ME 526/NSE 526: Numerical Methods For Engineering Analysis
Fall 2016

Instructor:	Name:	Dr. Sourabh V. Apte
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Class Schedule:	T Th	12.00-1.20 pm COVL 221
Course Textbook:	Fundamentals of Engineering Numerical Analysis, P. Moin Cambridge (Required Text) Numerical Methods for Engineers and Scientists, 2nd Ed.; J. D. Hoffman, McGraw Hill, 2001 (Suggested Reference) Numerical Recipies in Fortran (or C) (Recommended Reference)	
Prerequisites:	ME 373 (or instructor approval)	
Office Hours:	Wednesday and Friday: 9-11:30 Other possible times arranged by appointment.	

Course Description:

Numerical techniques provide a means for solving problems that are not easily solved with exact methods or problems that do not have an analytical solution. Many problems in engineering, science and applied mathematics fall under this category e.g: conventional problems in fluid mechanics, gas-dynamics, heat and mass transfer, nonlinear dynamics and control, chaos theory as well as modern applications of financial mathematics including prediction of stock-option prices and optimization of portfolios can all be investigated using numerical methods.

This is a first course in numerical methods designed for graduate students from different disciplines to learn the basic numerical methods used to solve a variety of differential equations governing different physical phenomena. Familiarity of linear algebra is essential. In addition, the students are expected to write their own computer programs to solve the problems. Proficiency in programming language is not necessary, however, basic knowledge of the logic and programming language is required.

The students taking this course will be able to apply the methods learned to the problems of their interest and understand the strengths and limitations of the numerical schemes used. The exercises, tests, and projects involved are intended to give important experiences with numerical methods. This will help students understand the fundamentals of many commercial softwares developed in computational fluids dynamics and finite-element method. Instead of using these as black boxes, you will learn why a particular method works (or doesn't work) for problems of interest from standard tools of stability analysis.

First half of the course will be devoted to methods used to solve Ordinary Differential Equations (ODEs). These form a basis of all numerical schemes used for Partial Differential Equations (PDEs). In the next half, methods for PDEs will be reviewed.

Course Objectives:

This course is intended to provide a background on basic numerical methods available to solve various types of differential equations. The decision of what type of scheme/method to use will be based on the features of the governing differential equations. Therefore, students must be able to distinguish between initial-value and boundary-value ordinary differential equations, and among elliptic, hyperbolic and parabolic partial differential equations. In addition, students should become proficient in developing finite difference equations using finite difference approximations, and be able to determine and discuss stability, consistency, order, and convergence of various methods.

Course Learning Outcomes:

The student, upon successful completion of this course, will be able to:

1. Identify initial and boundary value problems and choose appropriate numerical schemes.
2. Perform stability and modified wave number analysis to identify restrictions on step sizes.
3. Solve systems of stiff ordinary differential equations.
4. Solve elliptic, parabolic, and hyperbolic differential equations.

Classes/Attendance:

Each of you is responsible for the material covered during lecture. Lectures are designed to supplement the reading material in the text. The material in the textbook may not be followed in the order it is presented. The notation followed in the classroom may be different from the text. Class time is intended to be interactive and will include the class participation in solving problems. All dates given in the schedule are tentative and changes will be periodically announced in class. It is the sole responsibility of each student to remain informed of the course progress.

E-mail:

Each student is expected to create and access their engr (or onid) email. Messages about changes to class schedules, homework hints etc. may be sent out to students on this list. Additional help on homework problems will be provided during office hours. Please refrain from sending me detailed questions regarding homework help, computer program debugging etc. via email as it is best to clarify any difficulties in person.

Reading Material:

To enhance the learning process as well as class discussions, you should try to read the relevant material from text either prior or after the class. Major topics and difficult concepts presented in the text will be covered in detail during lecture. A second reading closely following the lecture is also extremely beneficial to the learning process.

