

Mathematics 1110H – Calculus I: Limits, Derivatives, and Integrals

TRENT UNIVERSITY, Summer 2026 (S62) [reading course]

Assignment #2

Due on Friday, 3 July.*

Please read Section 3.4 of *Sage for Undergraduates*, which is about plotting curves implicitly defined by equations in x and y , before tackling this assignment.

The `axes=True` and `gridlines="minor"` options mentioned in Section 3.4 are useful when working through some of the questions below. You will probably need to experiment a little with the limits for x and y in the plots to make sure that your plot displays the entire curve asked for.

A *cardioid* with parameter a , where a is a real number, is the set of points (x, y) satisfying the equation $(x^2 + y^2)^2 + 4ax(x^2 + y^2) - 4a^2y^2 = 0$.

1. What does the cardioid with parameter $a = 0$ look like? Explain why. [0.5]
2. Use SageMath to plot the cardioids with parameters $a = 1$, $a = -1$, $a = 2$, and $a = -2$, respectively. What effect do the changes in parameter have on the cardioid? [3]

A *limaçon* with parameters b and c , where b and c are real numbers, is the set of points (x, y) satisfying the equation $(x^2 + y^2 - bx)^2 = c^2(x^2 + y^2)$.

3. What does the limaçon with parameter $b = 0$ and $c = 0$ look like? Explain why. [0.5]
4. Use SageMath to plot the limaçons with parameters $b = \frac{1}{2}$ and $c = \frac{1}{2}$, $b = \frac{1}{2}$ and $c = 1$, $b = 1$ and $c = \frac{1}{2}$, and $b = 1$ and $c = 1$, respectively. What effect do the changes in parameter have on the limaçon? [3]
5. Find values for the parameters b and c for the limaçon that make it be the cardioid with parameter $a = -1$. [3]

Probable-Possible, my black hen,
She lays eggs in the Relative When.
She doesn't lay eggs in the Positive Now,
Because she's unable to Postulate How.

Frederick Winsor (from *The Space Child's Mother Goose*)

* You should submit your solutions via Blackboard's Assignments module, preferably as a single pdf. If that fails, please submit directly to the instructor on paper or via email to sbilaniuk@trentu.ca. You may work with others, use whatever tools you like, and look things up, so long as you write up your submission by yourself and give due credit to your collaborators and any tools or sources you actually used.