

## CE 529b Finite Element Analysis (3)

2020 Spring Semester — Tentative Course Syllabus

Lecture	Monday	6:40p.m. to 9:20p.m.	OHE 100D
Professor	Dr. A. Niazy, P.E.		
Email	<a href="mailto:Niazy@usc.edu">Niazy@usc.edu</a>		
Textbooks • Recommended	T. Belytshko, W. K. Liu, B. Moran, & K. Elkodary, "Nonlinear Finite Elements for Continua and Structures," 2nd edition," Wiley, 2014, ISBN-13: 978-1118632703.		
References	1. M.A. Crisfield, "Non-Linear Finite Element Analysis of Solids and Structures," Vol II, John Wiley & Sons; 1st edition, 1997.		
	2. K-J. Bathe, "Finite Element Procedures," Prentice-Hall, Englewood Cliffs, 1995.		
	3. J.N. Reddy, "An Introduction to Nonlinear Finite Element Analysis," Oxford University Press, 2004.		
	4. T.J.R. Hughes, "The Finite Element Method," Prentice-Hall, Englewood Cliffs, 1987.		
	5. E.L. Malvern, "Introduction to the Mechanics of a Continuous Medium," Prentice-Hall, Englewood Cliffs, N.J., 1969.		
	6. R. Cook, D. Malkus, M. Plesha, and R. Witt, "Concepts and Applications of Finite Element Analysis," 4 <sup>th</sup> Edition, 2002, Wiley."		
	7. H. Azaei, and M. Mamaghani, "Finite Element Analysis, Applications and Solved Problems using Abaqus," , 2017, ISBN-13: 978-1544625270.		
Course Description	Typical engineering problems discussed on a physical basis. Setup and solution of problems by means of the existing mathematical tools		
Course Objectives	The course is designed to build on the concepts presented in CE 529a by introducing nonlinear FEA analysis procedures considering geometric, material, and contact/impact nonlinearities. It is also designed to broaden the class of physical problems that can be solved by the FEA method to include thermal problems. Lastly, it is designed to introduce finite element computational procedure including both direct and iterative solvers, and eigenvalue techniques.		

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Learning Objectives	<p><b>Nonlinear Finite Element Analysis</b></p> <ol style="list-style-type: none"> <li>1. Nonlinear structural analysis concepts</li> <li>2. Total Lagrangian and updated Lagrangian methods</li> <li>3. Geometric nonlinearity - large strain</li> <li>4. Material nonlinearity - Hyperelastic materials</li> <li>5. Material nonlinearity - elastoplasticity</li> <li>6. Return algorithms - radial return</li> <li>7. Rate dependent materials</li> <li>8. Viscoelasticity</li> <li>9. Viscoplasticity</li> <li>10. Stability, bifurcation and nonlinear buckling</li> <li>11. Softening and localization</li> <li>12. Contact and impact nonlinearity</li> <li>13. Nonlinear solution algorithms - load and displ. steps</li> <li>14. Continuation methods including the Riks - Wempner procedure</li> </ol> <p><b>Finite Element Numerical Techniques - Solution</b></p> <ol style="list-style-type: none"> <li>1. Static solvers - band and profile, decomposition methods</li> <li>2. Parallel solvers</li> <li>3. Eigenvalue procedures - subspace and Lanczos</li> <li>4. Nonlinear static solvers including the BFGS method</li> <li>5. Iterative solvers including the conjugate gradient method</li> </ol> <p><b>Finite Elements in Heat Transfer</b></p> <ol style="list-style-type: none"> <li>1. Heat transfer - conduction, convection, radiation</li> </ol>
Policies on:	
Exams	<ul style="list-style-type: none"> <li>• Closed book.</li> <li>• Only one sheet of 8.5" x 11" paper (two pages) of formulae allowed.</li> <li>• Calculator.</li> <li>• Students <b>must turn in questions sheets</b> with their answer sheets at the end of each exam.</li> </ul>
Homework	Homework problems, which are assigned weekly, are <b>due on</b> the following <b>Monday, by 6:40 p.m.</b> in Los Angeles, CA, USA; <b>unless otherwise instructed.</b>
Late work	Not to be accepted.
Make-up work	No make-up on any examinations.
Incomplete work	To be graded accordingly.
Extra credit	No current plan for extra credit.
Final grade scheme is based on total percentage of graded coursework	Homework: : <b>20%</b>
	Project: <b>25%</b>
	Midterm Exam: <b>25%</b>
	Final Exam: <b>30%</b>
	Total: <b>100%</b>

