6) Create another arc.	

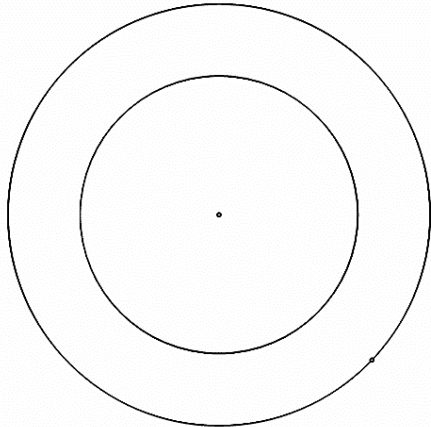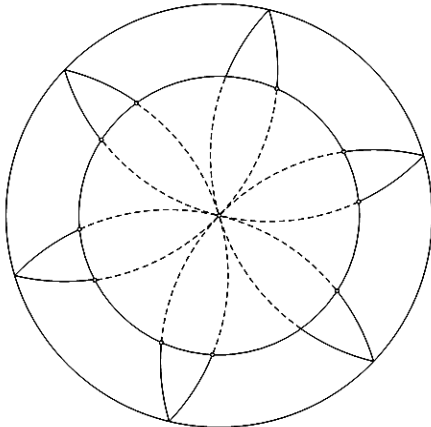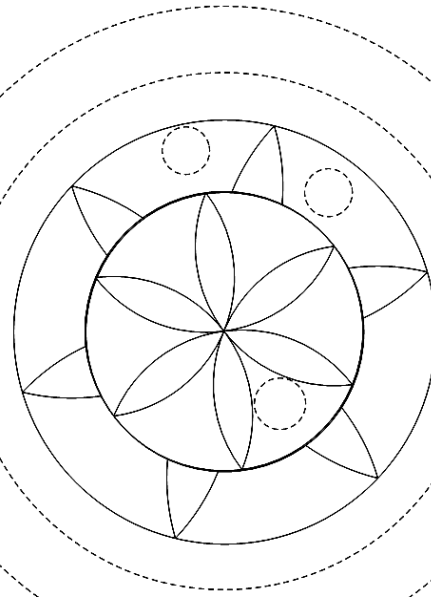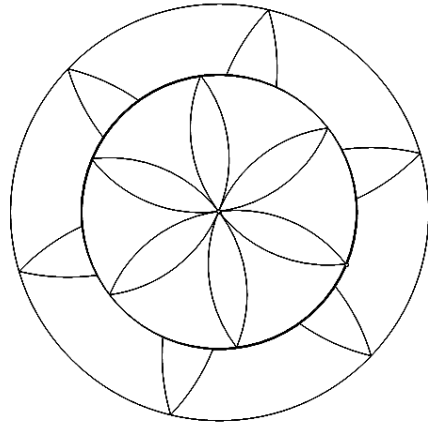|	
7) Continue until all six petals have been created.	
8) Place another random point on your circumference.	
9) Create another six petals to make a total of twelve. Petals should go under the original six petals by creating only the part of the arc required. Note: the shaded petals are in the background rather than the foreground.	

Mandala Project Directions

1) Create two concentric circles by using the same center point and creating two circles with different radii.	
2) Set your compass radius to match the radius of the larger circle.	
3) Construct the tips of the petals of a daisy design by following the steps to create a six petal daisy except allow the compass to mark only the arc between the two concentric circles. Note: Dotted arcs indicate the portions that are not drawn.	
4) Create a six or twelve petal daisy within any circle in your design.	

5) Optional: Add more circles wherever you want. The dotted circles show possible choices.	
6) Add symbols that represent your life. Examples might include your favorite colors, sport symbols, etc.	
7) Create a written expression of the meaning of your symbols. This could include paragraphs, poetry, songs, etc.	
8) Create a frame for your mandala.	
9) The title and your name should appear on the front of your project.	

Mandala Examples