CE 529b Finite Element Analysis (3)

2020 Spring Semester — Course Syllabus

CE 529b Spr. 2020	Tue./Thur.		5:00 p.m. to 6:20 p.m.	RTH 105
Professor	L. Carter Wellford			
Office	KAP 238B			
Phone	(213) 740-0607 Office at USC		(310) 968-1224 cell (use cell)	
Email	wellford@usc.edu			
Office Hours	Tue.-Wed. 11:00-12:00			
Teaching Assistant				
Email				
Office				
Office Hours				
Prerequisites	Graduate Standing			
Textbook	T. Belytshko, W. K. Liu, B. Moran, "Nonlinear Finite Elements for Continua and Structures", Wiley Not required, but useful			
Course Reader	Wellford, L.C., "CE 529b Class Notes", Not required, but extremely useful			
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 and fluid mechanics problems. Lastly, it is designed to introduce finite element computational procedure including both direct and iterative solvers, eigenvalue techniques, and geometric modeling, mesh generation, and model optimization approaches.			
Learning Objectives				
Policies on				
Late work	10% off, no credit if more than a week late			
Make-up work				
Incomplete work				
Extra credit				
Final grade schema is based on the following percentages of graded coursework :				
Homework	25 %	Homework assigned weekly, problems are due in class one week later		
Midterm	25 %	Date TBD		
Final Project	25 %	Due TBD		
Final Exam	25 %	Date TBD		
Total	100 %			

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Class Calendar (topic dates are subject to change)

Week	Date	Main Lecture Topics	Exams	Due Dates
1	1/14	Lect. 1 Nonlinear mechanics - positions, displacements, kinematics		
2	1/21	Lect. 2 Nonlinear mechanics – Stress		
3	1/28	Lect. 3 Nonlinear mechanics – balance laws, energy formulations		
4	2/4	Lect. 4 Total Lagrangian method in 1-D		
5	2/11	Lect. 5 Updated Lagrangian method in 1-D Lect. 6 Total Lagrangian method - multidimensional		
6	2/18	Lect. 7 Nonlinear constitutive models – hyperelastic materials		
7	2/25	Lect. 8 Nonlinear constitutive models - plasticity		
8	3/3	Midterm Exam		
9	3/10	Lect. 9 Nonlinear constitutive models - return algorithms Lect. 10 Nonlinear constitutive models – rate dependence		
	3/15-22	Spring Break		
10	3/24	Lect. 11 Solution of nonlinear problems – stability, continuation methods, line search, dynamic relaxation		
11	3/31	Lecture 12 Contact and impact problems		
12	4/7	Lecture 13 Thermal effects in solids		
13	4/14	Lecture 14 FEA for computational fluid mechanics Lecture 15 Viscoelasticity and creep		
14	4/21	Lecture 16 Geometric modeling, mesh generation, mesh optimization		
15	4/28	Lecture 17 Direct solution, decomposition methods, iterative solvers Lecture 18 Eigenvalue routines – subspace iteration, Lanczos		
	5/6	Final exam (4:30-6:30 PM)		

Nonlinear Finite Element Analysis

1. Nonlinear structural analysis concepts
2. Total Lagrangian and updated Lagrangian methods
3. Geometric nonlinearity - large strain
4. Material nonlinearity - Hyperelastic materials
5. Material nonlinearity – elastoplasticity
6. Return algorithms - radial return
7. Rate dependent materials
8. Viscoelasticity
7. Viscoplasticity
8. Stability, bifurcation and nonlinear buckling
9. Softening and localization
10. Contact and impact nonlinearity
11. Nonlinear solution algorithms - load and displ. steps
12. Continuation methods including the Riks - Wempner procedure

Heterogeneous Materials

1. Composite materials modeling
2. Homogenization

Finite Element Numerical Techniques - Solution

1. Static solvers - band and profile, decomposition methods
2. Parallel solvers
3. Eigenvalue procedures - subspace and Lanczos
4. Nonlinear static solvers including the BFGS method
5. Iterative solvers including the conjugate gradient method

Finite Elements in Fluid Mechanics and Heat Transfer

1. Viscous incompressible flow - Navier-Stokes equations
2. Heat transfer - conduction, convection, radiation
3. Fluid-thermal problems.

Finite Element Numerical Techniques - Preprocessing

1. Geometric modeling
2. Mesh generation - mapped and free.
3. Bandwidth minimization - Cuthill-McKee

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/.

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

Office location: STU 301

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

Phone number: (213) 740-0776