Tentative

Please see Course Info on D2L for the latest version of the syllabus

CE 529: Finite Element Analysis
Units: 4

Fall 2024:
- **Lecture: Wednesday, 6:00 PM - 9:20 PM**
  Location: VHE 206
- **Lab: TBD**

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Course Description

Typical engineering problems discussed on a physical basis. Setup and solution of problems by means of the existing mathematical tools.

Learning Objectives and Outcomes

To achieve fundamental understanding of the subject of finite element analysis and apply it to diverse problems with emphasis on Aerospace, Civil, and Mechanical Engineering.

- A. Variational Models
  1. Calculus of variations
  2. Constraints – Lagrange's multiplier
  3. Constraints – Penalty
  4. Galerkin's method.
- B. Continuum Finite Elements
  1. 1-D interpolation methods
  2. 2-D interpolation methods – rectangles and triangles
  3. 3-D interpolation methods – hexahedron, tetrahedron, prism.
- C. Isoparameteric Elements
  1. Mappings – physical system and natural coordinate system
  2. Numerical integration – Gauss' quadrature
- D. Numerical Implementation
- E. Elasticity Problems
  1. Plane stress and plane strain
  2. Stress calculation
  3. Incompressible problems
  4. Pressure, enforced displacement
- F. Axisymmetric Elasticity Problems
- G. Plate Problems
  1. Thin plates
  2. Thick plates
- H. Shell Problems
- I. Dynamic Problems
  1. Time history analysis
  2. Free vibration/eigenvalues and eigenvectors
- J. Nonlinear Problems
  1. Geometric nonlinearity
  2. Material nonlinearity
  3. Contact nonlinearity

Prerequisite(s)

CE 358 or equivalent.

Recommended Preparation

Good command of undergraduate Mathematics and Engineering Mechanics.

Course Notes

Lecture notes to be made available on DEN website. Login is needed:
https://courses.uscden.net/d2l/login

Required Textbook

D.L. Logan, "**A First Course in the Finite Element Method**," CL-Engineering, Sixth Edition, 2016, ISBN-13: 978-1-305-63511-1.

Reference Materials

The following **optional** references can be **supplementary** materials for the course:

1) H. Ataei, and M. Mamaghani, "Finite Element Analysis, Applications and Solved Problems using Abaqus," 2017, ISBN-13: 978-1544625270. Recommended.
2) Online Abaqus SIMULIA tutorials, e.g.:
    Getting Started with Abaqus | SIMULIA Tutorial - YouTube
    SIMULIA How-to Tutorial for Abaqus | Analysis of a 2D Truss (Part 1/2-Static) - YouTube
3) M. O. Safadi, "Elementary Vibration Analysis," Cognella, 2023.
4) M. O. Safadi, "Stress Analysis with Introduction to Finite Element Methods," Cognella, 2023.
5) K-J. Bathe, "Finite Element Procedures," Prentice-Hall, Englewood Cliffs, 1995.
6) M.A. Crisfield, "Non-Linear Finite Element Analysis of Solids and Structures," Vol. II, John Wiley & Sons; 1st edition, 1997.
7) T. Belytshko, W. K. Liu, B. Moran, & K. Elkodary, "Nonlinear Finite Elements for Continua and Structures," 2nd edition," Wiley, 2014, ISBN-13: 978-1118632703.
8) E.L. Malvern, "Introduction to the Mechanics of a Continuous Medium," Prentice-Hall, Englewood Cliffs, N.J., 1969.
9) R. Cook, D. Malkus, M. Plesha, and R. Witt, "Concepts and Applications of Finite Element Analysis," 4th Edition, 2002, Wiley."
10) S.S. Rao, "The Finite Element Method in Engineering," Butterworth-Heinemann, Elsevier Inc., Fifth Edition, 2010, ISBN-13: 978-1856176613.
11) J.N. Reddy, "An Introduction to Nonlinear Finite Element Analysis," Oxford University Press, 2004.
12) K. Huebner, D. Dewhirst, D. Smith, and T. Byrom, "The Finite Element Method for Engineers," 4th Edition, 2001, Wiley-Interscience."

Description and Assessment of Assignments

Homework:
Homework (HW) assignment and delivery will be per the class schedule, unless otherwise instructed. The homework delivery will be due at the start of the designated class on the specified delivery day on the class schedule, unless otherwise instructed. Students are to work independently on the HW assignments. Often, students are given one week to solve the HW, and no late HW is accepted. No exceptions except in situation-established emergency reasons; credit for such late homework is at the discretion of the instructor. HW assignments may involve a varying number of problems; however, in the end, the HW assignments are counted equally in computing the final HW grade.

Project:
The project typically requires the student to do all the following tasks:
1. Go through a set of step-by-step FEA tutorials using Abaqus software.
   - You need to download the ABAQUS student's version to use for the class related assignments and project. Here is the link that you may use:
     http://academy.3ds.com/software/simulia/abaqus-student-edition/
   - *You should download this software, get it to work, finish the first tutorial, and email me by the beginning of the 4th class session.*
2. Solve an assigned set of problems using the FEM (Finite Element Method) with help of FEA software (Abaqus).
3. Write a comprehensive report summarizing the FEM solutions using the FEA software. The report should include a description of the problem, the finite element models, solution results, and comments on the accuracy of the results.
4. Submit the report by the due date as required.

