MA206 Project #3-2 (250 pts) **DUE: In class Lesson 32**
Spring 1998 Expected time to complete: 4 hours
Issued Lesson 25

Each member of your group is expected to contribute up to 4 hours towards the completion of this project. This project effort is compensated by the absence of reading and drill assignments for Lesson 32, CP Bravo (2 hours) and one hour each from Lessons 30 and 31.

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 32 on 22-23 April 1998.**
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 NOT in your MA206 project group.**

PROJECT FORMAT NOTE:

1. Include an executive summary/memorandum and table of contents with your submission.
2. Include Project 3-1 as an appendix to this submission.

SITUATION CONTINUED:

You will now study a series RLC circuit, shown in Figure 2. This type of circuit can be tuned to react to certain frequencies. When an alternating current source is applied to the circuit, it will set up a current whose magnitude is largely dependent on the frequency of the source as compared to the "tuned" frequency of the circuit.

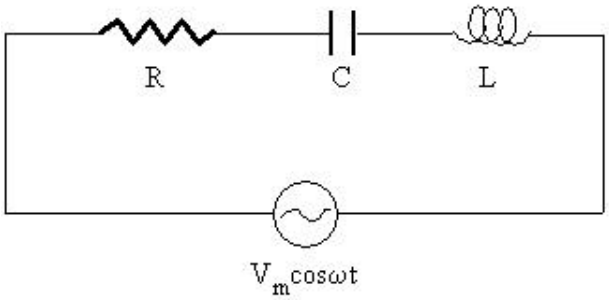

Figure 2. RLC Circuit

REQUIREMENTS CONTINUED:

1. Consider the RLC circuit shown in Figure 2.

a. (10) In the first part of this project you applied Kirchhoff's loop rule. Now apply the loop rule to this RLC circuit and write a differential equation with current (I) as the dependent variable. Show all your work. HINT: current is the rate of change of charge.

b. (40) Use mathematics to solve the differential equation to find the function for current in the circuit. You may assume that at the moment when the switch is closed, $I = 0$ and $\frac{d}{dt} I = 0$. What is the long-term behavior of the current?

c. (20) Now assume

$R = 200$ ohms	$e(t) = 5\cos(wt)$ volts
$L = 1$ henry	$C = 20$ microfarads

Plot the current vs. angular frequency (w). Interpret your results. Do you think that there is a frequency which maximizes the current? If so, where would it occur? Explain your reasoning.

d. (10) Use an appropriate technology to plot the power lost in the circuit vs. frequency. Describe this loss qualitatively. HINT: $P = VI$

e. (15) Describe some applications of an RLC circuit.

2. Suppose the RLC circuit you just analyzed is an integral component of a SINCGAAR's radio system. Furthermore, you are interested in modeling the lifetime of such a radio system. You learn that the Army Materiel Command (AMC) sponsored a study that measured the lifetimes of 50 SINCGAAR radio systems.

At this point you must access a MINITAB file containing the measurements described above. The file can be found on the MA206 home page. Look under the "Projects" section and click the "Radio Failure Time" link. This MINITAB file contains 500 lifetime measurements. Your group will randomly select a sample of 50 data points. Thus, each project group will work with a different data set for this project. Follow these instructions to create your data set:

(1) Start MINITAB.
(2) Open the data file using the "Open Worksheet" option under the "File" menu.
(3) Using the "Calc" menu, Set Base = xxxxxxxxx, using the SSN of the alphabetically ranking cadet in your project group.
(4) Go to the "Calc" menu and select "Random Data," and then "Sample from Columns." Sample 50 rows out of the original 500.
(5) When this is complete, you should have one column containing 50 data points.
(6) Save your newly created data set for use during the remainder of the project.

Note: This data set will be referred to as "Failure Time" in this project.

a. (15) Use Minitab, or any other appropriate technology, to generate some graphical representations of your Failure Time data. At a minimum, construct the following:

- 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. (10) 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. (10) Now we will attempt to use mathematics to model the radio lifetime data. Let the random variable T represent the radio Failure Time (in days). Do any of the distributions presented in MA206 model the probability distribution of your data set? If so, define the distribution of T and estimate the distribution's parameter(s). Clearly justify your selection of distribution and parameter estimation.

3. (10) Using your hypothesized distribution from part 2c above, compute the probability that a randomly selected SINCGAAR radio system operates for 30 days given the fact that it worked for two months.

Now you must take a sample of the "RC Time" averages that each MA206 project group reported during the first phase of the project. Select a sample of 60 "RC Time Averages" in a manner similar to that described in Requirement 2.

Note that each number in the "RC Time" column is the <u>average</u> of the 50 data points collected by a cadet project group. <u>Your</u> data point is in the column, but may not be one of the 60 you sample.

4. Let $\overline{X}$ be a random variable representing the sample average of the "RC Time" data.

a. (10) What should the distribution of $\overline{X}$ be? Why? Use a visual graphing technique to support your answer.

b. (10) Estimate the mean and variance of $\overline{X}$. Use your parameter estimates to compute the probability that $\overline{X}$ is between a and b. (Your instructor will provide you with the quantities a and b)

5. (10) Provide point estimates for the mean RC Time and mean Failure Time. Include the standard errors of your estimates. Explain your results.

6. Confidence Intervals.

a. (20) Construct 95 and 99% confidence intervals for the population mean RC Time and the population mean Failure Time. List and explain all assumptions required to construct these confidence intervals. Explain your results.

b. (15) List and explain three ways you could improve the precision of your RC Time confidence interval. Be specific and address your experimental procedures.

c. (10) Consider the RC Time and Failure Time data sets. In general, what assumptions are required to construct a confidence for the variance of a population? Where justified, construct a 95% confidence interval for the population variance of the RC Time and/or the Failure Time data.

7. (10) In 50 words or less, describe what you learned in MA206.

The remaining 25 points will be awarded by your instructor based upon how well you packaged and presented your analysis in your project submission.