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Emilie du Chatelet Activity

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Émilie du Châtelet Activity

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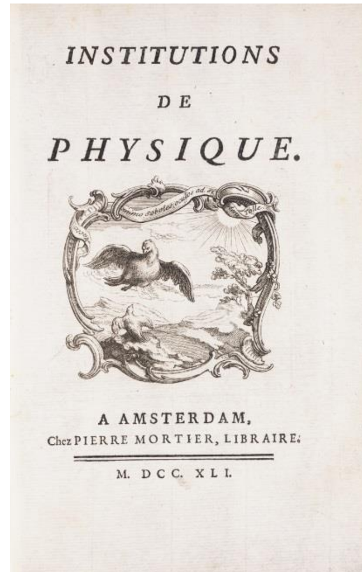
Overview: This activity was originally created for a Women in Mathematics course to provide students with a small taste of some basic mathematics connected to work of Émilie du Châtelet. The activity has the students use some algebra to look at rates of change (velocity and acceleration) of a paraboloid apparatus. It could also be used in other courses, such as history of math, high school or college algebra, and calculus.

Best known for her translation of and commentary on Newton's *Principia*, Émilie du Châtelet, also published other works. Born Gabrielle-Émilie Le Tonnelier de Breteuil, married to the Marquise du Chastellet, and mistress of the French poet Voltaire, Émilie was a mathematician and scientist in France during the Enlightenment. The image to the right is the title page of a revised French edition of Émilie du Châtelet's *Institutions de Physique*, published in 1741 in Holland. The first edition was published the previous year, and several other editions followed. Émilie wrote this book, in which she assimilated points of view of Descartes, Newton, and Leibniz, to teach new ideas in physics to her thirteen-year-old son. Notice that her name is not mentioned on the title page of this edition. There was a 1742 edition also published in Amsterdam which was not anonymous.



Each chapter begins with a delightful graphic exhibiting mathematics or science in some way. For example, Chapter 14 on the phenomena of gravity has a picture of a device used to demonstrate Galileo's law of natural motion. The paraboloid apparatus involves dropping balls on a spiral track to show that each turn of the spiral is traveled in the same amount of time (isochronism). In this activity, we will examine some mathematics connected to this device.

According to the virtual Galileo Museum (https://catalogue.museogalileo.it/object/ApparatusToDemonstrateIsochronismFallsAlongSpiral.html), there are only two such devices currently known to be in existence. The picture below is at the Galileo Museum (https://www.museogalileo.it/en) in Florence, Italy, taken by the author, Dr. Huffman, while on the 2012 MAA Study Tour.

Émilie and Voltaire conducted many experiments during their 15 years together at her estate house Cirey. Evidently Émilie was familiar with this device since a picture of it was included in her book. The spiral track is a curve on a paraboloid, which is a surface of revolution. To describe the spiral curve, we need a vector-valued function, which is beyond the prerequisites for this course. So, for this activity, we will simplify things and just work with level curves of the paraboloid, which will be circles. You could imagine looking down from above the apparatus and think of each lap around as a circle.

Before starting the activity, watch a video demonstration of the apparatus at https://catalogue.museogalileo.it/multimedia/IsochronismFallingBodiesAlongSpiralOnParaboloid.html .

1. According to the video, the first lap around has length 1. For simplicity, we will assume the lap is a circle. Recall that the circumference of a circle is πd, where d is the diameter of the circle.

a. What is the diameter d of a circle with circumference $\pi d = 1$? (Give an exact answer and then an approximate answer rounded to the nearest hundredth.)

b. What is the radius r of the circle? (Give an exact answer and then an approximate answer rounded to the nearest hundredth.)

c. Recall that the standard form of an equation of a circle is $(x-h)^2+(y-k)^2=r^2$, where r is the radius of the circle and the center is at the point (h,k). Assuming that the circle is centered at the origin (0,0), state the equation of the circle in standard form. (Use the exact answer for r.)

2. Follow the same steps to derive the equation of the circle in standard form whose circumference is 3.

3. Follow the same steps to derive the equation of the circle in standard form whose circumference is 5.

5. This paraboloid apparatus was designed to demonstrate Galileo's Law of Falling Bodies – bodies fall toward Earth at a constant acceleration due to gravity. In other words, if one ignores air resistance, acceleration is constant. We will use $a = 2$. Velocity will then be increasing during the fall in a manner proportional to time, $v = at = 2t$, and the total distance travelled will be directly proportional to the square of the time it takes to fall, so $\text{distance} = \frac{1}{2}at^2 = t^2$. (If you have had calculus, you can obtain velocity by integrating acceleration and distance by integrating velocity and using the initial conditions of starting at rest and starting distance 0. Often acceleration is given as a negative number to denote falling down, but we will go ahead and use a positive one.)

Fill in the following table assuming 1 second per loop. The symbol Δ means "change in." Does this apparatus demonstrate Galileo's Law of Falling Bodies by showing that acceleration is constant?

Loop	Total time by end of loop	Δt within the loop	Total distance t^2 ball has gone by end of loop	Δ(dist) within the loop	Average velocity in loop = $\frac{\Delta(dist)}{\Delta t}$	Actual Velocity at end of loop $v = 2t$	Average acceleration in loop $a = \frac{\Delta v}{\Delta t}$
1	1	1-0=1	1	1-0=1	$\frac{1}{1} = 1$	2	$\frac{2-0}{1} = 2$
2	2	2-1=1	4	4-1=3	$\frac{3}{1} = 3$	4	$\frac{4-2}{1} = 2$
3	3		9			6	
4							
5							
6							
