College of Engineering and Computer Science
Mechanical Engineering Department

California State University
Northridge

Mechanical Engineering 501A
Seminar in Engineering Analysis

Fall 2017 Number: 15966 Instructor: Larry Caretto

Course Outline (original, posted online August 18)

Catalog Description for ME 501A, Seminar in Engineering Analysis

Analytic and numerical methods applied to the solution of engineering problems at an advanced level. Solution methods are demonstrated on a wide range of engineering topics, including structures, fluids, thermal, thermal energy transport, and mechanical systems. This course emphasizes physical phenomena that can be described by systems of Ordinary Differential Equations.

Instruction information	
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Course Information	
Course number	15966
Class hours	Monday – Wednesday, 7:00 – 8:15 pm
Class location	Jacaranda 1610
Web site	http://www.csun.edu/~lcaretto/me501a

Expanded Description

This is the first course in a two-course sequence in engineering analysis. The one-year course deals with the analysis of these problems using classical mathematical solutions and applying techniques of numerical analysis to the problems.

While emphasizing "physical phenomena that can be described by systems of ordinary differential equations," the introductory 501A course also provides a common set of concepts that will be used throughout the one-year sequence. These concepts generalize the usual notion of two-dimensional and three-dimensional vectors that students have seen in courses from high-school physics to their engineering mechanics courses. In the general case, a "vector" may have an arbitrary number of components. In addition, the concept of two vectors being perpendicular (or orthogonal) so that their dot product vanishes is extended to integrals of functions. Similarly, the notion that vectors can be represented in terms of their basic components is extended to representing functions in terms of a set of basis functions.

Although there are no formal prerequisites for this course, 500-level courses are designed primarily for graduate students, but allow the enrollment of advanced undergraduates. All students in the course are expected to have a background in mathematics and numerical analysis that is equivalent to a graduate in mechanical engineering or other engineering discipline. This includes mathematics courses through ordinary differential equations and some familiarity with matrices and with numerical analysis. (This would be equivalent to the completion of Mathematics 280 and Mechanical Engineering 309 at CSUN.) This expected background material will be briefly reviewed at appropriate times during the course.

Textbook

The text listed below will be used during the one-year 501AB course. Reading assignments are listed as the sections or pages in this textbook. If you have another edition of the textbook make sure that you have the correct reading assignments for your edition.

Erwin Kreyszig, *Advanced Engineering Mathematics*, (tenth edition) Wiley, 2011. (ISBN: 9780470458365)

Course Conduct

Course Objectives – This course has three general goals: (1) enhance students' ability to perform more complex mathematical analyses of engineering problems and get actual answers to those problems; (2) improve students' understanding of how mathematical applications are defined, derived and used, and (3) give students the ability to read and understand publications in their field that make use of advanced concepts in engineering analysis.

In particular, students should be able to achieve the following goals by completing this course.

- Understand that seemingly disparate concepts such as vectors and function expansions have common vocabulary and that an understanding of one will strengthen the understanding of the other.
- Understand publications of applied engineering analysis that involve simultaneous linear equations, matrices, eigenvalues, ordinary differential equations, special functions such as Bessel functions, orthogonal functions, eigenfunction expansions.
- Be familiar with algorithms and software packages for solving simultaneous linear equations, matrix eigenvalue problems, and the numerical integration of systems of ordinary differential equations and understand the limitations of these approaches.
- Analyze engineering problems that require systems of simultaneous equations, obtain solutions to those problems where solutions are possible, and understand why unique solutions may not be possible.
- Perform manipulations of matrices when this is appropriate for the analysis of engineering systems.
- Understand the role that eigenvalues and eigenvectors play in engineering analysis, obtain these quantities in simple cases, and use software to obtain them in systems that are more complex.
- Understand when solutions to ordinary differential equations are possible and obtain solutions in those cases.
- Obtain power series solutions to ordinary differential equations.
- Obtain solutions to ordinary differential equations that involve special functions such as Bessel functions.
- Be familiar with the use of Laplace transforms for solving ordinary differential equations and be able to use a transform table to get such solutions in simple cases.
- Use various numerical algorithms and software packages for solving systems of ordinary differential equations and understand the approaches used to keep the accuracy to the solution within the bounds desired by the user. This ability should apply to initial value problems, boundary value problems, and eigenvalue problems.

