Mech 221: Computer Lab Learning Goals

These learning goals were developed by Brian Wetton, instructor for this course for 2008-2010, with input from CWSEI Science Teaching and Learning Fellows Costanza Piccolo, Paul Ottaway, and Warren Code. Compiled into this document January, 2011.

1 Lab 1

Pre-Lab Learning Objectives: After completing this pre-lab assignment, you should be able to:

- recognize the correct syntax of and describe the output of some MATLAB commands used to create and access parts of a vector, to perform numerical integration, and to create plots;
- determine an adequate number of points to get sufficient accuracy from a numerical integration method;
- interpret, modify, and write MATLAB code to implement algorithms for numerical integration.

Lab Learning Goals: After completing this lab, you should be able to use MATLAB to:

- generate vectors and define functions
- create plots using either the Command Window or the plot Graphical User Interface
- write a simple program, save it as an .m file, run it, edit it, and run it again
- perform numerical integration to a given accurancy

2 Lab 2

Pre-Lab Learning Objectives: After completing this pre-lab assignment, you should be able to:

- recognize the correct syntax of and describe the output of the following MATLAB commands: `length`, `max` and `abs`;
- write MATLAB `for` loops;
- describe the exact solution to a specific differential equation problem;
- write MATLAB code to implement the Forward Euler time-stepping method to find an approximate solution to a specific differential equation.

Lab Learning Goals: After completing this lab, you should be able to:

- debug simple MATLAB code;
- implement `for` loops in MATLAB;
- write and run MATLAB code to implement a Forward Euler method and compute approximate solutions to differential equation problems;
- generate plots to compare solutions;
- perform error analysis in the Forward Euler method.

3 Lab 3

Pre-Lab Learning Objectives: After completing this pre-lab assignment, you should be able to:

- use the MATLAB `format` command to change the number of digits displayed in output;
- write MATLAB `while` loops;
- write re-usable MATLAB code in a `function` in an `.m` file that takes inputs and gives outputs;
- Find approximate roots of a given function using Newton's method on a calculator;
- partially solve a specific separable differential equation (DE) to the form where the solution $y(x)$ at a given x is the root of a given function.

Lab Learning Goals: After completing this lab, you should be able to:

- debug MATLAB program code with loops and function calls;
- write `function` .m files in MATLAB;
- implement `while` loops in MATLAB;
- find roots using Newton's method in MATLAB;
- find solution values to separable differential equations using Newton's method in MATLAB.

4 Lab 4

Pre-Lab Learning Objectives: After completing this pre-lab assignment, you should be able to:

- access elements of matrix in MATLAB: individual entries, rows and columns;
- use the MATLAB command `legend` that will enhance figures with many plots on them;
- use the MATLAB routine "`ode45`" to approximate solutions of first order systems of differential equations;
- transform second and higher order ODEs into first-order systems of equations which can be approximately solved with `ode45`.

Lab Learning Goals: After completing this lab, you should be able to:

- convert *any* higher order DE to a first order system;
- use Euler's method to approximate solutions of *any* DE system;
- use `ode45` to approximate solutions of *any* DE system.

5 Lab 5

Pre-Lab Learning Objectives: After completing this pre-lab assignment, you should be able to:

- include `if...else...end` blocks in MATLAB code.
- understand the basics of how the MATLAB routine `ode45` works.
- solve differential equations analytically that have forcing terms that depend discontinuously on time and the solution.

Lab Learning Goals: After completing this lab, you should be able to:

- use `if...else...end` and `if...end` blocks to execute different commands based on different conditions.
- use `ode45` to approximate solutions of differential equations that have forcing terms or coefficients that depend discontinuously on time and the solution.

6 Lab 6

Pre-Lab Learning Objectives: After completing this pre-lab assignment, you should be able to:

- Use the MATLAB command `eig` to compute the eigenvalues and eigenvectors of a matrix.
- Do calculations with the amplitude-phase form of solutions of damped spring-mass systems.
- Rewrite two coupled second order equations that describe a damped mass-spring system with two degrees of freedom as a first order system with four unknowns.
- Find the matrix that corresponds to this system and understand the behaviour of the system from the eigenvalues of this matrix.

Lab Learning Goals: After completing this lab, you should be able to:

- Use the `eig` command to find the eigenvalues of matrices that describe coupled mass-spring systems.
- Use the `ode45` command to compute approximate solutions to these systems.

7 Lab 7

Pre-Lab Learning Objectives: After completing this pre-lab assignment, you should be able to:

- rewrite the equations governing the dynamic response of the motor to a given electrical input into a second order ODE.
- obtain properties of the motor like the time constant, natural frequency, etc from the coefficients of the ODE derived above.

Lab Learning Goals: After completing this lab, you should be able to:

- use the MATLAB command `ode45` to simulate the behaviour of the Parker BE341F DC motor (and other physical systems given their specifications).