CONCORDIA UNIVERSITY
FACULTY OF ENGINEERING AND COMPUTER SCIENCE
DEPARTMENT OF MECHANICAL INDUSTRIAL & AEROSPACE ENGINEERING

Numerical Methods in Engineering (ENGR 391)

***Professor*:**	Ida Karimfazli (EV4.181)
***Course Website*:**	Access from your "My Concordia" portal *https://users.encs.concordia.ca/~idak/engr391/*
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Prerequisites:	ENGR 213, 233; COMP 248 or COEN 243 or MECH 215 or BCEE 231

Course Objective:

Engineers depend on mathematical equations to describe behaviour of many physical systems. In practice these equations cannot be solved analytically, therefore, numerical methods are often used. This course introduces engineering students to a variety of numerical methods and algorithms. It is an introductory course, and can be complemented by a variety of other courses geared at different approaches to numerical simulation of the many phenomena occurring in different engineering disciplines, e.g. Fluid mechanics, Solid mechanics, etc. The numerical techniques learned in this course enable students to work with mathematical models of technology and systems.

General Topics:

1. Introduction and error analysis
2. Roots of equations
3. Linear algebraic equations
4. Regression and interpolation
5. Numerical integration
6. Numerical differentiation
7. Ordinary differential equations
8. Solution of nonlinear equations
9. Introduction to partial differential equations

Recommended references:

- *Numerical Analysis*, R. Bhat & A. Kaushal, Alpha Science Publishers ISBN 978-1-78332-346-3
- *Numerical Methods for Engineers and Scientists: An Introduction with Applications Using Matlab*, A. Gilat and V. Subramaniam, John Wiley & Sons, Inc. 3rd edition
- *Numerical Methods for Engineers*, S.C. Chapra and R.P. Canale, 5th edition, McGraw-Hill.
- *Numerical Analysis*, T. Bauer, Pearson Education, 2006.
- *Numerical Analysis*, R.L. Burden and J.D. Faires, 7th ed. Brook/Cole Publishing Company.
- *Numerical Methods Using Matlab*, J.H. Mathews and K.D. Fink, Pearson Education, 2004.
- *Elementary Numerical Analysis*, Atkinson and Han, 3th edition, Wiley, 2004.

Graduate Attributes

ENGR391 emphasizes and develops the CEAB (Canadian Engineering Accreditation Board) graduate attributes and indicators:

Attribute	**Indicator**	**Level of knowledge**
A knowledge base for engineering Demonstrated competence in university-level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.	Knowledge-base for specific engineering field	Advanced
	Knowledge-base of natural science	Advanced
Use of engineering tools An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.	Ability to use appropriate engineering tools, techniques and resources	Intermediate
	Ability to select appropriate tools, techniques, and resources	Intermediate
	Demonstrate awareness of limitations of tools, create and extend tools as necessary	Intermediate

Course learning outcomes

Select, apply, and adapt a wide array of numerical techniques aiming to solve specific engineering problems.	**A knowledge base for engineering /** Knowledge-base for specific engineering field / Knowledge-base of natural science
Identify the associated limitations and advantages of different numerical methods.	**Use of engineering tools**/ / Demonstrate awareness of limitations of tools, create and extend tools as necessary
Transcribe any numerical method into an algorithm that is easily implementable in modern engineering tools (Matlab, etc…)	**Use of engineering tools**/ Ability to use appropriate engineering tools, techniques and resources

Grading Scheme:

1 project (during second part of the term) 10%
Midterm exam (Thursday, 18 October 2018, 4:15 PM) 25%
See Moodle for more details.
Final exam (closed book and notes) 65%

Examinations:

- Students are allowed a **double-sided letter sized** sheet of paper as a crib sheet during midterm and final exams.
- Students are allowed a standard ENCS calculator (non-programmable) to bring to the exams.
- No make-up midterm will be given, a valid reason (doctor's note presented prior to the exam) is required to write the final exam for 90%.

Students with Disabilities:

Student with disabilities are encouraged to contact the instructor as early as possible in order to efficiently accommodate their needs.

Passing Criteria and Other Remarks

- In order to pass the course, students must obtain a passing mark of 50% on the final exam
- There is no fixed relationship between marks and letter grades.
- Events beyond the control of the instructor may require changes to this outline.
- You are responsible for all material covered in class;
- Midterm and Final examinations will not evaluate any Matlab skills

Code of conduct

- Students should be aware of the University and become familiar with the University's Code of Conduct located at:
- http://web2.concordia.ca/legal_counsel/policies/english/AC/code.html. There will be a zero tolerance policy pertaining to violations of this code. In the event of an offense, an Incident Report will be completed and submitted to the Dean. Plagiarism may be punished by failure of the exam, or the course, and may lead to expulsion from University.
- Do not copy, paraphrase or translate anything from anywhere without stating from where you obtained it! *http://www.concordia.ca/programs-and-courses/academic-integrity/plagiarism/*

COURSE CONTENT

1. Solution of Equations for Engineering Design and Analysis
   Introductory topics
2. Numerical Search for Roots of Algebraic and Transcendental Equations
   - Bisection Method
   - Method of False Position
   - Newton-Raphson Method
   - Modified Newton Raphson Method
   - Secant Method
3. Methods to Solve Linear Simultaneous Equations
   - Gauss Elimination with Pivoting strategies
   - LU-Decomposition Solving equations with the LU decomposition
     - Doolittle's Method
     - Crout's Method
     - Matrix Inverse with the LU decomposition
   - Backward / forward errors
   - Norms and Condition Number
   - Gauss-Seidel Method
   - Solution of Non Linear Equations (Newton's Method)
4. Function Approximation and Interpolation
   - Discrete least square approximation
   - Linearization of non-linear relationship
   - Coefficient of Determination – r^2
   - Least square function approximation
   - Normal equations
   - Interpolation with Divided Differences

- Lagrange Polynomials

5. Numerical Integration
    - Trapezoidal rule
    - Simpson's 1/3 and 3/8 Rule
    - Romberg integration
    - Richardson's method for error estimations
    - Gauss Quadrature
6. Numerical Differentiation
    - Forward, Backward, Central Differences
    - Divided Difference Table
7. Numerical Solutions of Ordinary Differential Equations
    - Euler's Method
    - Runge-Kutta Methods
    - System of First-Order ODEs and Higher-Order Initial Value Problems
    - Introduction to adaptive methods
    - Stability and conditioning of ODE solvers
    - Multiple steps methods
8. Introduction to Partial Differential Equations
    - Elliptic partial differential equations
    - Parabolic partial differential equations