# CEE/ME 5/7362 Engineering Analysis with Numerical Methods

(Elective Course)

**Instructor:** Usama El Shamy, Ph.D., P.E.
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**Catalog Course Description**
Applications of numerical and approximate methods in solving a variety of engineering problems. Examples include equilibrium, buckling, vibration, fluid mechanics, thermal science, and other engineering applications.

**Prerequisite**
Permission of Instructor

**Textbook and Other Related Material**
Chapra, S., Applied Numerical Methods with MATLAB for Engineers and Scientists, McGraw-Hill, 3rd Ed., 2012.

**Course Objectives**
The goal of this course is to introduce students to applied computational methodologies to solve engineering problems when no closed-form, analytical solution exists. Emphasis will be placed on understanding the fundamental concepts behind various numerical methods, implementing basic numerical methods using technical computing, and utilizing sophisticated numerical methods available. With respect to engineering issues, the student will:

1. Select and use appropriate methods for finding roots of equations as well as interpolation and approximation methods.
2. Use numerical methods to solve systems of equations.
3. Design computer programs and use packaged software to solve engineering problems.
4. Use numerical methods for differentiation and integration with engineering applications.
5. Understand the processes of numerical simulation, modeling, optimization, identification, and visualization of engineering systems.
6. Solve boundary value problems using the finite difference method.
7. Solve time-dependent problems

**Course Requirements**

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|---|---|
| Homework | 25% of grade |
| Term Project | 25% of grade |
| Midterm Exam | 25% of grade |
| Final Exam | 25% of grade |

**Curriculum Professional Component Allocation**
Engineering Science and Design: 3 Term Credit Hours or 100 percent of the course content

**Student Learning Outcomes**

1. Students will be able to solve problems using algebraic, geometric, calculus, statistical and/or computational methods.
2. Students will be able to interpret and/or draw inferences from mathematical models, data, graphs or formulas.

**Relevant Program Outcomes**

This course includes, but is not limited to, content that supports the educational objectives and outcomes of the environmental and civil engineering programs. Specific emphasis is placed on students attaining and demonstrating:

- An ability to identify, formulate, and solve engineering problems (Outcome E).
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (Outcome K).

**Topics Covered**

| Date | Topic | Reference |
|---|---|---|
| 05/14 | Mathematical Modeling and Numerical Methods and MATLAB Fundamentals | Chapters 1 and 2 |
| 05/15 | Programming with MATLAB and Error Estimate | Chapters 3 and 4 |
| 05/18 | Roots: Open and Closed Methods | Chapters 5 and 6 |
| 05/19 | Optimization/ Linear Algebra | Chapters 7 and 8 |
| 05/20 | Gauss Elimination/LU Factorization/Iterative Methods | Chapters 9, 10, and 12 |
| 05/21 | Numerical Integration and Differentiation | Chapters 19-21 |
| 05/22 | Boundary-Value Problems | Chapter 24 |
| 05/22 | **MIDTERM-Take Home Exam due 5/26 by 11 am.** | |
| 05/26 | Initial-Value Problems | Chapter 22 |
| 05/27 | Initial-Value Problems / Linear Regression | Chapters 22 and 14 |
| 05/28 | General Least Square/Interpolation | Chapters 15 and 17 |
| 05/29 | Polynomial Interpolation/Splines | Chapters 17 and 18 |
| 05/29 | **FINAL EXAM-Take Home Exam due 5/30 by 4 pm.** | |

Prepared by: Usama El Shamy Date: 2/9/15

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Disability Accommodations: Students needing academic accommodations for a disability must first contact Ms. Rebecca Marin, Coordinator, Services for Students with Disabilities (214-768-4557) to verify the disability and establish eligibility for accommodations. They should then schedule an appointment with the professor to make appropriate arrangements. (See University Policy No. 2.4.)

Religious Observance: Religiously observant students wishing to be absent on holidays that require missing class should notify their professors in writing at the beginning of the semester, and should discuss with them, in advance, acceptable ways of making up any work missed because of the absence. (See University Policy No. 1.9.)

Excused Absences for University Extracurricular Activities: Students participating in an officially sanctioned, scheduled University extracurricular activity will be given the opportunity to make up class assignments or other graded assignments missed as a result of their participation. It is the responsibility of the student to make arrangements with the instructor prior to any missed scheduled examination or other missed assignment for making up the work. (University Undergraduate Catalogue)

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Catalog Course Description:

Applications of numerical and approximate methods in solving a variety of engineering problems. Examples include equilibrium, buckling, vibration, fluid mechanics, thermal science, and other engineering applications.

Course Offering Justification:

This course serves as a technical elective for senior students in the Civil and Environmental Engineering and Mechanical Engineering Departments. It may also serve as a substitute for the required course CEE 3310 Computational Methods for Civil and Environmental Engineering Applications for Civil and Environmental Engineering Students.

Instructor's Bio:

Dr. Usama El Shamy is an Associate Professor in the Civil and Environmental Engineering at Lyle School of Engineering. He has taught this course at SMU in summer of 2014 and Jan Term 2015. He has been teaching CEE/ME 5/7361 Matrix Structural Analysis and Introduction to Finite Element Methods for the past six years. This course builds on knowledge of MATLAB and implementation of numerical techniques gained from the proposed course CEE/ME 5/7362.

Benefits and learning outcomes:

- How can you find the roots of an equation and utilize that for solving problems in fluid mechanics?
- How can you solve linear systems of equations using MATLAB and utilize that for solving engineering problems?
- How can you use MATLAB to optimize a given set data from experiments?
- How can you present your results as animations?
- How can you carry out numerical differentiation and integration?
- How can you solve for the temperature field in a heated plate or find the characteristics of flow in porous media?
- How can you numerically evaluate the dynamic response of single and multi-degree of freedom systems?