AE8104 Finite Element Analysis of Composites (3 credits)
Fall 2022
Class time: TBD, East Middle Hall 4-301
https://oc.sjtu.edu.cn/courses/36842

Course objective:

This course aims at providing fundamental and practical notions in finite element analysis. The course will present systematic approaches for the derivation of various finite elements. The students will also be introduced to numerical techniques for the solution of the discretized governing equations. Practical aspects such as mesh generation and choice related to numerical integration will also be presented. This course will mostly be based on structural analysis, focusing on both isotropic and composite materials. Students need to program their own FE code to accomplish homework and final project.

Instructors:

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TA:

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Office Hours:

To be determined.

Textbook:

1. Class Notes;
2. Finite Element Analysis of Composite Materials, Ever J. Barbero;
3. The Finite Element Method: Its Basis & Fundamentals 7th Edition, O.C.Zienkiewicz.

Prerequisites:

Student should have previous knowledge or currently registered to courses: Solid Mechanics, Mechanics of Composites, Linear Algebra, and Numerical analysis. Moreover, this course requires some programming knowledge with C/C++, FORTRAN, Java, Python or any other computer language you prefer. Matlab is not recommended for graduate students.

Grade Policy:

Letter grade's policy is subjected to SJTU policy:
A+ [95, 100], A [90, 95), A- [85, 90);
B+ [82, 85), B [78, 82), B- [75, 78);
C+ [71, 75), C [67, 71), C- [63, 67);
D [60, 63), F [0, 60).

Homework 30%, Quiz 10% (two quiz), Midterm exam 30%, Final project 30%.

Class Policy:

1. Class attendance is **mandatory**. If a student is absent, proper documented justification is **required**;

2. All holidays or special events observed by organized religious will be honored for those students who show affiliation with that particular religion;
3. Professional behavior is expected in this course. Cell phone, laptop and tablet should be turned off unless for class needed.

Policies against plagiarism:

1. Homework and final project: if there is evidence that a student has copied some solution material (from another student and/or a manual), grade zero will be assigned to this particular homework (project);
2. Midterm exam and quiz: If a student is caught taking information or passing information from or to another student during an exam, grade zero will be assigned to the exam (quiz).

Students with Disabilities:

If you anticipate issues related to the format or requirements of this course, please meet with me. I would like us to discuss ways to ensure your full participation in the course. If you determine that formal, disability-related accommodations are necessary, it is important that you notify me of your eligibility for reasonable accommodations. We can then plan how best to coordinate your accommodations.

Class Agenda (Tentative):

Week	Content	Dates
1	**Syllabus** **Chapter I. Introduction** **Chapter II. Construction of FE equations** - Minimization of potential energy; - Rayleigh-Ritz method;	Sept 24
2	- Galerkin method; - Variational approach. **Chapter III. One-Dimensional Problem** **3.1. 2-noded truss element** - Shape functions;	Oct 8
3	- Coordinate transformation; - Assemble global stiffness matrix; - Boundary conditions; - Reduced stiffness matrix; - Calculate nodal and elemental variables.	Oct 15
4	**3.2. 3-noded truss element** - Elemental stiffness matrix; - Coordinate transformation. **3.3. Multi-Point Constraints (MPC)**	Oct 22
5	**Quiz** **Chapter IV. Two-Dimensional Problem** **4.1. Constant Strain Triangle (CST) element** - Parent coordinate system; - Approximated solution; - Shape function; - Jacobian matrix; - Elemental stiffness matrix; - Equivalent nodal force.	Oct 29
6	**4.2. Bilinear quadrilateral element** - Parent coordinate system; - Approximated solution; - Shape function; - Elemental stiffness matrix; - Numerical integration; - Equivalent nodal force; - Stress and strain extraction.	Nov 5
7	**4.3. Shear locking and hourglass mode** **4.4. Pascal’s triangle** **4.5. Quadratic triangle element** **4.6. Quadratic quadrilateral element** **4.7. 9-noded quadrilateral element** **4.8. Axisymmetric Problem**	Nov 12
8	**Chapter V. Three-Dimensional Problem** **5.1. 4-noded tetrahedral element** **5.2. 10-noded tetrahedral element** **5.3. 8-noded hexahedral element** - Selectively Reduced Integration (SRI); - Equivalent nodal force. **5.4. 20-noded hexahedral element** - 14-Points Rule (14PR); - Equivalent nodal force.	Nov 19
9	**Midterm exam**	TBD

10	**Chapter VI. Solution Technique** **6.1. Gauss elimination** **6.2. LU decomposition** **6.3. LDL^T decomposition** **6.4. Conjugate Gradient method** - CG algorithm; - Preconditioned CG algorithm; - Choice of preconditioner. **6.5. Generalized Minimal Residual method** - Krylov subspace; - GMRes algorithm; - Preconditioned GMRes algorithm. **6.6. Convergence analysis**	Nov 26
11	**Chapter VII. Structural Element** **7.1. Euler-Bernoulli beam element** - Beam theory; - Governing equation; - Galerkin's method; - Shape function; - Elemental stiffness matrix; - Coordinate transformation; - Equivalent nodal force.	Dec 3
12	**7.2. Timoshenko beam element** - Shape function; - Elemental stiffness matrix. **7.3. Nonconforming plate element** - Plate theory; - C_1 continuity; - Shape function; - Elemental stiffness matrix; - Equivalent nodal force.	Dec 10
13	**7.4. Conforming plate element** - Shape function; - Elemental stiffness matrix; - Equivalent nodal force; - Mixed interpolation for transverse shear strains.	Dec 17
14	**Quiz** **Chapter VIII. Modeling Macromechanical Structures of Composites** **8.1. Modeling composite laminate with shell element** **8.2. Modeling composite laminate with solid element** **8.3. Failure criteria and continuum damage mechanics**	Dec 24
15	**Chapter IX. Modeling Micromechanical Structures of Composites** **9.1. Continuous fiber reinforced composites** **9.2. Short fiber reinforced composites**	Dec 31
16	**Chapter X. Dynamic and Buckling Analyses** **10.1. Linear buckling analysis** **10.2. Derivation of mass matrices** **10.3. Computation of eigenvalues and mode shapes**	Jan 7