**Concordia University  
Faculty of Engineering and Computer Science  
Department of Mechanical and Industrial Engineering**

**NUMERICAL METHODS IN ENGINEERING**

**ENGR 391 - SECTION AB**

**SUMMER I - 2016**

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**Instructor** Dr. Pierre Q. Gauthier  
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**Prerequisites** ENGR 213, 233; COMP 248 or COEN 243 or MECH 215 or BCEE 231

**Office hours** Tuesdays from 17:00 to 18:00, by appointment

**Course Schedule**

Lecture: A**A**, Tuesday & Thursday 18:30 – 21:00, SGW MB-2-270

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| --- | --- | --- | --- |
| Tutorial: | |  | |
| AH | Tu&Th 21:10 – 22:00, SGW H-929 |  |  |
| AI | Tu&Th 17:30 – 18:20, SGW H-929 |  |  |
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**Textbook**

* “*Numerical Methods for Engineers and Scientists: An Introduction with Applications Using Matlab*”, A. Gilat and V. Subramaniam, John Wiley & Sons Inc., 3rd edition

**Other references**

* *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, 3rd edition, Wiley, 2004.

**Course objectives**

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, Circuit analysis, 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. Solving Nonlinear Equations (Roots of Equations)

3. System of Linear Algebraic Equations

4. Curve Fitting – Regression and Interpolation

5. Eigenvalues and Eigenvectors

6. Numerical Integration and Differentiation

7. Ordinary Differential Equations

**Course website**

Additional notes and announcements may be posted on Moodle available through MyConcordia portal at www.myconcordia.ca.

**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**

Upon successful completion of ENGR391, the students will be able to:

* Select, apply, and adapt a wide array of numerical techniques aiming to solve specific engineering problems.
* Identify the associated limitations and advantages of different numerical methods.
* Transcribe any numerical method into an algorithm that is easily implementable in modern engineering tools (Matlab, etc…)

**Grading scheme**

* 2 quizzes (closed book and notes) 40%
* Bonus (MATLAB assignment) 5%
* Final exam (closed book and notes) 60%

**Examinations**

* All exams are closed book, closed notes.
* Students are allowed a standard ENCS calculator (non-programmable) to bring to the exams.
* Students are allowed a **single-sided letter sized hand-written sheet of paper** as a crib sheet in quizzes and final exams.
* Electronic communication devices (including cellphones) are not allowed in examination rooms.
* **Quiz 1** will be held during regular class time on **Thursday May 19** and covers the material from the beginning of the course up to and including Norms and Condition Number as listed in the section below.
* **Quiz 2** will be held during regular class time on **Tuesday June 9** and covers the material from Gauss Seidel until and including Higher Accuracy Formulas as listed in the section below.
* Quizzes are mandatory and no make-up quizzes will be given.

**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.

**Course content and covered text book material:**

1. Introduction, errors and Taylor Series Expansion (Ch. 1, 2.7 of textbook)

2. Solving Nonlinear Equations (Roots of Equations) (Ch. 3.1 – 3.7, MATLAB 3.8)

* Bisection Method
* Method of False Position
* Newton-Raphson’s Method
* Secant Method
* Fixed Point Iteration

3. System of Linear Algebraic Equations (Ch. 4.1 – 4.3, 4.5 – 4.6.1, 4.10, 4.11, 4.7.2, 3.10.1, MATLAB 4.8)

* Gauss Elimination with Pivoting strategies
* LU-Decomposition
* Using Gauss Elimination (A=LU)
* Solving equations with the LU decomposition
  + Crout’s Method
  + Doolittle’s Method
  + LU decomposition using pivoting strategies (PA=LU)
  + Matrix Inverse with the LU decomposition
* Norms and Condition Number
* Gauss-Seidel Method
* Solution of Non Linear Equations (Newton’s Method)

4. Curve Fitting – Regression and Interpolation (Ch. 6.1 – 6.5, MATLAB 6.7)

* Least Square Regression
* Linear Regression – Error Quantification
* Coefficient of Determination – r2
* Linearization of non-linear relationship
* Newton’s Interpolating Polynomials and Divided Difference Table
* Non-Linear Interpolation
* Lagrange Polynomials

5. Eigenvalue and Eigenvectors (Ch. 5.1 – 5.5, MATLAB 5.7)

* Characteristic Equation
* Power Method
* Inverse Power Method
* Shifted Inverse Method (Gerschgorin Circle Theorem)

6. Numerical Integration and Differentiation (Ch. 8.1 – 8.4, 9.1, 9.3 – 9.5, MATLAB 8.7, 9.7)

* Finite Difference Approximation of the Derivative
* Forward, Backward, Central Differences
* Divided Difference Table
* Higher Accuracy Formulas
* Trapezoidal Rule and Simpson’s 1/3 and 3/8 Rule
* Gauss Quadrature

7. Ordinary Differential Equations (Ch. 10.1, 10.2, 10.5.1, 10.5.3, 10.8, 10.9, MATLAB 10.10)

* Euler’s Methods
* Runge-Kutta Methods
* System of First-Order ODEs and Higher-Order Initial Value Problems

**Students with disabilities**

Student with disabilities are encouraged to contact the instructor as early as possible in order to efficiently accommodate their needs. Centre for students with disabilities: *supportservices.concordia.ca/disabilities*

**Student responsibilities**

* Be present in lectures as notes are presented on the board in class.
* As the material is cumulative, keep up with the content covered in the weekly lectures.
* If you are uncertain of certain concepts, seek help right away; make use of your instructor’s office hours.
* Take the time to solve the assignments yourself.

**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/*](http://www.concordia.ca/programs-and-courses/academic-integrity/plagiarism/)

**Student services**

* Concordia Counseling and Development: *cdev.concordia.ca*
* Concordia library citation and style guides: *library.concordia.ca/help/howto/citations.html*
* Advocacy and support services: *supportservices.concordia.ca*
* Student Transition Centre: *stc.concordia.ca*
* New Student Program: *newstudent.concordia.ca*
* Student success center: *studentsuccess.concordia.ca*
* Health services: *health.concordia.ca*