**ENGR 2013: Engineering Analysis and Applications**

**Laboratory No. 9: How Can We Rotate Objects in 3D?**

**Goal:** This lab demonstrates how to plot and rotate objects in 3D. It builds on what we did in Lab No. 3.

**Preliminary Work:** Walk through the plotting steps described in this article:

*https://pythonnumericalmethods.berkeley.edu/notebooks/chapter12.02-3D-Plotting.html*

Once you have mastered the basics, then you can study this article on rotating 3D objects:

[*https://www.geeksforgeeks.org/computer-graphics-3d-rotation-transformations/*](https://www.geeksforgeeks.org/computer-graphics-3d-rotation-transformations/)

Finally, you can study this article to understand how to generate a projection of your rotated cube on a 2D surface:

*https://stackoverflow.com/questions/29549905/pylab-3d-scatter-plots-with-2d-projections-of-plotted-data*

In this lab we will work through a few simple examples.

**Tasks:**

1. *Visualize the Data:* Write a Python program, **p01.py**, that generates and plots a cube in 3D.
2. *Rotation:* Write a Python program, **p02.py**, that rotates and plots the rotated cube. Your program should take an angle in degrees as an argument (technically it should take two angles, but we will keep this lab simple). You can decide whether you want to rotate around a particular axis or point in space – it is up to you. Be prepared to explain your method to the course instructors.
3. *Projection:* project the rotated cube onto the $xy$ plane and plot the projection in 3D (**p03.py**), as demonstrated in the above tutorial.
4. *Have Some Fun:* Generate an interesting shape not discussed in the previous steps (e.g., a parallelepiped). Demonstrate you can rotate and plot this shape (**p04.py**). Your program should take an angle (or perhaps two angles!) in degrees as an argument. You will be graded on your creativity!

**Summary:**

As we learned before, one of the core operations in computer graphics is an image rotation. In the early days of computers, these were restricted to 2D plots. However, today, we can of course interactively rotate shapes in 3D space effortlessly due to advances in computer graphics software and hardware. To learn more about 3D plotting in Python, go here:

*https://www.geeksforgeeks.org/introduction-to-3d-plotting-with-matplotlib/*