ME 711 Advanced Engineering Analysis, Fall 2023

Instructor: Dr. Xiangfa Wu
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Lecture Hours: **10:00-10:50 AM (MWF)**, Room **215**, Dolve Hall (Aug. 21 – Dec. 15) (Dead Week: Dec. 4 – Dec. 8); **Holidays:** Labor Day: Sept. 4 (Monday); Veterans Day: Nov. 10 (Friday); Thanksgiving: Nov. 22-24 (Wednesday, Thursday & Friday)

All Electronic Notes & Example Solutions Are Available in the Course Blackboard.

Special Days: Aug. 30 (Wednesday): Withdraw to zero credits at 100% refund

Sept. 29 (Friday): Withdraw to zero credits at 75% refund

Oct. 29 (Sunday): Withdraw to zero credits at 50% refund (no refunds for withdraw after this day)

Nov. 9 (Thursday): Last day to drop class with "W" record; last day to withdraw with zero credit for the fall

Office Hours: **Monday & Wednesday: 3:00-4:30PM**, other hours by appointments

Classroom: Dolve Hall 215

Course Credit: **3**

Final Exam: 8:00 -10:00 AM, Tuesday, Dec. 12, 2023

References:

1. *Applied Numerical Methods for Engineers and Scientists, S. S. Rao, Prentice Hall, (2002).*
2. *Applied Numerical Methods with MATLAB® for Engineers and Scientists (3rd Edition), S. C. Chapra, McGraw-Hill (2012).*
3. *Advanced Engineering Mathematics (5th Edition), Dennis G. Zill, Warren S. Wright, Jones & Bartlett (2014).*

Course Website:

Most course materials will be posted at the course website (https://bb.ndsu.nodak.edu). Please make sure that you have the access to this site.

Course Goals:

A thorough overview is given on fundamental numerical methods used for solving applied mathematical problems commonly encountered in engineering. The emphasis is made on the development, implementation, and application of typical numerical algorithms to get the relevant engineering problems solved. For each numerical method, the theoretical foundation will be presented and the implementation of these techniques will be addressed. Different methods will be compared and contrasted on the basis of accuracy, stability, speed of convergence, ease of implementation, etc. In addition, a brief introduction on a few fundamental topics of applied mathematics (beyond undergraduate calculus, linear algebra, and ordinary differential equations, etc.) will be given.

Course Description:

Mathematical analysis and numerical treatment of engineering problems; eigenvalue problems in lumped and distributed parameter systems; advanced mathematics applied to engineering design.

Anticipated Course Outcomes:

At the end of ME 711, students will be able to understand, formulate, and implement various applied mathematical methods for solutions of linear algebraic systems of equations, numerical solutions of eigenvalue problems, interpolation and numerical techniques for curve-fitting data, numerical solution of nonlinear equations (both individual and systems), numerical differentiation and integration, numerical solution of ordinary and partial differential equations, etc. Students will also get the chance to learn several fundamental topics of applied mathematics.

Course Grading System:

Placement Exam (Friday, 9/1):	**3%** [**Bonus**: Exam content: **Calculus I, II, III & ODEs-Closed Books**]
Homework	**50% +2.5% [Bonus: If all problem solutions are tidily typed.]**
Mid-term exam (1)	**25%**
Final exam	**25%**
Total	**100%**

Final course grade will be assigned according to:

A	90% or greater
B	80% to less than 90%
C	70% to less than 80%
D	60% to less than 70%
F	Less than 60%

Homework Assignments (50%):

- Each homework assignment is due two weeks after it is assigned (usually on Friday), at the beginning of the lecture. Solutions to the homework assignments will be explained in class after grading and will be posted in Dolve hallway (2nd floor) out of instructor's office (Dolve 206). There will be a 20% grade deduction if the homework assignments are turned in at the time later than the due time, unless special arrangements are made in advance (at least **24** hours). After the solutions are posted or explained in the class, **NO** makeup homework submissions will be accepted.

