Computer Applications in Engineering and Construction
CVEN302-501
Dr. James M. Kaihatu
Coastal and Ocean Engineering Division
Zachry Department of Civil Engineering
Instructor and TA Information

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Course Description

- **Objective:** Develop efficient, computer-oriented solutions to engineering problems
  - Implement common numerical solution methods to engineering problems
  - Determine performance of numerical solutions and numerical error
  - Design, implement and test numerical programs
  - Analyze and present numerical results
Course Description


Text: CVEN302 – Computer Applications in Engineering and Construction – Texas A&M University by Thomson Custom Publishing (custom MATLAB manual)

Prerequisites: ENGR112; MATH308 or registration therein

Course website:
(also navigable from home page)
  - Most information will be password protected
Grading

• Homework: 30%
• Exam 1 (10 March: 7:00pm-8:40pm): 20%
• Exam 2 (22 April: 7:00pm-8:40pm): 20%
• Final (11 May 8:00am-10:00am): 30%
Organization of Class

• MW lectures
  – Focus on methods
  – Some in-class computer demos
  – Homework – hand calculations

• Friday lectures
  – “Lab” class
  – Problem solving
  – Homework - programming exercises
Ground Rules

• Homework due at the *beginning* of class on the due date
  – Homework assignments will be posted on web page
  – No late homework will be accepted
  – Valid university excuse: notify instructors in advance (exception: genuine emergency)
  – Blind copying of homework will lead to zero.
Ground Rules

• Exams:
  – Two evening exams (10 March and 22 April – 7:00pm – 8:40pm)
  – Final exam (11 May – 8:00am – 10:00am)
  – *Closed book and closed notes*
  – One single-sided 8 ½”x11” formula sheet allowed
  – Ensure that you have sufficient blank paper, writing implements and a working calculator with you
    • You do **not** want to use mine!

HP42S circa 1989 with RPN notation (no “equal” sign)
Computer Methods in Engineering
Example: Deflection of a Beam

\[ \frac{d^2}{dx^2} \left( EI \frac{d^2u}{dx^2} \right) = w \]

- Relates deflections \( u \) to applied load \( w \)
- For ideal situations – can be integrated analytically
- What if:
  - \( I \) changed with distance?
  - \( E \) changed with distance?
  - Applied load changed with time?

NOW WHAT?
Beam Deflection Software (not free!)

Or...write it yourself!
How?

• Reduce $4^{th}$ order ODE to system of $1^{st}$ order ODEs

\[ EI \frac{d^4 u}{dx^4} + \frac{d^2 EI}{dx^2} \frac{d^2 u}{dx^2} = w \Rightarrow \frac{du}{dx} = v \]

\[ \frac{dv}{dx} = f(v,u,x) \text{ and so on} \]

• Approximate derivatives:

\[ \frac{du}{dx}(x) \approx \frac{u(x_i + \Delta x) - u(x_i)}{\Delta x} \]

• Create matrix and solve system of equations

• Congratulations! You’ve save the company a bunch of money!
Example: Making Sense of Data
What Kind Of Fit Will You Have?

Linear Fit?

Deaths per 100,000 to income inequality
• R-square = 0.5

Estimated vs. observed accuracy of DNA protein bindings in cancer cells from amino acid sequence
• R-square = 0.92
What Kind Of Fit Will You Have?

Polynomial Fit?

Polynomial fit of ocean wave data

Temperature data deduced from ice cores as a function of time
Example: Forces on Objects

- Contours of pressure on aircraft
- Pressure contours on turbomachinery
- Pressure contours on a dam

\[ F = \text{Pressure} \times \text{Area} \]
Numerical Integration to Find Areas and Volumes

Trapezoidal Integration

Simpson’s Rule Integration

Multi-dimensional integration
Example: Determining Length of Ocean Waves

$L$ related to wave period $T$ and water depth $h$

\[
\left( \frac{2\pi}{T} \right)^2 = g \left( \frac{2\pi}{L} \right) \tanh \left( \frac{2\pi}{L} h \right)
\]

**Problem:** Equation is implicit in $L$
Root Finding Methods

Bracketing Methods
- Surround the root with two guesses
- Refine guesses and close in on root

Open Methods
- Do not bracket root
- Use some property of the function to close in on root (e.g., slope of function)
Programming Languages

• A set of instructions read and executed by a computer
• The most “basic” – machine language
• High level languages – translate between commands and machine language
  – BASIC – usually the first language taught
  – FORTRAN – standard for scientific programming
  – COBOL – used in business applications
  – C – small, portable lower-level language
  – Others: C++, Python, Perl...
Programming Language - MATLAB

Matlab: **Matrix Laboratory**

- Widely used in academia and industry
- Relatively easy to learn and use
- Simplified manipulation of matrices and systems of equations
- “Dynamic typing”
  - No need to declare variable types
- Flexible plotting and animation options
- GUI builder