CE 546: Structural Mechanics of Composite Materials  
Units: 2  
Fall 2020—Wednesdays: once weekly  
Location: Online  
Instructor: A. Niazy, Ph.D., P.E.  
Contact Info: niazy@usc.edu  
Grader Assistant: TBD  
Contact Info: TBD  

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 Outcomes  
Achieve fundamental understanding of the subject of structural mechanics of composite materials and applications in aerospace, civil, and mechanical engineering.  
- Develop a strong understanding of the role of constituents in overall response of composite lamina.  
- Develop a strong understanding of 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 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.
Course Notes

A course reader to be available DEN website. Login is needed:
https://courses.uscden.net/d2l/login

Required Textbook


References

Description and Assessment of Assignments

Homework:
Homework problems, usually assigned weekly, are due on the following Wednesday, by 7:00 p.m. in Los Angeles, CA, USA; unless otherwise instructed. Students are to work independently on the HW assignments. For the most part, students are given 1 week to solve the HW, and no late HW is accepted. HW assignments may involve a varying number of problems; however, in the end, the weekly HW assignment 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 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.

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.
- Students must turn in questions sheets with their answer sheets at the end of each exam.
- No make-up on any examinations.

Grading Breakdown

A weighted average grade will be calculated as follows:

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>20%</td>
</tr>
<tr>
<td>Project</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>40%</td>
</tr>
</tbody>
</table>
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 is subject to revision depending on the overall class performance.

A 93-100
A- 90-92
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) are due at the beginning of class on the due date. 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. 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, 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 will be reported to the University’s academic integrity office.

Grading Timeline

- Homework assignments will be graded and scores given roughly one week after their due date.
- Midterm exam will be graded and scores given roughly one week after the exam date.
- Final exam score will be given roughly one week after the exam date.
## Tentative Course Lecture/Schedule: A Weekly Breakdown

<table>
<thead>
<tr>
<th>Week</th>
<th>Topics</th>
<th>Textbook Reading Assignments</th>
<th>Assignment</th>
<th>Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>Sections 1.1-1.4, 1.6, 1.7, Appendix A</td>
<td>HW 1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Elasticity: Anisotropic, Monoclinic, Orthotropic, Plane Stress conditions</td>
<td>Chapter 2 all, Appendix B, Appendix C</td>
<td>HW 2</td>
<td>HW1</td>
</tr>
<tr>
<td>3</td>
<td>Anisotropic Elasticity: [S], [Q], [S_bar], [Q_bar]</td>
<td>Chapter 2 all, Appendix B, Appendix C</td>
<td>HW 3</td>
<td>HW2</td>
</tr>
<tr>
<td>4</td>
<td>Thin Plate Theory: Overview</td>
<td></td>
<td>HW 4</td>
<td>HW 3</td>
</tr>
<tr>
<td>5</td>
<td>Classic Lamination Theory: Introduction, Assumptions, Stress/ Strain Distribution</td>
<td>7.1, 7.2, 7.3, 7.4, 7.5</td>
<td>Project</td>
<td>HW 4</td>
</tr>
<tr>
<td>6</td>
<td>Classic Lamination Theory: ABD Matrix, Bending</td>
<td></td>
<td>HW 5</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Midterm Exam</td>
<td></td>
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<tr>
<td>8</td>
<td>Classic Lamination Theory: Buckling, Vibration</td>
<td>7.9, 8.3.3</td>
<td>HW 5</td>
<td></td>
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<tr>
<td>9</td>
<td>Strength and Failure: Introduction, Maximum stress &amp; Maximum strain Criteria</td>
<td>4.1, 4.2, 10.3.1-10.3.3</td>
<td>HW 6</td>
<td></td>
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<tr>
<td>10</td>
<td>Strength and Failure: Tsai-Hill &amp; Tsai-Wu Criteria</td>
<td>4.2.1, 4.2.2, 4.2.3</td>
<td>HW 7</td>
<td>HW 6</td>
</tr>
<tr>
<td>11</td>
<td>Micromechanics of Composites: Introduction</td>
<td>3.1, 3.2, 3.3, 4.3</td>
<td>HW 7</td>
<td></td>
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<tr>
<td>12</td>
<td>Micromechanics of Composites: Stiffness</td>
<td>3.1, 3.2, 3.3, 4.3</td>
<td>HW 8</td>
<td>Project</td>
</tr>
<tr>
<td>13</td>
<td>Micromechanics of Composites: Strength</td>
<td>3.1, 3.2, 3.3, 4.3</td>
<td>HW 9</td>
<td>HW 8</td>
</tr>
<tr>
<td>14</td>
<td>Laminate Design: Fatigue, Stress Concentration</td>
<td>7.4, 7.8.1, 7.10, 7.7, 9.1, 9.2, 9.2.2</td>
<td>HW 9</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Laminate Design: Inter-laminar Stresses</td>
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<tr>
<td>16</td>
<td>Final Exam</td>
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</tbody>
</table>
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
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:

Student Health Counseling Services - (213) 740-7711 - 24/7 on call engemannshc.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) 740-4900 - 24/7 on call engemannshc.usc.edu/rsvp
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086 equity.usc.edu, titleix.usc.edu
Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421 studentaffairs.usc.edu/bias-assessment-response-support
Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation 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 Support and Advocacy - (213) 821-4710
studentaffairs.usc.edu/ssa
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.