CALIFORNIA STATE SCIENCE FAIR
2009 PROJECT SUMMARY

Name(s)
Brian S. Lee

Project Number
S1609

Project Title
Mathematical Approaches to a Neat Problem

Abstract

Objectives/Goals
This project introduces a neat problem in two different settings that are mathematically the same. The first setting has two cylindrical tanks where the tank on the right is filled with water and the tank on the left is empty. The two tanks are connected by a pipe at the bottom and the right tank has an outlet pipe at bottom. The second setting involves an electrical circuit with two capacitors, two resistors, and a battery. The capacitor on the right is initially charged while the capacitor on the left has no charge at all. The question is: will the water level on the left (L) tank always be lower than the water level on the right (R) tank? Or, will the charge on the left capacitor always be lower than the charge on the right capacitor? The objective of this project is to use a mathematical model of differential equations to answer the question algebraically and numerically and verify with an experiment.

Methods/Materials
Algebraic method - Given a mathematical model of differential equations, solve it for the ratio of R/L at equilibrium under various constants. Numerical method - Use TI-89 calculator program and functions to find numerical solutions of the differential equations at different constants. Experimental method - build a circuit using two capacitors, two resistors, and a 6 volts battery. Use DataMate software and TI-89 for collecting data. Vary the resistor values to see the effects on the ratio of R/L. With the two voltage probes on the two capacitors, the CBL 2 will take the measurements and transfer them to the TI-89 for graphs and data storage.

Results
All of the graphs with any pair of resistors in the experiment show that the charges in the left capacitor exceed the charges in the capacitor on the right after they intersect with each other. Also, as for the algebraic and numerical methods, any combination of constants a, b, and c gave us the R/L ratio of less than one at equilibrium, which indicates that the water level or charges on the left tank or capacitor becomes greater than those on the right after a while.

Conclusions/Discussion
The results from all three approaches concur that the water level or charge on the left water tank or capacitor is greater than the one on the right. Thus, I conclude that the experiment correctly verified the results of algebraic and numerical approaches and that my hypothesis was partially correct.

Summary Statement
The purpose of this project is to solve a neat problem algebraically and numerically using a mathematical model of differential equations and to verify them with an experiment.

Help Received
My AP Calculus teacher Mr. Jacotin helped me with understanding of the equilibrium points in differential equations.