THE UNIVERSITY OF COLORADO BOULDER

ASEN 5007: Introduction to Finite Element Methods
Fall 2020

SYLLABUS

Instructor: Assistant Professor John Evans
E-mail Address: john.a.evans@colorado.edu

Teaching Assistant: Mary Bastawrous
E-mail Address: mary.bastawrous@colorado.edu

Lecture: Time: Tuesday/Thursday, 1:15 pm – 2:30 pm
Location: AERO 111 (Tu: Last Names A-K, Th: Last Names L-Z)

Zoom Link: https://cuboulder.zoom.us/j/92493180405
Zoom Meeting ID: 924 9318 0405

Office Hours: John Evans: Tuesday/Thursday, 4:00 pm – 5:00 pm
Mary Bastawrous: Monday/Wednesday, 4:30 pm – 5:30 pm

Zoom Link: https://cuboulder.zoom.us/j/97725619027
Zoom Meeting ID: 977 2561 9027

Web Page: Canvas (canvas.colorado.edu)

Course Objective:

Introduces finite element methods used for solving linear problems in structural and continuum mechanics. Covers modeling, mathematical formulation, and computer implementation.

Prerequisites:

This class requires an undergraduate course in matrix algebra. Students should also have experience with vector calculus and differential equations, and it is highly recommended that students have a working knowledge of MATLAB.

Required Textbooks:

There are no required textbooks for this class. Instead, notes will be released on a periodic basis to students through the course website.

Reference Textbook:

The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Hughes, Dover, First Edition, 2000.

Topics:

1. History of Finite Element Analysis
2. Finite Element Analysis of a One-Dimensional Model Problem
3. Finite Element Analysis of Two-Dimensional Steady Heat Conduction
4. Primal Finite Element Analysis of Plane Strain Linear Elastostatics
5. Mixed Finite Element Analysis of Plane Strain Linear Elastostatics
6. Finite Element Analysis of Plane Strain Linear Elastodynamics

Class Format:

The class meets twice a week for an hour and fifteen minutes of formal lecture and discussion.

Grading:

10% Homework Assignments (4 x 2.5%)
15% Mini-Project Assignment
25% Midterm Quizzes (5 x 5%)
20% Midterm Exam
30% Final Exam

Grades will be posted to the class website on Canvas.

Homework Assignments:

There will be four homework assignments covering both theory and implementation:

Assignment 1: One-Dimensional Finite Element Analysis
Assigned: 09-03, Due: 09-24 (Start of Class)
Assignment 2: Finite Element Analysis of Steady Heat Conduction
Assigned: 10-15, Due: 11-05 (Start of Class)
Assignment 3: Primal Finite Element Analysis of Plane Strain Linear Elastostatics
Assigned: 11-05, Due: 11-19 (Start of Class)
Assignment 4: Mixed Finite Element Analysis of Plane Strain Linear Elastostatics
Assigned: 11-19, Due: 12-03 (Start of Class)

Homework assignments are to be turned in through the course website. Students should make an effort to turn in assignments that are organized, professional looking, and legible. Homework assignments will be graded on a completion basis only, and solutions will be made available so students can check the correctness of their work.

Collaboration is permitted on homework assignments. This means students may discuss the means and methods for solving problems and even compare answers, but students are not free to copy someone else's homework assignment. The work that a student turns in must be his or her own – copying is not allowed and will not be tolerated. Students who are caught copying (or providing his or her assignment to another) will receive an "F" for the course and reported to the Dean's office for further punitive action.

Mini-Project Assignment:

Students will use MATLAB to implement a finite element method for a one-dimensional model problem in the first half of the semester:

Mini-Project: Computer Implementation of a One-Dimensional Finite Element Code
Assigned: 09-24, Due: 10-15 (Start of Class)

In this mini-project assignment, students will not only create a MATLAB code to solve the given model problem using a finite element method, they will also create a MATLAB post-processing scheme to visualize the resulting solution field and construct a suitable verification test to confirm their code works as intended.

The mini-project assignment is to be turned in through the course website. Submissions should be organized and professional looking. Code should be commented. A readme should be included indicating how to run a student's code. The mini-project assignment will be graded on both a completion basis and a correctness basis.

Collaboration is permitted on the mini-project assignment. This means students may discuss the means and methods for solving problems and even compare answers, but students are not free to copy someone else's code MOSS (Measure Of Software Similarity) will be used to detect potential cases of plagiarism. Students who are caught copying code (or providing his or her code to another) will receive an "F" for the course and reported to the Dean's office for further punitive action.

Midterm Quizzes:

There will be five midterm quizzes throughout the semester:

Quiz 1: Strong, Weak, and Minimization Forms • Galerkin's Method and Ritz's Method
Date: 09-10
Quiz 2: 1-D Finite Element Basis Functions • Stability and Error Analysis
Date: 09-17
Quiz 3: Finite Element Implementation • Verification and Validation
Date: 10-01
Quiz 4:Essential and Natural Boundary Conditions • 2-D Finite Element Basis Functions
Date: 10-22
Quiz 5: Volumetric Locking • Mixed Form of Elasticity and Constraint Counting
Date: 11-24

Each quiz will test a student's understanding of basic finite element concepts. Students will have ten to fifteen minutes to complete each midterm quiz.

