MA206 Project #3-1 (50 pts) **DUE: In class Lesson 25**
Spring 1998 Expected time to complete: 2 hours
Issued Lesson 22

Each member of your group is expected to contribute up to 2 hours towards the completion of this project. This project effort is compensated by the absence of reading and drill assignments for Lesson 20, CP Alpha.

GENERAL:

1. The project will be worked in groups of three or four as determined by your instructor.
2. For project format, follow the guidance given in the Project and Technical Report Format and Writing Guide. This guide is available on the MA206 home page (http://www.dean.usma.edu/math/core/ma206/index.htm) by clicking on the "Project Template" link under "Administrative Links".
3. You will integrate mathematics, science and technology throughout the course of this interdisciplinary applications project. With this in mind, it is important that you review material from your MA104 and PH202 courses. If you do not review this material, you may not be able to complete the entire project.
4. Follow the Department of Mathematical Sciences policy on reporting numerical answers. This policy is also available on the MA206 home page. Click on "Significant Digits Memorandum" under "Administrative Links" to access this.
5. **This project is due in class at Lesson 25 on 2-3 April.**
6. **This is a graded homework assignment. You are required to document any assistance that you received in accordance with *Documentation of Written Work*, July 1997. This includes assistance from any cadets in your PH202 RC Circuit lab group who are NOT in your MA206 project group.**

PROJECT FORMAT NOTES:

1. Submit your project in a folder.
2. Create one title page that you will use for the remaining parts of this project.
2. Do NOT include an executive summary or table of contents for this portion of the project.

SITUATION:

Physics is generally regarded as the most fundamental physical science. It is a science based on experimentation and theory. The goal of physics is to develop theories that are capable of predicting the outcomes of experiments. These theories are expressed in the language of mathematics. Technology facilitates the use of mathematics within the science. In this project, you will integrate science, mathematics and technology within an important division of physics - electromagnetism.

You will study RC and RLC circuits; two fundamental components found in common electronic devices. The first circuit to be analyzed is the RC circuit – which is shown in Figure 1. When a potential difference is applied across a capacitor, the rate at which it charges up depends on its capacitance and on the resistance in the circuit.

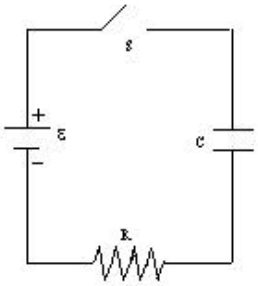

Figure 1. RC Circuit

DATA COLLECTION:

You will collect data for this project during your PH202 RC Circuit Lab. In this lab you will vary the resistance in your circuit and measure the time it takes for the voltage to reach $0.632e$, where e is the voltage on the power supply. Once complete, you are to set the resistance in your circuit to 10,000 ohms and take 50 such time measurements. This data set, referred to as "RC Time, is an essential part of this project. Each project group is responsible for collecting its own data set, and saving it for use during the remainder of this project.

Note: Report the average of your data set to your instructor.

REQUIREMENTS:

1. Consider the RC circuit shown in Figure 1.

a. (5) Kirchoff's rules are based on two physics principles dealing with laws of conservation. Explain Kirchoff's rules and how they apply to circuits in general.

b. (5) Apply Kirchoff's loop rule to the circuit after the switch is closed and write a differential equation with charge (q) across the charging capacitor as the dependent variable. Show all your work.

c. (10) Using the mathematical techniques you learned in MA104, derive the function for the voltage across the charging capacitor as a function of time (t). Assume $q(0) = 0$, or that the capacitor is fully discharged prior to charging.

d. (5) Describe some applications of an RC circuit.

2. Now consider your "RC Time" data set.

a. (10) Using Minitab, or any other appropriate technology, generate some visual representations of your data. Use the visual graphing techniques you learned in Block 1 to analyze your RC Time data set. At a minimum, construct the following graphs of your data set:

- Stem-and-Leaf Display
- Histogram
- Boxplot

Comment on the shape and symmetry of your data set. What do the different graphs tell you about your data?

b. (5) Use Minitab's "Descriptive Statistics" macro to generate various measures of location and variability. Briefly define and relate each measure to you data set. How do these measures agree with your comments from part (a) above?

c. (5) Identify sources of error that contributed to the variability in your data. Explain how each of these sources affected your data. Recall that you performed this experiment to measure C, the capacitance, of your capacitor. How does the variability in your data affect your ability to measure C? Recommend how one might reduce or control these sources of variability if performing this experiment again.

d. (5) Now you will use mathematics to model the RC Time data set. Define a random variable, X, that represents the population of your data set. Do any of the distributions presented in MA206 model the probability distribution of your data set? If so, define the distribution of X and estimate the distribution's parameter(s). Clearly justify your selection of distribution and parameter estimation.