THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Aerospace Engineering and Engineering Mechanics

COE 352 Advanced Scientific Computing
Fall 2021

SYLLABUS

Unique Number:	13640
Instructor:	Corey Trahan, Ph.D. POB 6.240, trahancj@gmail.com
Time:	MWF 11:00-12:00
Location:	In Person
Teaching Assistant:	
Web Page:	http://canvas.utexas.edu
Catalog Description:	Restricted to computational engineering majors. Topics in advanced numerical methods and scientific computation. Subject matter may vary. Three lecture hours a week for one semester. May be repeated for credit when the topics vary. Prerequisite: Mathematics 427J or 427K, and Statistics and Data Sciences 329C (or Statistics and Scientific Computation 329C) or Mathematics 340L with a grade of at least C- in each; and Computational Engineering 211K with a grade of at least C- or programming experience.

Catalog description: http://catalog.utexas.edu/undergraduate/engineering/courses/aerospace-mechanics/

Course Objectives:	Students will be introduced to advanced concepts and algorithms for solving engineering problems. The course expands upon prior knowledge in mathematics, numerical methods and scientific computing.
Prerequisites:	Mathematics 427J or 427K, and Statistics and Data Sciences 329C (or Statistics and Scientific Computation 329C) or Mathematics 340L with a grade of at least C- in each; and Computational Engineering 211K with a grade of at least C- or programming experience.

Knowledge, Skills, and Abilities Students Should Have Before Entering This Course:
Programming experience in Matlab and C or C++. Introductory numerical methods including numerical linear algebra, interpolation, numerical integration, and numerical ODEs and PDEs. Knowledge of linear algebra, calculus and analytical solutions to differential equations.

Knowledge, Skills, and Abilities Students Gain from this Course (Learning Outcomes):
Ability to formulate and solve large-scale engineering problems involving differential equations and linear

and nonlinear systems of equations. Understanding of error and error analysis in approximation of solutions to engineering applications. Ability to translate engineering problems into scientific software and to verify code for correctness and efficient implementation.

Impact On Subsequent Courses In Curriculum:
None

Relationship of Course to Program Outcomes:
This course contributes to the following ABET Criterion 3 outcomes and those specific to the EAC accredited program.

Outcome	√	**Outcome**	√
a. An ability to apply knowledge of mathematics, science, and engineering	√	g. An ability to communicate effectively	
b. An ability to design and conduct experiments, as well as to analyze and interpret data		h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.		i. A recognition of the need for and an ability to engage in life-long learning	
d. An ability to function on multi-disciplinary teams		j. A knowledge of contemporary issues	
e. An ability to identify, formulate, and solve engineering problems	√	k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	√
f. An understanding of professional and ethical responsibility			

ABET Aerospace Engineering Program Criteria Achieved:
This course contributes to the ABET Criterion 3 student outcomes that took effect with the Fall 2019 semester. For more information, see *Criteria for Accrediting Engineering Programs, 2019 – 2020* at https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/

STUDENT OUTCOME	
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	√
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3. an ability to communicate effectively with a range of audiences	
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions	

in global, economic, environmental, and societal contexts	
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

Topics:
List the major topics in the course and in parentheses the number of classes in which the topic is covered; assume 42 classes as in a MWF class on a long-session semester for this purpose. Give also in separate parentheses the Program Outcomes and Program Criteria addressed by each topic referenced by letter.

Numerical linear algebra (5) (a,e,k,P)
Topics in Applied Mathematics (10) (a,e,k,P)
Boundary Value Problems and Discretizations (11) (a,e,k,P)
Function Approximations (2) (a,e,k,P)
Initial Value Problems (8) (a,e,k,P)
Solving Large Systems of Equations (4) (a,e,k,P)

Professionalism Topics:
None

Design Assignments:
None

Laboratory Assignments:
None

Computer:
Students should have access to Matlab and a computer with a C or C++ compiler.

Text:
Computational Science and Engineering, Gilbert Strang, Wellesley-Cambridge Press. ISBN 978-0-9614088-1-7.

Class Format:
Lecture

Class Schedule:
Aug 30-September 11: Numerical Linear Algebra: review, matrix factorizations, Singular Value Decomposition, Proper Orthogonal Decomposition, Principal Component Analysis
September 13-October 4: Topics in applied mathematics and engineering: Equilibrium, oscillations, least squares, numerical methods for ODEs, nonlinear problems, numerical optimization, weighted least squares
October 4-13: Boundary value problems: second order equations, Galerkin's method
October 16: Test 1 (in class)

October 18-November 1: Boundary value problems: Finite element methods for second and fourth order equations, numerical integration, FEM for Poisson's equation and other applications
November 4-November 11: Function approximations: FFT; Initial Value problems, stability and convergence
November 13: Test 2 (in class)
November 15-December 11: Initial value problems: conservation laws, finite difference methods

Final Exam: Date TBD by Registrar's Office.

Class Outline:
Chapter 1: Numerical Linear Algebra
Chapter 2: Topics in Applied Mathematics (2.1, 2.2, 2.3, 2.6, 2.7, 2.8)
Chapter 3: Boundary Value Problems (3.1, 3.2, 3.3, 3.4, 3.6, 3.7)
Chapter 4: Fourier Series and Integrals (4.1, 4.3)
Chapter 6: Initial Value Problems (6.1, 6.2, 6.3, 6.5, 6.6)
Chapter 7: Solving Large Systems

Grading:
The final grade will be weighted as follows:
Projects 1 and 2: 30%
Homework: 70%
Attendance is expected but will not be graded. The +/- system will be used.

Project Policy:
Projects are a vital part of this class and assist in the practical understanding of the topics discovered. This course is designed to give students a real-world introduction into scientific computing, and these projects are designed for this purpose. Projects are NOT group assignments. They are taken just as seriously as exams and graded heavily. Note that both projects are multi-component, so be careful and read through them to accomplish all that is needed.
Project preparation should reflect your professional standards as future engineers.

Homework Policy:
Homework assignments are essential to learning the material in this class. Assignments will consist of written problems out of the book and/or coding assignments. There will be 7 assignments. Unless indicated, homework assignments are not group projects.

Examinations:
Projects have replaced exams for this course.

Attendance:
Regular attendance is expected.

Office Hours:
Office hours are scheduled online on Mondays 12:00-2:00pm and Wednesdays 12:00-2:00pm.

Important Dates:
September 4: last day of official add/drop
September 14: last day to drop class for possible refund
November 1: last day to withdraw/drop a course with approval, last day to change to/from pass/fail.

Special Notes:
The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TDD or the Cockrell School of Engineering Director of Students with Disabilities at 471-4321.

Evaluation:
Note that the Measurement and Evaluation Center forms for the Cockrell School of Engineering will be used during the last week of class to evaluate the course and the instructor.

Prepared by: Instructor Name :: Corey Trahan Date: August 27, 2019