Collaboration on the midterm quizzes will not be tolerated. Students who are caught in these activities will receive an "F" for the course and reported to the Dean's office for further punitive action. Students are free to ask the instructor any clarification questions.

Midterm Exam:

There will be a midterm exam on November 10, 2020. This midterm exam will test material associated with "History of Finite Element Analysis", "Finite Element Analysis of a One-Dimensional Model Problem", and "Finite Element Analysis of Two-Dimensional Steady Heat Conduction". It will also test material associated with Homework Assignments 1 and 2, the Mini-Project Assignment, and Midterm Quizzes 1-4.

The midterm exam will consist of a closed-book portion and an open-book portion. The closed-book portion will test a student's understanding of basic finite element concepts, while the open-book portion will test a student's understanding of applied finite element concepts. Students will have seventy five minutes to complete the midterm exam.

Collaboration on the midterm exam will not be tolerated. Students who are caught in these activities will receive an "F" for the course and reported to the Dean's office for further punitive action. Students are free to ask the instructor any clarification questions.

Final Exam:

There will be a final exam on December 12, 2020. The final exam will test all material associated with the course except that associated with "Finite Element Analysis of Plane Strain Linear Elastodynamics". In particular, it will test material associated with Homework Assignments 1-4, the Mini-Project Assignment, Midterm Quizzes 1-5, and the Midterm Exam.

The final exam will consist of a closed-book portion and an open-book portion. The closed-book portion will test a student's understanding of basic finite element concepts, while the open-book portion will test a student's understanding of applied finite element concepts. Students will have two and a half hours to complete the final exam.

MATLAB, Gmsh, and Paraview:

The homework and mini-project assignments will make heavy use of MATLAB, Gmsh, and Paraview. Each of these software packages is available for Windows, MacOS, and Linux. CU Boulder has a campus site license for MATLAB. To download MATLAB, visit:

https://oit.colorado.edu/software-hardware/software-downloads-and-licensing/matlab#download

Gmsh is freely available to download at:

https://gmsh.info

Paraview is freely available to download at:

https://www.paraview.org

It is recommended that students download these packages as soon as possible.

Slack:

A Slack channel has been created to foster communication. Students will receive an e-mail invitation to join this channel. Students can use Slack to ask questions regarding lecture material, homework and mini-project assignments, midterm quizzes, and the midterm and final exams.

Late Assignment and Missed Exam Policy:

Generally speaking, late assignment submissions will not be accepted, and there will be no make-up quizzes or exams. That being said, we are living in unusual times, so please contact the instructor if you are unable to submit an assignment or take a quiz or exam due to illness, technical issues, or other challenging extenuating circumstances. Reasonable accommodations will be made where appropriate provided you contact the instructor before the assignment due date or quiz or exam date.

Requirements for COVID-19:

As a matter of public health and safety due to the pandemic, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements, and public health orders in place to reduce the risk of spreading infectious disease. Required safety measures at CU Boulder relevant to the classroom setting include:

- maintain 6-foot distancing when possible,
- wear a face covering in public indoor spaces and outdoors while on campus consistent with state and county health orders,
- clean local work area,
- practice hand hygiene,
- follow public health orders, and
- if sick and you live off campus, do not come onto campus (unless instructed by a CU Healthcare professional), or if you live on-campus, please alert CU Boulder Medical Services.

Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policies on COVID-19 Health and Safety and classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please see the "Accommodation for Disabilities" statement on this syllabus.

Before returning to campus, all students must complete the COVID-19 Student Health and Expectations Course. Before coming on to campus each day, all students are required to complete a Daily Health Form.

Students who have tested positive for COVID-19, have symptoms of COVID-19, or have had close contact with someone who has tested positive for or had symptoms of COVID-19 must stay home and complete the Health Questionnaire and Illness Reporting Form remotely. In this class, if you are sick or quarantined, please simply inform the instructor that you will not be attending lecture in-person. All lectures will be streamed via Zoom and recorded for later viewing by students. If you are unable to complete an assignment, quiz, or exam due to illness, please inform the instructor before the assignment due date or quiz or exam date so that proper accommodations can be made.

Accommodation for Disabilities:

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

Classroom Behavior:

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on classroom behavior and the Student Code of Conduct.

Preferred Student Names and Pronouns:

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Honor Code:

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu); 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found at the Honor Code Office website.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation:

The University of Colorado Boulder (CU Boulder) is committed to fostering an inclusive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127

or cureport@colorado.edu. Information about the OIEC, university policies, anonymous reporting, and the campus resources can be found on the OIEC website.

Please know that faculty and instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about options for reporting and support resources.

Religious Holidays:

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, you must let the instructors know of any such conflicts within the first two weeks of the semester so that we can work with you to make arrangements.

See the campus policy regarding religious observances for full details.

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Prepared by: John Evans Date: August 20,2020