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### **Tentative Class Calendar** (topics and dates are subject to change)

Week	Monday	Topic	Assignment	Delivery
1	1/13	Nonlinear mechanics - positions, displacements, kinematics.	HW 1	
2	1/20	<i>No Class, Martin Luther King Day, university holiday</i>		
3	1/27	Nonlinear mechanics – Stress	HW 2	HW 1
4	2/3	Nonlinear mechanics – balance laws, energy formulations	HW 3	HW 2
5	2/10	Total Lagrangian method in 1-D	HW 4	HW 3
6	2/17	<i>No Class, Presidents' day, university holiday</i>		
7	2/24	Updated Lagrangian method in 1-D Total Lagrangian method - multidimensional	HW 5	HW 4
8	3/2	Nonlinear constitutive models – hyperelastic materials	HW 6/ <b>Project</b>	HW 5
<b>9</b>	<b>3/9</b>	<b>Midterm Exam (120 minutes)</b>		
10	3/16	<i>Spring Recess: Monday, March 15 - Sunday, March 22</i>		
11	3/23	Nonlinear constitutive models – plasticity. Return algorithms. Rate dependence	HW 7	HW 6
12	3/30	Solution of nonlinear problems – stability, continuation methods, line search, dynamic relaxation	HW 8	HW 7
13	4/6	Contact and impact problems	HW 9	HW 8
14	4/13	Thermal effects in solids	HW 10	HW 9
15	4/20	Viscoelasticity and creep	HW 11	HW 10/ <b>Project</b>
16	4/27	Direct solution, decomposition methods, iterative solvers. Eigenvalue routines – subspace iteration, Lanczos		HW 11
17	5/4	<i>Study Days: Saturday, May 2 – Tuesday, May 5.</i>		
<b>18</b>	<b>5/11</b>	<b>Final Exam, (120 minutes): 7:00pm to 9:00pm</b>		

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### STATEMENT ON ACADEMIC INTEGRITY

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own.

All students are expected to understand and abide by these principles. *SCampus*, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A:

<http://www.usc.edu/dept/publications/SCAMPUS/gov/>

Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at

<http://www.usc.edu/student-affairs/SJACS/>

The Viterbi Honor Council presents the following honor code:

Engineering enables and empowers our ambitions and is integral to our identities. In the Viterbi community, accountability is reflected in all our endeavors.

Engineering + Integrity.  
Engineering + Responsibility.  
Engineering + Community.  
Think good. Do better. Be great.

These are the pillars we stand upon as we address the challenges of society and enrich lives.

### STATEMENT FOR STUDENTS WITH DISABILITIES

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible.

#### DSP Contact Information

Location: STU 301

Hours open: 8:30 a.m. until 5:00 p.m., Monday — Friday

Phone number: (213) 740-0776

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### 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" <https://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, <http://policy.usc.edu/scientific-misconduct>.

#### Support Systems:

*Student Counseling Services (SCS)* - (213) 740-7711 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. <https://engemannshc.usc.edu/counseling/>

*National Suicide Prevention Lifeline* - 1-800-273-8255

Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. <http://www.suicidepreventionlifeline.org>

*Relationship and Sexual Violence Prevention Services (RSVP)* - (213) 740-4900 - 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender-based harm. <https://engemannshc.usc.edu/rsvp/>

*Sexual Assault Resource Center*

For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: <http://sarc.usc.edu/>

*Office of Equity and Diversity (OED)/Title IX Compliance* – (213) 740-5086

Works with faculty, staff, visitors, applicants, and students around issues of protected class. <https://equity.usc.edu/>

*Bias Assessment Response and Support*

Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. <https://studentaffairs.usc.edu/bias-assessment-response-support/>

*The Office of Disability Services and Programs*

Provides certification for students with disabilities and helps arrange relevant accommodations. <http://dsp.usc.edu>

*Student Support and Advocacy* – (213) 821-4710

Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. <https://studentaffairs.usc.edu/sssa/>

*Diversity at USC*

Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. <https://diversity.usc.edu/>

*USC Emergency Information*

Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible, <http://emergency.usc.edu>

*USC Department of Public Safety* – 213-740-4321 (UPC) and 323-442-1000 (HSC) for 24-hour emergency assistance or to report a crime.

Provides overall safety to USC community. <http://dps.usc.edu>