Subject Class_Math_____ UNIT___Geometry_____ Grade Level _7-9__
Teacher Name ___Dr. Joseph_

LESSON PLAN: Math Example – Circle Geometry: A Paper Folding Journey

1. What is the **ESSENTIAL QUESTION** that I want my students to be able to answer?

   Why are circles important in our lives? What are some applications of circles in our world today?

2. What **STATE/NATIONAL STANDARD(s)** am I addressing in this lesson?

   NCTM Standards and Expectations: Geometry 9-12 (National Standard)
   - Draw and construct representations of two- and three-dimensional geometric objects using a variety of tools.

   Common Core State Standards for Mathematics (National Standard)
   - G-CO-12: Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.).

   New York State Standards
   - 7.G.3: Identify the two-dimensional shapes that make up the faces and bases of three-dimensional shapes (prisms, cylinders, cones, and pyramids)

3. What are the MAIN IDEAS (maximum of 3) students need to know about this topic? **(OBJECTIVES/PERFOMANCE INDICATORS)**

   Given a circular cutout students be able to **construct** and **identify**:
   the radius, diameter and center of a circle;
   the vertex, base and midpoint base of a triangle;
   two-dimensional shapes (semi-circle/half circle, quarter-circle, triangle, parallelogram-rhombus, trapezoids; and three-dimensional shapes (tetrahedron, frustum).

4. What **MATERIALS** (e.g. activity sheet, lyrics, map, software, etc.) will I use in this lesson?

   Circle Cut-out, Scissors, Computer w/Internet and Projector, Dr. Joseph's Paper Folding Website: **http://tinyurl.com/4f9yb7l**

5. What AIM question will I ask the class to answer? **(UNIT QUESTION(s))**

   What is a Circle? What geometric shapes can be constructed from a circle?

6. How will I open the lesson and capture student interest? **(MOTIVATION)**
   Circles are part of our everyday life. Wheels, plates, CD's, and coins are some examples…can you think of others?

7. What **LEARNING THEORY** are you using to develop this lesson?
   (*Refer back to the objectives of this lesson and focus on the verbs)* According to Bloom's Taxonomy **identifying** concepts falls within the **Knowledge level** of the taxonomy, and **constructing** falls within the **Synthesis/Creation level**.

According to psychologist Jean Piaget's, children are active learners who master concepts by progressing through three levels of knowledge--concrete, pictorial, and abstract. The use of manipulatives enables students to explore concepts at the first, or concrete, level of understanding (See article on Using Manipulatives: http://www.teachervision.fen.com/pro-dev/teaching-methods/48934.html).

8. What **ACTIVITIES** will I use to help students discover what they need to learn and that will enable all students to demonstrate their learning?

   Using a Math Manipulative: Paper folding activity – this activity requires students to follow specific procedures in order to discover the geometric properties of a circle.

9. Provide a clear description of the **PROCEDURES** you will use to implement the lesson. In the event of an absence, a substitute teacher should be able to follow the procedures you provide below to implement your lesson.

   a. Distribute the paper circles to each student, and go to Dr. Joseph's Paper folding website: http://tinyurl.com/4f9yb7l
   b. Ask class, "What is a circle?" List students' responses on the board. "The locus of points equidistant to a fixed point" should be included in the discussion.
   c. Look at the shape you are holding. Describe it. It is a (***circle***).
   d. Look at the outer edge of your circle. What is the distance around the outside of the circle called? (***Circumference***)
   e. Fold your circle directly in half and crease it well.
   f. Open the circle, the crease you made is the (***diameter***) of the circle.
   g. Hold the circle at the ends of the crease. Fold your circle in half again, but this time match up the end points of the crease.
   h. Open your circle, is this also a diameter? How do you know? Do the lines (***intersect***)? Yes. Is there something special about the way these lines intersect? They create four 90^{o} (or right) angles. This special type of intersection is called (***perpendicular***).
   i. Place a dot, no bigger than the width of a pencil, at the point where the creases connect. This is called the (***center***) of the circle.
   j. Using your pencil, trace one of the lines from the center to the edge of the circle. This line from the center is called a ***(radius***).
   k. Fold in one of the outer, curved edges of the circle until it just touches the dot in the middle. Crease it well.
   l. Open the fold and look at the crease you just made. Is it a diameter? Is it a radius? Why or why not? This line is called a (***chord***).
   m. Look at the curved part of the circle between the points where this line touches the outside of the circle. This is called an (**arc**). Can you find other arcs on your circle?
   n. Take the opposite side of your circle and fold it so that the curved part just touches the center and the bottom forms a perfect point. Your circle will look like an ice cream (***cone***). Crease it well.
   o. Fold the top of your ice cream cone down until the curved part just touches the center of the circle. The top corners should make perfect points, crease well. Now describe the shape you have. ***(Triangle***) Do you notice anything special about this triangle? Look at all of the (***angles***), they are the same as well as all of the sides are the same. This triangle is called an (***equilateral and/or acute triangle***). You could also use (***equiangular***).
   p. Fold the new triangle in half by matching up two of the points. Crease well. The new cease splits the triangle in half, this line is called the (***height*** or ***altitude***). Can you figure out anything else about this triangle? It is a (***right triangle***).
   q. Open the right triangle up to the equilateral triangle.

r. Take the top corner of the big triangle and fold it. By folding along the crease of the height you can match the top point up to the bottom crease line. On the inside you will now see three smaller triangles.
s. Turn the paper over so that you do not see the creases. What is this shape called? Since it has four sides it can be classified as a (***quadrilateral***). Since this quadrilateral has two sides that are (***parallel***) and two that are not it is also called a (***trapezoid***).
t. Turn it back over so that you now see all of the creases. Fold one of the outer triangles in so that it lies directly on top of the center triangle. Turn it back over and describe the shape you now see. In mathematics this shape is called a (***rhombus***).
u. Turn your shape back over and fold the last outer triangle over onto the center one again. You should now have a smaller equilateral triangle.
v. Open up all three of the small triangles. Bring the three loose points together so that you now have a (***pyramid***). At this point you can discuss (***faces***) (***edges***) (***points***) (***vertices***) (***base***) and the fact that this is a (***triangular pyramid***) and not a squared pyramid like those built in Egypt.
w. Open your pyramid back up to the large equilateral triangle.
x. Fold over one of the points so that it just touches the dot in the middle. What shape have you re-created? The trapezoid though not the traditional shape it can still be identified as a trapezoid.
y. Fold one more of the points in so that it just touches the dot in the middle. Now what shape do you have? (***Pentagon***) Even though it is not the traditional shape you are accustomed to, it still has five sides, therefore it is still classified as a pentagon.
z. Now fold in the last point. What shape is it now? (***Hexagon***) Discuss (***plane***) figures.
aa. Turn to the other side and fit one of the corners into a flap on the opposite side of the triangle. You may have to try more than one. Choose the one that makes the best fit. Slide the last corner under/inside the others. You have now created a (***truncated tetrahedron***)!
bb. For any of the shapes during this activity you can have students calculate the surface area, volume, perimeter and/or area.

(See http://www.math.wichita.edu/history/activities/geometry-act.html)

10. What Key Questions will I ask to help summarize, assess, and facilitate learning? **(Assessment/Content Questions)**

What is a circle? What geometric shapes can we create with a circle? What is the difference between a 2D and 3D figure? See additional questions within the Procedures section above.

11. How will you know that your students have learned what you wanted them to learn? **(ASSESSMENT linked to OBJECTIVES)**

If the constructions are correct, each student will be able to show their three-dimensional final tetrahedron or frustum. I will ask each student to show me their final product.