Class participation – Learning engineering subjects is a difficult task that can only be done by working problems on your own. Your learning in this course will be a combination of textbook material, lecture material and in-class discussion. Your active participation in class exercises and discussion is essential to your learning of the subject matter. Your own work in problem solving is a key to your mastery of the subject matter.

Class courtesy – To keep a good learning environment your fellow students you should come to class on time and not leave before class is over. Turn off your cell phone while you are in class. Do not disturb others by talking during lecture. If you do not understand some point of the lecture, ask the instructor for clarification. Please do not wear strong scents in perfume, after-shave, colognes, etc.; this can be especially troublesome for your fellow students with allergies.

Homework – Weekly homework assignments are given on the course web site. These are all problems from a previous edition of the text. These assignments will be collected and graded. Solutions to the homework will be posted on the course web site. Homework should be done neatly, but there is no required format for the homework. Use your own professional standards for the format you use in submitting homework problems.

Class sessions – At appropriate times during the class there will be the opportunity for you to work in problem-solving groups on exercises designed to help you learn the subject matter. These exercises will be done in groups and will include problems from the weekly homework assignments.

Grading – Your grade in this course will be based on weekly homework assignments, two seventy-five-minute midterm exams, and a final exam. These will be weighted as follows in computing the final grade:

Weekly homework assignments	10%
Two midterm examinations	50%
Final examination	40%

The translation of a final numerical score into a letter grade rests solely on the judgement of the instructor. Plus/minus grading will be used in this course as indicated in the criteria below:

A: Student knows almost all the course material and is able to apply it to new problems similar to those covered in the course.

A–: Student satisfies one, but not both, of the conditions for an A grade.

B+: Student understands the fundamental aspects of the course and can apply this knowledge to problems covered in the course.

B: Student can apply almost all the fundamental aspects of the course to problems covered in the course.

B–: Student has learned some course material but is not able to apply all the fundamental points of the course.

C: Student has failed to demonstrate knowledge of the course material beyond a minimal level.

F: Student has violated campus guidelines for academic honesty.

No make-up exams – There are no make-up examinations. Students who miss a midterm exam will receive a grade for the missed exam, based on their performance on all the other exams that they took. All students must take the final exam. If you cannot take this exam because of illness or other reason you must request an incomplete (I) grade in writing from the Office of Admissions and Records. Students who do not take the final examination will receive a grade of WU (unauthorized withdrawal) in the course. This counts the same as an F in the computation of the grade point average.

Plagiarism vs*. Collaboration* – Students often work together on assignments. This collaboration is helpful and encouraged. By working together, each of you can improve your learning of the subject. However, there is a difference between working together to learn the material and copying another student's work and passing it off as your own. Submitting another person's work as your own is a violation of academic standards and University regulations. It is unethical behavior for people working in engineering and science or studying to work in these fields. Each student must submit his or her own work to pass the course.

Written assignments or exam solutions that are identical and, in the instructor's judgment, indicating copying, will result in an F grade in the course for both students involved. The instructor will notify the Associate Dean of the College of Engineering and Computer Science and the Dean of Students of any cheating incidents in this class.

Add-drop policy – Students are expected to be familiar with the University regulations for adding and dropping classes. Students who find that they do not have enough time to prepare for this class or who have difficulty with the initial homework assignments should consider dropping the class within the appropriate deadline. Students who do not complete the course work and do not withdraw from the class will receive a grade of WU, denoting an unsatisfactory incomplete. As noted above, such grades count the same as an F grade in the computation of students' grade point averages.

