**Prior projects:** Prior to doing this project, students should have done these project:

- Guidelines for 3D Graphing

**Philosophy behind this project:**
Our primary goal for the semester is to improve students' conceptual understanding of Calculus 3. We found that students often get caught up in the computations of line integrals, Green's Theorem, Stokes' Theorem, and the Divergence Theorem that hinders developing a sense of what their work represents or means.

The university provides students with free access to Mathematica. Our intention is to encourage students to take advantage of this resource to ease some of the pressure that may come from intensive computations. This project functions as a walk through introduction to Mathematica for students.

A secondary goal for the semester is to improve students' spatial visualization skills. We ask to create 3D graphs by hand and Mathematica. Having students work with multiple methods for generating visuals is aimed to address this.

**Learning Goals:**

1. Introduction to basics of Mathematica, such as notation and plotting
2. Review of 3D coordinate system
3. Review of plotting points in 3-space
4. Review of vector notation
5. Review of unit vector
6. Review plotting vectors
7. Review of vector addition
8. Review of scalar multiplication
9. Review of polar coordinates
10. Review of parameterization
11. Review of sketching graphs in 3-space
12. Review of equation of circle and sphere

**Implementation Notes:**

1. Instructor and TA will need to know some Mathematica basics to help facilitate this project.
2. Students will need access to a laptop with Mathematica installed on it to complete this project. Since there will be students who may not have a laptop or forget to bring their laptop to class, be sure to create groups where at least one (preferably two) members of the group have a laptop with Mathematica installed.
3. Students should begin this project before coming to Thursday's recitation. During the first day of class they should be instructed to install Mathematica on their computers. Also, students should attempt pages 1 and 2 after the first day of class. Before the recitation (Day 4), they should also attempt pages 3 and 4. Encouraging students to work on this project before the recitation will help them arrive to class with questions or issues they encountered.
4. Throughout this project students are expected to discover the appropriate syntax for different Mathematica functions. As different groups learn how to use Mathematica, you should encourage them to share out to the rest of the class or other groups.
5. When discussing Mathematica, remind students that it is a tool that they should not become overly reliant on, and that they will be expected to work through computations and create graphs by hand on quizzes and exams.
6. Page 1 gives an example to help students learn how to use Mathematica for basic computations.
7. Page 2 introduces students to using Mathematica for graphing, and has students practice orienting themselves to Mathematica's output using the right-hand coordinate system.
8. Page 3 is more practice using Mathematica for computations in the context of vector operations.
9. Page 4 asks students to use Mathematica to graph vector addition and scalar multiplication to see how these operations impact vectors.
10. Page 5 has the students review polar coordinates and parametric equations. We ask the students to use the internet to learn the syntax for plotting parametric equations in Mathematica.
11. Page 6 asks the students to practice orienting themselves to Mathematica's output of a space curve. The students then work on the spatial visualization by hand drawing the helix. There is also a review of creating a parametric equation for the helix.
12. Page 7 has more practice with the 3D coordinate system. Note on the first problem, students will not be able to determine the difference between the $x$-axis and $y$-axis due to symmetry of the hemisphere. Students are asked to create a drawing of the hemisphere by hand. We may want to encourage students to focus just on the first octant due to the symmetry of the hemisphere. Lastly, the we ask for students to come up with a function representation for the hemisphere, and then search how to use Mathematica to plot their hemisphere function.

**Wrap-Up:**

1. How much the students work on this project before Thursday's recitation will dictate how much time you will have for a wrap-up.

2. The wrap-up should emphasize that Mathematica is a powerful tool, but students should not become too dependent on it.

3. There needs to also be a discussion of the importance of being able to visualize objects in 3-space. Students will need this throughout the semester for understanding derivatives in 3-space, finding bounds of integration, and theorems in vector calculus.