USC Viterbi
School of Engineering
Sonny Astani Department of Civil and Environmental Engineering

Tentative

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

CE 529: Finite Element Analysis
Units: 4

Summer 2022:

- **Tuesday, 6:00 PM - 9:20 PM**
- **Thursday, 6:00 PM - 9:20 PM**

Location: Online/TBD

Instructor: Professor A. Niazy, Ph.D., P.E.
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Grader Assistant: TBD
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For Viterbi IT: engrhelp@usc.edu

For ITS: consult@usc.edu

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 in 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) K-J. Bathe, "Finite Element Procedures," Prentice-Hall, Englewood Cliffs, 1995.
4) M.A. Crisfield, "Non-Linear Finite Element Analysis of Solids and Structures," Vol. II, John Wiley & Sons; 1st edition, 1997.
5) T. Belytshko, W. K. Liu, B. Moran, & K. Elkodary, "Nonlinear Finite Elements for Continua and Structures," 2nd edition," Wiley, 2014, ISBN-13: 978-1118632703.
6) E.L. Malvern, "Introduction to the Mechanics of a Continuous Medium," Prentice-Hall, Englewood Cliffs, N.J., 1969.
7) R. Cook, D. Malkus, M. Plesha, and R. Witt, "Concepts and Applications of Finite Element Analysis," 4th Edition, 2002, Wiley."
8) S.S. Rao, "The Finite Element Method in Engineering," Butterworth-Heinemann, Elsevier Inc., Fifth Edition, 2010, ISBN-13: 978-1856176613.
9) J.N. Reddy, "An Introduction to Nonlinear Finite Element Analysis," Oxford University Press, 2004.
10) 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. For the most part, 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, and start working the tutorials by June 1, 2021.*
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%
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

				Assignments	
Session	Date	Topic	Textbook Reading Assignments	Assignment	Delivery
1	19-May	Introduction to The Finite Element Method	Chapter 1, Section 2.6, Section 3., 3.1, 3.10, 3.11	HW 1	
2	24-May	Variational Models, Calculus of Variations	Chapter 1, Section 2.6, Section 3, 3.1, 3.10, 3.11	HW 2/ **Project**	
3	26-May	Constraints – Lagrange's multiplier, Penalty – Galerkin Method	Section 3.12, 3.13, Section 4., 4.1, 4.2, 4.7, 4.8	HW 3	HW 1
4	31-May	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	2-Jun	Static Condensation, Elasticity Problems, Numerical Implementation, Stress Calculation	Chapter 10	HW 5	HW 3
6	7-Jun	Continuum Elements II, Axisymmetric Problems	Section 4.6, Section 6.1-6.4, Section 7.5, Section 5.6, Chapter 8 -10	HW 6	HW 4
7	19-Jun	Plate Theory; Plate Elements; Kirchhoff and Mindlin Elements	Chapter 12	HW 7	HW 5
8	**14-Jun**	**Midterm Exam (120 min): 7:00 PM - 9:00 PM**			HW 6
9	15-Jun	DKQ Plate Elements, Shell Theory, Analysis of Shells	Chapter 12	HW 8	HW 7
10	21-Jun	Structural Dynamics, Time History Analysis, Free Vibration	Chapter 16	HW 9	
11	23-Jun	Geometrically Nonlinear Analysis of Bars, Beams, Buckling,		HW 10	HW 8
12	28-Jun	Geometric Nonlinearity – Nonlinear Mechanics		HW 11	HW 9
13	30-Jun	Geometric Nonlinearity – Total and Updated Lagrangian Methods		HW 12	HW 10
14	5-Jul	Material Nonlinearity – Plasticity Fundamentals, Return Algorithms		HW 13	HW 11/**Project**
15	7-Jul	Contact Problems			HW12/HW13
16	**12-Jul**	**Final Exam (120 min): 7:00 PM - 9:00 PM**			

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

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

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 | Title IX – (213) 821-8298
equity.usc.edu, titleix.usc.edu
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
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Campus Support and Intervention - (213) 821-4710
campussupport.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu
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
dps.usc.edu, emergency.usc.edu
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) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.