Changes – Students are responsible for all changes to this outline announced in class.

Schedule of lecture topics and exams

The "Pages" columns below gives the assigned reading pages from two editions of the required text by Kreyszig.

Dates	Subject Matter	Pages 9th edition	Pages 10th edition
August 28	Course overview, typical problems and methods used. Review vectors and dot products from mechanics. Basic concepts of matrices, row and column vectors.	271-286	255-270
August 30	Determinants and matrix inverses. Properties of determinants. Formulas for finding determinants and matrix inverses.	296-322	291-308
September 4	**Labor Day Holiday – No Class**		
September 6	General vector and inner-product spaces, basis for a set of vectors, linear dependence, orthogonality, and norms. Introduction to solution of simultaneous linear equations.	287-301, 323-329	272-287, 309-317
September 11	Gaussian elimination. Rank of a matrix. Existence and uniqueness of solutions to simultaneous equations. Solutions to homogenous equations. Cramer's rule.	302-307	288-293
September 13	Matrix eigenvalues and eigenvectors. Solution of matrix eigenvalue problems from basic definitions.	333-343	322-333
September 18	Similar matrices and conversion of a matrix to a similar diagonal matrix. Numerical determination of matrix eigenvalues. Special matrix types.	345-361, 863-861	334-351, 876-884
September 20	Introduction to numerical analysis. Finite representation of numbers.	780-789, 844-870	790-796, 844-870
September 25	Methods for solving simultaneous linear equations. Avoiding round-off errors. Software packages.	840-844	852-857
September 27	Basic concepts in the solution of ordinary differential equations. Existence and uniqueness of solutions. Basis of solutions.	1-53	1-54
October 2	Second order homogenous linear differential equations. Solutions for constant coefficients	54-79	54-77
October 4	Non-homogenous second order linear differential equations. Homogenous and particular solutions. Variation of parameters.	78-101	79-102
October 9	Higher-order equations. Forced vibrations.	105-121	105-121
October 11	Systems of equations. Conversion to higher order equations and use of matrix analysis.	124-139	124-139
October 16	Power series solutions of ordinary differential equations. Frobenius method.	166-187	167-185
October 18	**First midterm exam covers material up to and including October 9 lecture.**		
October 23	Applications to Frobenius method to Bessel's equation. Bessel functions of various kinds and orders.	189-202	187-200
October 25	Introduction to Laplace transforms and solutions of differential equations using Laplace transforms.	220-232	203-216
October 30	Laplace transform solutions systems of differential equations. Finding inverse transforms. Shifting theorems.	233-262	217-246
November 1	Phase-plane analysis of systems of equations, critical points and stability.	139-161	140-163

Dates	Subject Matter	Pages 9th edition	Pages 10th edition
November 6	Basic concepts of finite-difference and finite-element numerical methods. Interpolation polynomials. Error in polynomials and derivative approximations from polynomials. Taylor series derivative approximations. Truncation and roundoff error.	780-786, 797-808, 827-828	787-796,808-819, 838-839
November 8	Basic numerical approach for solving ordinary differential equations.	886-897	900-910
November 13	Extrapolation, implicit and multistep methods for numerical solution of ordinary differential equations.	886-897	911-914
November 15	**Second midterm exam covers up to and including November 1 lecture.**		
November 20	Analysis of numerical methods, accuracy and stability. Introduction to systems of ordinary differential equations.	902-908	915-921
November 22	Systems of ordinary differential equations, stiff systems, Gear's method.		
November 27	The shoot-and-try method for boundary-value problem in ordinary differential equations.		
November 29	Finite-difference solutions of boundary-value and eigenvalue problems.		
December 4	Finite-element solutions of boundary-value problems.		
December 6	Review for the final exam.		
December 11	**Monday – Final Examination 8:00 to 10:00 pm**		

References

See Appendix 1 in Kreyszig for a list of books and journals that are appropriate references for this course.