EC 2000 Modules

Computational Skills Module
Instructors Manual

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Objectives:

At the end of this module, the students should be able to:

1. Use Matlab to solve computational problems
2. Give a step by step description of how to compute the solution to an engineering problem.
3. Determine the accuracy of computed results.

Justification:

Modern engineering problems often require extensive computation. To adequately solve these problems, engineers need to be proficient with computational tools, and be able to precisely define their problems and call in the help of the computer to solve their problem.

Prerequisites by Topic:

1. Pre-Calculus Mathematics.
2. Integration and Two Dimensional Integration.
3. Differential Equations.
4. Matrices and Linear Algebra.
5. Knowledge of mean and variance statistics.
6. Some prior experience with computers.

Classroom Requirements:

The optimal classroom will have:

1. Projection system for Powerpoint presentations.
2. Computers at student desks with Matlab installed and operational.

These are not absolutely necessary, but would enable the instructor to do in-class computing exercises.

Class 1. Use of Matlab

Goal: At the end of this lecture, you should be able to use Matlab to solve computational problems.

Preclass assignment: Sketch the function $f(t) = u(t-1)e^{-(t-1)^2}$ for t = 0 to t=3, when u(t) is the unit step function, u(t) = 1, t ≥ 0, u(t) = 0, t< 0.

Challenge Problem: Water flows into a basin with flow rate $f(t) = u(t-1)e^{-(t-1)^2}$ liters/second. Find the amount of water added to the basin during the period from t=0 to t=3. Also, plot f(t) versus t. (Note: u(t) is the unit step function.).

Student Cooperative Exercise (Groups of 2 or 3): Find a mathematical expression for the water added to the basin during $0 < t < 3$.

Discuss integration by rectangles.

Discuss basic Matlab syntax.

Discuss solution by an iterative loop.

Discuss solution by Matlab functions and vector operations.

Discuss simple Matlab graphics. Plot f(t) versus t.

Student Exercise: Write a sequence of Matlab instructions to plot the function f(t) = t sin(t), for $0 < t < 2$.

Discuss how to use the online help.

Student Exercise: Use the online help to find out how to calculate the logarithm base 10 of 35. (Requires computers with Matlab in the classroom.)

Class 2. Creating Algorithms to Solve Problems.

Goal: At the end of this class you should be able to give a step-by-step description of how to compute the solution to an engineering problem.

Challenge Problem: Find the surface area of one side of an arbitrarily shaped flat component. The component fits in a 1m x 1m square.

Discuss a step by step approach to solving the challenge problem.

Discuss a Matlab program to solve the challenge problem.

Discuss levels of abstraction.

Student Cooperative Exercise: Develop a step-by-step procedure for opening a door.

Student Exercise: Develop a step-by-step procedure for computing the mean and variance of 10,000 data points.

Student Exercise: Write a sequence of Matlab instructions to compute the mean and variance of 10,000 data points.

Class 3. Determining the accuracy of results.

Goal: At the end of this class, you should be able to determine the accuracy of computed results.

Challenge problem: Simulate the solution to the differential equation:

$$\dot{x} = -x^2 \sin(x)$$

for 0 < t < 5, when x(0) = 1.33, $\dot{x} = dx/dt$.

Discuss Euler Method.

Solve using the Euler Method.

Student Cooperative Exercise: Make a list of all possible sources of inaccuracy in this solution.

Discuss the effect of step size on accuracy.

Student Exercise: Select a good step size to obtain accuracy to about 1 % for the solution to: $\dot{x} = -x^2 \sin(x) + \sin(10t)$

Discuss Underflow Error.

Grading Guidelines

It is recommended that students be graded in two manners for this module. The computational exercises are designed to be done at home, and require the kind of skills taught in the modules. To maintain individual accountability, a quiz, or quizzes are also recommended.

Assignment Samples

See attached file of assignments for each class.

Reference Sources:

Books:

1. M. Herniter, *Programming in Matlab,* Brooks/Cole, 2000.
2. D. M. Etter, *Engineering Problem Solving With MATLAB*, Prentice Hall, 1993.
3. D. M. Etter, *Introduction to MATLAB For Engineers and Scientists*, Prentice Hall, 1996.
4. Rudra Pradap, *Getting Started with MATLAB*, Saunders College Publishing, 1996.

Journals

1. ASEE Prism
2. Journal of Engineering Education
3. Journal of Computers in Education

Articles

1. C. J. Egelhoff, D. M. Blackketter, J. L. Benson, "Algorithms for Solving Nonlinear Equation Systems Assist Students to Become Better Problem Solvers," *Proceedings of the 29th ASEE/IEEE Frontiers in Education Conference*, p. 12a4-17 – 12a4-22, 1999.
2. J. Ramos, C. Yokomoto, "Making Probabilistic Methods Real, Relevant, and Interesting Using MATLAB," *Proceedings of the 29th ASEE/IEEE Frontiers in Education Conference*, p. 13b4-2 – 13b4-7, 1999.
3. P. R. Turner, "Teaching Scientific Computing Through Projects," *Proceedings of the 29th ASEE/IEEE Frontiers in Education Conference*, p. 11b4-1 – 11b4-6, 1999.

Other Resources

1. Association for the Advancement of Computing in Education (AACE) www.aace.org. Mostly geared for K-12.
2. ABET plans posted on the web.

Outcomes Assessment

Outcome 1: Use Matlab to solve computational problems.

1. Assign a computational problem, and have each student produce a Matlab m-file that solves the problem.
2. Give a quiz on basic Matlab commands and syntax.

Outcome 2: Give a step by step description of how to compute the solution to an engineering problem.

1. Assign an engineering problem with no obvious analytical solution, and ask each student to develop an algorithm to solve that problem. Do not accept any Matlab code. The algorithm should be expressed as a series of steps.
2. Assign a vague procedure description for solving a given problem, and have them create a step by step procedure to solve the problem. Here the basic idea is provided, and they need to make it specific enough to describe an algorithm.

Outcome 3: Determine the accuracy of computed results.

1. Given several sets of numbers to add together, have each student determine when an underflow will occur, assuming standard Matlab floating point arithmetic.
2. Have each student determine the maximum error in the calculation of the mean of 10,000 data points.