GRACE Education Curriculum Satellites	
Teachers	Grades 9-12
Pre-Algebra & Algebra	

The Conics of Orbital Paths

[The Shapes of Orbital Paths]

Background Information:

Satellites may follow one of four different flight paths: a circle, an ellipse, a parabola, or a hyperbola. All Earth satellites travel in ellipses. **GRACE** will travel in an elliptical orbit. The rate of speed of a satellite is a determining factor of the orbital path it will take.

Objectives: The students will:

- Model the paths in which spacecraft may travel.
- Become familiar with the basic concepts of the conics of mathematics.

Standards: Math: algebra; measurement; geometry
Science: unifying concepts & processes; physical science

Vocabulary:

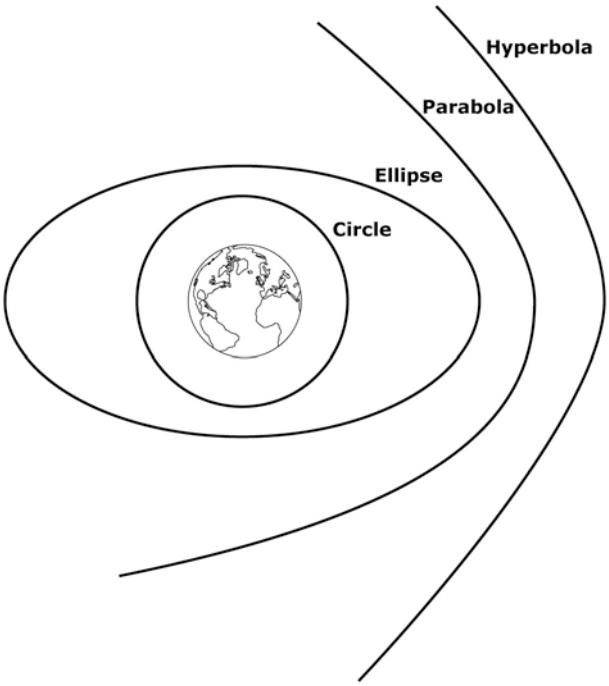
orbital path	ellipse	Parabola
hyperbola	circular orbit	conics
escape velocity		

Materials:

Cone-shaped paper cups (4 per group or 4 per student)
Construction paper (4 per group or 4 per student)
Scissors
Tempera powder, ink, or rubber-stamp pad
Cutting tool or single-edged razor blade

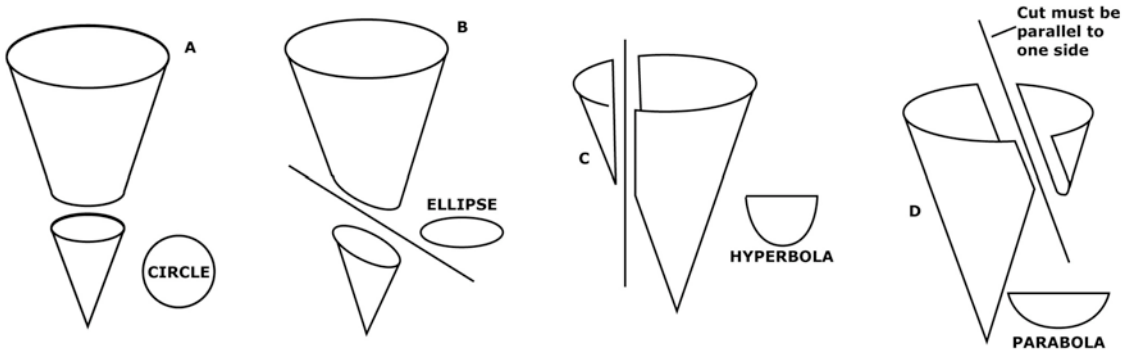
Directions to the Teacher:

1. A review of the shapes of the circle, ellipse, parabola and hyperbola may be needed.



2. Start by having the students cut out a circle, ellipse, parabola and hyperbola from the construction paper. Have the students compare the cut outs using the questions on the provided handout.
3. Once this is complete, discuss with the students where these shapes originate. Your discussion may be as follows:

   Orbits take us into the conics of Mathematics. This subject helps to explain the shapes for our orbital paths. The name conic is from the cone. All shapes of orbital paths may be found by slicing a cone. We will be creating these paths in our next activity.
4. Have the students cut four cones as shown below:



Dip the edges of each shape/cut into the tempera powder/ink/rubber stamp and print the shape on a piece of paper. Make sure you label each shape correctly as you go. Identify the differences between the circle and ellipse, as well as between the parabola and hyperbola. Again, discuss which are complete (closed) – the Circle and Ellipse and which are incomplete (open) – the Parabola and Hyperbola.

5. Discuss with your students the two rates of speed which determine the four types of orbital paths. A rate of over 17,500 miles per hour will put the satellite into orbit (circular or elliptical) and a rate of 25,000 miles per hour (escape velocity) to go into deep space (parabolic or hyperbolic). You may wish to have the students try to guess the speed and the associated type of orbit. The final two questions on the handout can be answered after this discussion.

Extensions:

Find an example of satellites that travel in each of the four orbital paths.

Select one satellite to do in-depth research and report back to the class.

Play the "Ellipse Game" at: http://johnbanks.maths.latrobe.edu.au/Games/Ellipse/

References /Resources:

http://www.space.edu/projects/book/chapter5.html

Name: _____

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Answer the following questions after making the cutouts.

1. What do you notice about each shape? (complete, incomplete)

2. What shapes do you have a complete cut-out of?

3. Why do you think the incomplete cut-outs are incomplete?

Answer the following questions after the discussion of rate of speed for orbits.

4. What shape(s) or orbit will support a speed of 17,500 miles per hour?

5. What shape(s) will orbit at least 25,000 miles per hour?

6. Why do you think the different shapes occur at the different rates of speed?