**ENGR 2013: Engineering Analysis and Applications**

**Laboratory No. 8: Can We Model Physical Systems Using a System of Differential Equations?**

**Goal:** Understand how to model a real world physical system using a system of differential equations.

**Preliminary Work:** Read the example titled “Nutrient Flow in an Aquarium” in this document: *https://www.math.utah.edu/~gustafso/2250systems-de.pdf*. We will focus on this system of equations:

where

**Tasks:**

1. Solve the system of equations analytically by computing the eigenvalues and eigenvectors. Plot the functions and .
2. Using a numeric differential equation solver in Python, solve the same set of equations and demonstrate that your solutions match the analytic solutions by plotting the results and comparing them to the plots generated from the analytic solution.

**Summary:**

Electrical circuits and networks can be modeled as a system of differential equations. The outputs for both DC and AC inputs can be computed by solving such a system of equations. Further, both the transient and steady-state solutions can be obtained using the methodology above.

Even more interesting is the fact that a linear th-order differential equation can be transformed to first-order differential equations and solved using the techniques above. Hence, the ability to model a physical system as a system of linear differential equations, even if they are nonlinear equations, is an extremely important engineering tool. This is essentially the essence of what an engineer does – model physical systems with an appropriate level of mathematics that allow the system to be understood, manipulated and optimized.