

USC Viterbi

School of Engineering
*Sonny Astani Department
of Civil and Environmental
Engineering*

CE 546: Structural Mechanics of Composite Materials
Units: 2
Fall 2020— Wednesday, 6:40 PM- 8:20 PM

Location: Online

Instructor: Professor A. Niazy, Ph.D., P.E.
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Course Description

Structural mechanics and applications of composites are discussed: anisotropic materials; laminated composites; buckling and dynamics; strength and failure; inter-laminar stresses; de-lamination; design considerations.

Learning Objectives and Outcomes

Achieve fundamental understanding of the subject of structural mechanics of composite materials and applications in aerospace, civil, and mechanical engineering. By the end of this course, students will be able to:

- Develop a framework for the role of constituents in overall response of composite laminae.
- Develop mathematical relationships that show how a set of laminae with different orientations affects the overall laminate properties and response.
- Analyze stresses and strains in anisotropic and orthotropic materials having continuous reinforcement.
- Use the Classical Lamination Theory to assess the role of individual plies on overall axial, bending and twisting deformation of laminates under applied loads.
- Apply these concepts to analyze and design fiber-reinforced composites for engineering applications.
- Use failure theories for multiaxial loading to determine if the composite will fail for known loading and use this knowledge to design failure resistant structures.
- Predict composite properties based on micromechanical theories.

Prerequisite(s)

CE 358 or equivalent.

Recommended Preparation

Undergraduate Mathematics.

Course Notes

Lecture notes prepared by the instructor to be made available on DEN website. Login is needed:

<https://courses.uscden.net/d2l/login>

Required Textbook

R. F. Gibson, "Principles of Composite Materials Mechanics," 4th Edition, CRC Press, Inc., 2016, ISBN-13: 978-1-4987-2069.

Reference Materials

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

- 1) E. J. Barbero, "Introduction to Composite Materials Design," 3rd Edition, CRC Press, Inc., 2017, ISBN-13: 978-1-315-296487.
- 2) K. Kaw, "Mechanics of Composite Materials," 2nd Edition, CRC Press, Inc., 2005.
- 3) G. H. Staab, "Laminar Composites," 2nd Edition, Butterworth-Heinemann, Inc., 2015, ISBN-13: 978-0128024003.
- 4) M. W. Hyer, "Stress Analysis of Fiber-Reinforced Composite Materials," McGraw-Hill Inc., 1998.
- 5) R. M. Jones, "Mechanics of Composite Materials," 2nd Edition, Taylor & Francis, Inc., 1999.
- 6) J. N. Reddy, "Theory and Analysis of Elastic Plates and Shells," CRC, 2nd edition, December 2006.
- 7) P. L. Gould, "Analysis of Shells and Plates," Prentice Hall, 1999.
- 8) R. Szilard., "Theory and Analysis of Plates," Prentice Hall, 1974.
- 9) Y. C. Fung, "Foundation of Solid Mechanics," Prentice Hall, 1969.

Description and Assessment of Assignments

Homework:

Homework (HW) problems, often assigned weekly, are due on Wednesdays per the class schedule, at the beginning of the classes; 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 course project involves the development of a viable numerical tool (a spreadsheet or a small program using Excel, MathCAD, or Matlab) to assess, among several things, the failure of a composite laminate. Textbook examples to be used to help to verify the developed tool. The developed tool is to be used to solve a set of assigned problems. Results are to be delivered in a written report.

The project is to be carried on an individual basis. The project work will be delivered in one *.zip project file (Excel, Mathcad, or Matlab files of the tool, and brief description to guide the use of the program, input/output of the problems and solution results. There will not be required presentations of the project results. Requirements for the Project Report will be provided. The project delivery is due per the class schedule, at the beginning of the class; 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 are two exams, a midterm exam and a 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	20%
Project	20%
Final Exam	40%

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. If the steps are not clear, 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 will be graded and returned usually within one week after their due dates.
- Midterm exam will 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 usually communicated within one week after the exam date.
- Letter grade of the student in the class is posted to the school grading system (GRS) usually within one week after the exam date.

Tentative Course Lecture/Schedule: A Weekly Breakdown

Week	Wednesday	Topics	Textbook Reading Assignments	Assignment	Delivery
1	8/26	Introduction	Sections 1.1-1.4, 1.6, 1.7, Appendix A	HW 1	
2	9/2	Elasticity: Anisotropic, Monoclinic, Orthotropic, Plane Stress conditions	Chapter 2 all, Appendix B, Appendix C	HW 2	HW1
3	9/9	Anisotropic Elasticity: [S], [Q], [S_bar], [Q_bar]	Chapter 2 all, Appendix B, Appendix C	HW 3	HW2
4	9/16	Thin Plate Theory: Overview		HW 4	HW 3
5	9/23	Classic Lamination Theory: Introduction, Assumptions, Stress/ Strain Distribution. Project	7.1, 7.2, 7.3, 7.4, 7.5	Project	HW 4
6	9/30	Classic Lamination Theory: ABD Matrix, Bending		HW 5	
7	10/7	Midterm Exam	6:40 PM – 8:10 PM		
8	10/14	Classic Lamination Theory: Buckling, Vibration	7.9, 8.3.3		HW 5
9	10/21	Strength and Failure: Introduction, Maximum stress & Maximum strain Criteria	4.1, 4.2, 10.3.1-10.3.3	HW 6	
10	10/28	Strength and Failure: Tsai-Hill & Tsai- Wu Criteria	4.2.1, 4.2.2, 4.2.3	HW 7	HW 6
11	11/4	Micromechanics of Composites: Introduction/ Stiffness	3.1, 3.2, 3.3, 4.3	HW 8	HW 7
12	11/11	Micromechanics of Composites: Stiffness/ Strength	3.1, 3.2, 3.3, 4.3	HW 9	HW 8, Project
13	11/18	Laminate Design: Fatigue, Stress Concentration, Inter-laminar Stresses.	7.4, 7.8.1, 7.10, 7.7, 9.1, 9.2, 9.2.2		HW 9
14	11/25	No Class. Thanksgiving Recess.			
15	12/2	Final Exam	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.