Homework Assignments:

Homework assignments are designed to enhance knowledge of the course material and develop numerical problem-solving skills. Best way to learn about a numerical scheme is to implement and “play” with it. Homework will be assigned periodically and should be turned in at the beginning of class on the day it is due. Illegible or sloppy homework will not be graded. Late submission may result in loss of grade points.

Depending upon the number of students, instructor may decide to form groups of TWO students for homework assignments and project. In this case, one report per group should be submitted. Also the group members once selected should not change over the duration of the course. If you prefer to work alone, you may do so.

Homework assignments should include the differential equation, the finite difference approximations, and the finite difference equations wherever applicable. Homework should also include at least the first 10 and last 5 computer iterations output in tabulated form, the entire solution graphed, and the computer code. Paper conservation is encouraged. The computer code must be well commented (on top of each subroutine comments should be given). This is a good practice in computer programming. In addition the notation used and the basic algorithm must be well described in the text.

Use of Fortran, Fortran90, C, or Matlab is allowed. You may use any graphics software you like. All graphs should be clearly labeled and readable. Tecplot and Matlab are good for plotting results of numerical analysis. Those who are serious about scientific computing should try to complete assignments in Fortran, Fortran90 or C. Matlab may be used, however future use of Matlab for computational fluids is limited. This course can also be taken as a means to "learn" a new language if you are not familiar with scientific computing languages.

Test:

Make-up test will only be given for situations approved by the instructor prior to the start of the test, except under clearly unavoidable or emergency circumstances. Unapproved absences from tests will result in a grade of zero (0) for the test missed. For approved absences, a make up test will be given at a time convenient for the instructor.

Performance Criteria and Grading:

Your overall grade in this class will be determined by your performance on homework, midterm exam, and final exam. The type of test (open/close book, take home etc.) will be announced in the class. There will be several homework assignments, not all will have same amount of work involved and may carry different weights. The final course grade will be determined using the following breakdown.

Final Exam	35 %
Homework	65 %

Disability Access Services:

Accommodations are collaborative efforts between students, faculty and Disability Access Services (DAS). Students with accommodations approved through DAS are responsible for contacting the faculty member in charge of the course prior to or during the first week of the term to discuss accommodations. Students who believe they are eligible for accommodations but who have not yet obtained approval through DAS should contact DAS immediately at (541) 737-4098.

Cheating/Student Conduct:

Copying of any material, term paper, etc., and plagiarizing contents will be considered cheating and may result in a grade of zero on that piece of work. In addition, any instance in which a student is caught cheating will be handled in accordance to the policies mentioned in the Schedule of Classes and at the following web site:
http://oregonstate.edu/studentconduct/offenses-0

<u>Course Schedule:</u> (Subject to change)

<u>Week</u>	<u>Date</u>	<u>Topic</u>
1	9-22	Introduction, Taylor Series
2	9-27	Numerical Differentiation
	9-29	Numerical Differentiation; ODEs : Initial Value Problems (IVP), Errors
3	10-4	ODEs – IVP: Stability and Schemes
	10-6	ODEs – IVP: Stability, Schemes
4	10-11	ODEs IVP: Schemes and Stability
	10-13	ODEs - System of ODEs, Stiff Systems
5	10-18	ODEs: Boundary Value Problems (BVP)
	10-20	ODEs: BVP
6	10-25	Introduction to PDEs
	10-27	Elliptic Equations, Inversion Schemes
7	11-1	Parabolic Equations, von-Neumann Stability
	11-3	Parabolic Equations, Accuracy/Consistency, Modified Eqs.
8	11-8	Parabolic Equations
	11-10	Convection-Diffusion
9	11-15	Convection-Diffusion, solution strategy
	11-17	Hyperbolic Equations
10	11-22	**NO CLASS (Away from Office)**
	11-24	**Thanksgiving**
10	11-29	Hyperbolic Equations
	12-1	Review
	12-9	Final Exam 9:30am

NOTE: The schedule may change based on the progress in each class. There will be roughly 5/6 Homeworks distributed evenly over the term.