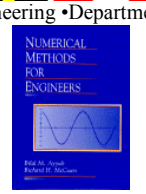
INTRODUCTION (Syllabus, Numerical Methods & Computational Tools)

• A. J. Clark School of Engineering •Department of Civil and Environmental Engineering



by

Dr. Ibrahim A. Assakkaf

Spring 2001

ENCE 203 - Computation Methods in Civil Engineering II

Department of Civil and Environmental Engineering
University of Maryland, College Park

Course Syllabus

• A. J. Clark School of Engineering • Department of Civil and Environmental Engineering

UNIVERSITY OF MARYLAND
Department of Civil and Environmental Engineering
College Park Campus
Spring Semester 2001

ENCE 203 – Computation Methods in Civil Engineering II (3 credit)
MWF 10:00 am – 10:50 am, EGR 3106

INSTRUCTOR:

	Name:	Dr. Ibrahim A. Assakkaf
	Office Hours:	MW 11:15 am - 1:15 pm and by appointment
	Room:	0305, Engineering Classroom Building (EGR)
		Center for Technology and Systems Management
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Course Syllabus

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GRADER:

Name:	Mr. Yong Kwon Song
Office Hours:	WF 11:00 am - 12:00 noon
Room:	EGR 1107
Telephone:	(301) 486-0362
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TEXTBOOK: Ayyub and McCuen, Numerical Methods for Engineers, Prentice Hall, NJ, 1996.

REFERENCE: Chapra and Canale, Numerical Methods for Engineers, McGraw Hill, NY, 1988.

GRADING: HW (15%), Exam #1 (25%), Exam #2 (25%), Final Exam (30%), and Quizzes (5%).

Course Syllabus

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PREREQUISITES:

- MATH 241
- ENES 220
- Permission of Department
- ENCE majors only

GENERAL COURSE DESCRIPTION (UM SCHEDULE OF CLASSES): Grade Method: REG/P-F/AUD. Prerequisites: MATH 241, ENES 220, and permission of department. Corequisite: MATH 246. For ENCE majors only. Formerly ENCE 301. Elementary numerical analysis: roots of equations, systems of linear algebraic equations, curve fitting, integration, and solution of ordinary differential equations. Numerical techniques are presented in the context of engineering applications, and example problems are solved using a variety of computer-based tools (structure programming, spreadsheet, and computational/symbolic processing software packages).

Course Syllabus

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COURSE OUTLINE & SCHEDULE:

Week	Date	Topic	Source
1.	January 29	Word processing, and Spreadsheet software	Handout
2.	February 5	Introduction: Numerical analysis in engineering, Taylor series	Chapter 1
3.	February 12	Matrices: Operations, Vectors, Determinants, Rank, Applications	Chapter 2
4.	February 19	Numerical methods: Introduction, Accuracy, Errors	Chapter 3
5.	February 26	Roots of Equations	Chapter 4
6.	March 5	Roots of Equations	Chapter 4
		EXAM I	
7.	March 12	Simultaneous Linear Equations	Chapter 5
8.	March 19-23	**** SPRING BREAK (NO CLASSES) ****	
9.	March 26	Simultaneous Linear Equations	Chapter 5
10.	April 2	Interpolation	Chapter 6
11.	April 9	Interpolation	Chapter 6
12.	April 16	Differentiation	Chapter 7
13.	April 23	Integration	Chapter 7
		EXAM II	
14.	April 30	Differential Equations	Chapter 8
15.	May 7	Differential Equations	Chapter 8
16.	May 14	Differential Equations, Review	Chapter 8
17.	May 17	**FINAL EXAM (Thursday, 8:00 am – 10:00 pm, EGR 3106)**	

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HOMEWORK ASSIGNMENTS:

Professional presentation of homework assignments is required. Professional presentation consists of neat and organized solution of problems on **one side of 8.5"x11" papers**. Any homework not complying with professional standards will not be graded and will be assigned zero credit. The homework assignments are due one week after they are assigned. Late homework assignments will not be accepted.

EXAMS:

All students must take all exams including the final exam. Only extenuating circumstances will be accepted as excuse for missing an exam. Health related excuses require **medical reports** and the **signature of a physician** that provided treatment.

Major Topics

- Matrices and Vectors
- Roots of Equations, $f(x)=0$
  - These problems are concerned with the value of a variable that satisfies a single equation.
  - These problems are specially valuable in engineering design contexts where it is often impossible to explicitly solve design equation for parameters

Major Topics

- Systems of Linear Simultaneous Equations
  - Similar to roots of equations in the sense that are concerned with values that satisfy equations.
  - A set of values is sought that simultaneously satisfies a set of linear algebraic equations.

Major Topics

- Interpolation
  - Interpolation is used where the objective is to determine intermediate values between relatively error-free data points such as the case of tabulated information.
  - For these situations, the strategy is to fit a curve through the data points and use the curve to predict the intermediate values.

Major Topics

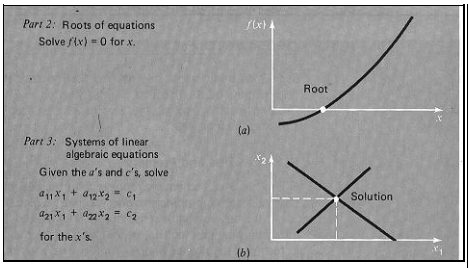
- Differentiation & Integration
  - A number of engineering problems require a numerical derived estimate of a derivative of a function $f(x)$.
  - Integration has many applications in engineering practice:
    - Determination of centroids of oddly shaped objects to calculation of total quantities based on sets of discrete measurements.
  - Integration is important for the solution of differential equations.