There is no required presentations of the project results. The project delivery is due per the class schedule, at the start of the class meeting, unless otherwise instructed. No late project is accepted. No exceptions except in situation-established emergency reasons; credit for such late project is at the discretion of the instructor.

Exams:
There will two exams: One midterm exam and one final exam.
   - Closed book.
   - Only one sheet of 8.5" x 11" paper (two pages) of formulae allowed.
   - Calculator.
   - No make-up on any examinations.

Grading Score Breakdown

A weighted average grading score will be calculated as follows:

Homework	20%
Midterm Exam	25%
Project	20%
Final Exam	35%
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Total	100%

Grading Scale

Students will be graded based on their total scores (possibly relative to the overall class performance). The following is a rough guideline and may be subject to revision depending on the overall class performance.

A 95-100
A- 90-94
B+ 87-89
B 83-86
B- 80-82
C+ 77-79
C 73-76
C- 70-72
D+ 67-69
D 63-66
D- 60-62
F 59 and below

Assignment Submission Policy

- Late Student Work: Completed assignments (HW/Project) are due per class schedule at the beginning of class. If the student work cannot be turned in at the beginning of class on the due date, prior permission from the instructor to change the due date is necessary. Credit for such late work is at the discretion of the instructor. Without permission, the student work will not be graded and zero will be given for the associated work assignment.
- Answers should be clearly and fully justified as well as organized. If the answers/steps are not clear, not justified, not organized, points will be deducted, even if the final answer is correct.
- Reasonable collaboration in solving homework problems is allowed. Exchanging solutions, finding solutions on the web or elsewhere, and/or blindly copying previous years' solutions are not allowed. Violations result in losing the credit for the entire problem(s) in which the violation occurred and to be reported to the University's academic integrity office.

Grading Timeline

- Homework assignments are intended to be graded and returned usually within one week after their due dates.
- Midterm exams are intended to be graded and returned usually within one week after the exam date.
- Final exam will be graded. Only the student score in the final exam will be communicated. The student score in the final exam is intended to be communicated usually within one week after the exam date.
- Letter grade of the student in the class is intended to be posted to the school grading system (GRS) usually within one week after the exam date.

Tentative Course Lecture/Schedule: A Weekly Breakdown

Week	Monday	Topic	Textbook Reading Assignments	Assignments Assignment	Assignments Delivery
1	28-Aug	Introduction to The Finite Element Method	Chapter 1, Section 2.6, Section 3., 3.1, 3.10, 3.11	HW 1	
2	4-Sep	Variational Models, Calculus of Variations	Chapter 1, Section 2.6, Section 3., 3.1, 3.10, 3.11	HW 2/ Project	
3	11-Sep	Galerkin Method, Constraints – Lagrange's multiplier, Penalty	Section 3.12, 3.13, Section 4., 4.1, 4.2, 4.7, 4.8	HW 3	HW 1
4	18-Sep	Continuum Elements I, Isoparametric Element, Numerical Integration	Section 3.2, Section 4.4, Section 6., 6.1, 6.6, Section 10., 10.1, 10.2, 10.3, 10.4, 10.5	HW 4	HW 2
5	25-Sep	Static Condensation, Elasticity Problems, Numerical Implementation	Chapter 10	HW 5	HW 3
6	2-Oct	Stress Calculation, Continuum Elements II	Section 4.6, Section 6.1-6.4, Section 7.5, Section 5.6, Chapter 8 -10	HW5/HW 6	HW 4
7	9-Oct	Axisymmetric Problems; Plate Theory;	Chapter 12	HW 7	HW 5
8	16-Oct	Midterm Exam (120 min): 7:00 PM - 9:00 PM			
9	23-Oct	Plate Elements; Kirchhoff and Mindlin, DKQ Plate Elements		HW 8	HW6/HW 7
10	30-Oct	Shell Theory. Analysis of ShellsStructural Dynamics, Time History Analysis, Free Vibration	Chapter 12	HW 9	
11	6-Nov	Geometrically Nonlinear Analysis of Bars, Beams, Buckling,		HW 10	HW 8
12	13-Nov	Geometrically Nonlinear Analysis of Bars, Beams, Buckling (Cont.). Geometric Nonlinearity – Nonlinear Mechanics		HW 11	HW 9
13	20-Nov	Geometric Nonlinearity – Nonlinear Mechanics (Cont.). Geometric Nonlinearity – Total and Updated Lagrangian Methods			HW 10/Project
14	27-Nov	Holiday, No class			
15	4-Dec	Material Nonlinearity – Plasticity Fundamentals, Return Algorithms, Contact Problems			HW11
16	11-Dec	Final Exam (120 min): 7:00 PM - 9:00 PM	Refer to the final exam schedule in the USC Schedule of Classes at classes.usc.edu.		

Statement on Academic Conduct and Support Systems

Academic Integrity:
The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, compromises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - *(213) 740-9355 – 24/7 on call*
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline - 988 for both calls and text messages – 24/7 on call
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL) – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - (213) 740-0776
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - (213) 740-0411
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - (213) 740-2101
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-2850 or otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.