- Homework problems will be solved either by hands or by computational or programming software (e.g., MATLAB, python, MathCAD, C, or FORTRAN, etc. while **MATLAB** is highly recommended). Please make sure your handwritings are neat and well organized, otherwise, it will be returned to you without grading, or points will be deduced (You are **Strongly** encouraged to type all your homework assignments, projects, and take-home exams if scheduled). If programming is involved, **Both** the scripts and numerical results should be printed out and turned in. All pages of the homework assignments must be stapled together. **All home assignments are required to submit to the instructor in hardcopy or electronically by an email attachment of a single PDF file.**

- Students are encouraged to discuss homework problems with each other. However, copying homework solutions or programming scripts are **Extremely** forbidden. Students getting involved in copying homework or exams will result in

ZERO grades for that particular homework assignment or exam, and/or will be advised to drop the class and reported to the department and graduate school.

Examinations (50%):

Two exams will be given [one midterm exam (**25%**) and one final exam (**25%**)]. Student who falls ill or knows in advance s/he will be missing an exam for a good reason (e.g., wedding, family emergency, etc.) is encouraged to notify the instructor by e-mail prior to the exam, if at all possible. A makeup exam could be scheduled provided that an authorized document is provided. Students missing an exam without a valid excuse will receive a grade of **ZERO** for that exam.

Auditing of Graded Work:

Students are welcome to discuss with the instructor about the grading of exams and homework assignments. Auditing of a work must be made within one weeks after the work has been returned to the student. Contact the instructor during office hours to discuss grading problems.

Academic Honesty Statement:

All work in this course must be completed in a manner consistent with the NDSU University Senate Policy, Section 335. Code of Academic Responsibility and Conduct (available on the Web at http://www.ndsu.nodak.edu/policy/335.htm). Violation of this code will result in a penalty or penalties to be determined by the instructor to fit the extent of the offense and the circumstances of the particular case. The instructor may: (1) fail the student for the particular assignment or exam, (2) give the student a failing grade in the course, or (3) recommend that the student drop the course.

Attendance:

The student is responsible for **ALL** the materials presented in class whether or not s/he is present in class. If they miss a class, it is the student's responsibility to obtain notes from a classmate (all electronic class notes can be downloaded from Blackboard). Full credits can be received for work turned in a late time due to an excused absence. It is the student's responsibility to contact the instructor in such a case. If the student is going to miss an exam for a good reason (e.g. illness, family emergency, etc.), s/he should submit a written document with the signature of an authority **BEFORE** the exam to arrange for a make-up test.

Veterans and student soldiers with special circumstances or who are activated are encouraged to notify the instructor in advance

Disabilities:

Any student with disabilities who needs special accommodations is encouraged to talk to the instructor as soon as possible in making appropriate arrangements for those accommodations.

Tentative Course Topics:

1. Introduction
    - Error analysis
    - Foundations of matrix analysis
2. Numerical solution of linear algebraic systems of equations
    - Ill-conditioned equations
    - LU decomposition, Jacobi iteration, Gauss-Seidel iteration, relaxation method
    - Overdetermined, underdetermined, and homogeneous equations
3. Numerical solution of nonlinear equations
    - Bisection, Newton-Raphson, secant method, and fixed point iterations
    - Simultaneous nonlinear equations
    - Convergence
4. Numerical solution of eigenvalue problems
    - Jacobi method, Given's method and Power method
5. Curve-fitting and function approximation
    -Interpolation: Lagrange polynomial and splines
    -Multiple variables
    -Regression
6. Numerical differentiation
7. Numerical integration
    - Newton-Cotes formulas, and Gauss quadrature
    - Numerical integration in two and three-dimensional domains
8. Numerical methods for ordinary differential equations
    - Euler's and Runge-Kutta methods
    - Stiff equations
    - Shooting methods and Finite difference
    - Simultaneous ODEs
9. Numerical solution of partial differential equations
10. Topics on applied mathematics (analytic methods)
    - Dimensional analysis and scaling
    - Complex analysis
    - Fourier and Laplace transforms and applications
    - Calculus of variations
    - Discontinuous functions and special functions