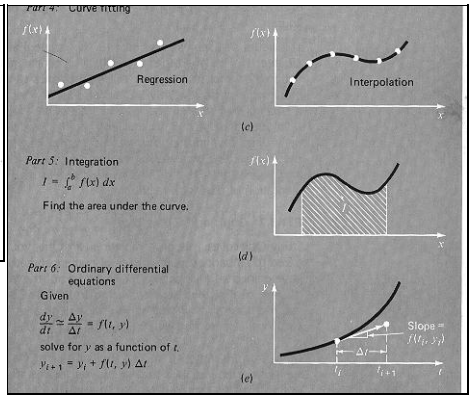
Major Topics

- Differential Equations
  - Both ordinary and partial differential equations are of great importance in engineering practice.
  - This is because many physical laws are presented in terms of the rate of change of a quantity, rather than the magnitude
  - Two types addressed:
    - Initial-value problems
    - Boundary-value problems

Major Topics

- Summary of Numerical Methods





Source: Chapra & Canale (1988)

Numerical vs. Analytical Methods

- Analytical Methods
  - Solution have been derived for some engineering problems using analytical (or exact) methods.
  - In general there are few closed-form engineering or "exact" solutions.
  - These solutions are often useful and provide excellent insight into the behavior of an engineering system.

Numerical vs. Analytical Methods

- Examples Analytical Solution
  - Differentiation

$$\frac{dy}{dx}\left(x^2-\sin(x)\right)=2x-\cos(x)$$

  - Integration

$$\int x^3+x-e^x=\frac{x^4}{4}+\frac{x^2}{2}-e^x+c$$

  - Root(s) of an Equation

$$ax^2+bx+c=0\Rightarrow x=\frac{-b\pm\sqrt{b^2-4ax}}{2a}$$

Numerical vs. Analytical Methods

- Numerical Methods
  - Numerical methods are techniques by which mathematical problems are formulated so that they can be solved with arithmetic operations.
  - Numerical methods involve large numbers of tedious calculations.
  - These methods have gained popularity due to the advancements in efficient computational tools such as digital computers and calculators.

Numerical vs. Analytical Methods

- Need for Numerical Methods
  - There are in general few analytical (closed-form) solutions for many practical engineering problems.
  - Numerical methods can handle:
    - Large systems of equations
    - Non-linearities
    - Complicated geometries that are not uncommon in engineering practice and that are often impossible to solve analytically.

Numerical vs. Analytical Methods

- Examples Solutions that Require Numerical Methods
  - Integration

$$F = \int_0^{30} \left(\frac{\cos(z) + z}{5 + z} \right) e^{-2z/30} dz$$

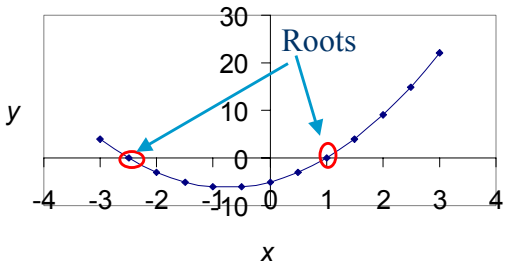
  - Root(s) of an Equation

$$y = 2x^2 + 3x - 5 = 0 \qquad \frac{x}{1 + \sin(x)} + e^x = 0$$

Numerical vs. Analytical Methods

- Example Numerical Solutions

x	y
-3	4
-2.5	**0**
-2	-3
-1.5	-5
-1	-6
-0.5	-6
0	-5
0.5	-3
1	**0**
1.5	4
2	9
2.5	15
3	22



$$y = 2x^2 + 3x - 5 = 0$$

Computers and Software

- Computers Evolution Era (Chapra & Canale 1988)
  - Zero Generation - Manual & Mechanical (pre 1951)
  - First Generation – Vacuum tubes (1951 – 1958)
  - Second Generation – Transistors (1958 – 1964)

Computers and Software

- Computers Evolution Era (Chapra & Canale 1988)
  - Third Generation – Integrated circuits (1964 – 1971)
  - Fourth Generation – Very large scale integration (1971 – present)
    - Mainframes, Supercomputers
    - Personal Computers, Microcomputers, and Minicomputers

Computers and Software

- Computers Evolution Era (Chapra & Canale 1988)
  - Fifth Generation (1990?)
    - Parallel Processing
    - Artificial intelligence

Computers and Software

- High-level Languages
  - FORTRAN (introduced by IBM in 1957)
    - FORTRAN = *FORmula TRANslation*
    - *Developed for the IBM 704 Computer*
    - *Developed by John Backus and a team of 13 other programmers*
  - BASIC
  - Pascal
  - Others

Computers and Software

- Software Packages
  - MATLAB
  - MathCad
  - Spreadsheet
    - MS Excel
    - Quattro Pro

Computers and Software

- Spreadsheets and Engineering
  - Spreadsheet is special type software that allow the user to enter and perform calculations on rows and columns of data displayed on computer monitor.
  - Advantages of Spreadsheet
    - Easy to use and understand
    - Provide organized record of user computation
    - Entire calculation can be updated easily
    - Suitable for “what if?” scenarios

Computers and Software

■ Spreadsheet Calculations

B5 = B3 + B4

	A	B	C	D	E	F	I
1							
2							
3	X =	10					
4	Y =	13.5					
5	Sum =	23.5					
6							
7							
8	u =	45					
9	v =	25					
10	$\sqrt{uv} =$	33.54102					
11							
12							

B10 = sqrt(B8*B9)