Syllabus
MAE 157: Lightweight structures — Winter Quarter 2011
(Required for AE; Elective for CE, ME and MSE)

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Office hours: Tuesdays, 3.30-5pm

Class schedule: *Lecture:* TTh 5.00 – 6.20pm, SSL 270
Discussion: M 9.00 – 9.50am, ET 204
W 12.00 – 12.50pm, ET 204

Textbook: THG Megson, *Introduction to Aircraft Structural Analysis*, Elsevier, 2010.

References: THG Megson, *Aircraft Structures for Engineering Students,* Elsevier, 4th Ed., 2007.

CT Sun, *Mechanics of Aircraft Structures,* Wiley, 1998.

HD Curtis, *Fundamentals of Aircraft Structural Analysis*, McGraw-Hill, 1997.

TR Chandrupatla, AD Belegundu, *Introduction to Finite Elements in Engineering*, 3rd Ed., Prentice Hall, 2002.

Hand-outs from the instructor will be posted on the course website.

Course website: https://eee.uci.edu/11w/19150

Course Noteboard: https://eee.uci.edu/boards/w11/MAE157/

The noteboard contains a forum for the class, where students can ask questions and suggest answers to other students' questions. The instructor and teaching assistant will act as loose moderators, but the noteboard is student-run. **Students are encouraged to ask questions on the board as opposed to emailing the instructors, as this will lead to faster response**. The moderators reserve the right to remove duplicate questions, wrong answers, or any irrelevant material.

Course description: The aim of the course is to empower you with the necessary tools to design minimum-weight structures under any loading constraints. Although analytical solutions will be presented for one-dimensional structures under simple loads, the Finite Element method will be emphasized as the ideal platform for the solution of nearly any structural problem. During the course, you will:

- Calculate stress and strain distribution in lightweight beams, shafts, columns and plates.
- Learn the fundamentals of two-dimensional elasticity and failure criteria (for both yielding and buckling).
- Design minimum-weight structures subject to multiple requirements (strength, stiffness, size, etc…).
- Learn the fundamentals of the Finite Element method and its applications to lightweight structures.
- Analyze the structural response of lightweight structures under complex static loading scenarios.

Prerequisites By Topic: Statics of solid bodies. Analysis of structures. Mechanics of materials. Stress and strain.

Lecture topics

- Introduction on aircraft construction. Motivation for lightweight structures. Common materials used in the aero industry. Materials properties.
- Review of statics and strength of materials: equilibrium of materials points and rigid bodies, analysis of statically determinate trusses, normal and shear stress, solution of statically determinate problems.
- Introduction to elasticity: equilibrium, compatibility and constitutive equations for isotropic elastic solids. 2D Elasticity (plane stress and plane strain). Transformation of stresses and strains. Strain energy.
- Yielding criteria (Tresca and Von Mises).
- Moment and shear force distributions in beams
- Symmetric and unsymmetric bending of solid and thin-walled beams.
- Shear flow and shear stresses in transversely loaded thin-walled beams:
    - Open sections. Shear Center.
    - Closed sections.
- Torsion of shafts with thin-walled single-cell (open and closed) and multi-cell sections.
- Buckling of columns and thin plates.
- Fundamentals of matrix methods of structural analysis and FEM.
- Applications to aircraft construction.
- Fundamentals of fracture and fatigue.

Computer Usage: A commercial programming language (e.g. MATLAB) will be used to develop codes for matrix analysis of structures, and/or structural optimization. In addition, students will learn how to use a commercial Finite Element code (ABAQUS)

for the structural analysis of more complex lightweight structures. Both programs will be used to tackle the design project.

Design Project Description: A lightweight structure that meets ideal design criteria (i.e. mass, deflection, strength, etc.) is to be designed by groups of approximately 10 students. Several discussion sessions are dedicated to the project (particularly in the second half of the quarter). Topics to be covered are: problem definition, design variables, design constraints, the optimization procedure, and interpretation of results. Students have full access to ABAQUS and MATLAB in two computer labs.
Details of the design project will be announced soon.

Computer labs:
The open labs include:
ECT 123 is the main computer lab used for instruction and it is open to Engineering students on a walk-in basis when sections are not scheduled. Check the schedule posted by the door for details. To access the lab after 5:00pm, students can use the door code sent to their email addresses on a quarterly basis. Students who do not receive door codes may pick one up at the Student Affairs Office front desk.
AIRB 2040 This computer lab is used primarily for drop-in use. While the lab is available at all times, the main building door is locked Monday-Friday after 10:00pm and on Sundays. Students can use ECT 123 when AIRB 2040 is inaccessible. The AIRB building is attached to the parking structure next to the Henry Samueli School of Engineering. Students must use the door code sent to their email addresses to open the lab door. Students who do not receive door codes may pick one up at the Student Affairs Office front desk.
The same door code is used for both labs.
Priority is given to scheduled sections in both computer labs.
The Windows computers in both labs are the same hardware and have the exact same software installed. Printers are available in each room. To print, students must get a print card from the Payprint machines in the NACS computer labs, 1st floor of Engineering Gateway. To log in, use your UCINetID and password. Select UCI.EDU for the domain. Students should save data to their server space (currently a 50MB limit) or to an external flash drive. Sometimes the lab manager has to re-image the labs mid-quarter so any data you save on the computers can be lost.

Grading Criteria:
Homework: 20%
Term Project: 15%
Midterm: 30%
Final: 35%
Attendance to lectures and discussion sessions is mandatory.
A peer-grading scheme will be adopted to assign individual grades for the team-based design project.

Homework Policy:
There will be weekly homework assignments throughout the course. Homework

assignments are posted on the website on Friday afternoon. They are due on the following Friday, at 1pm in the drop box on the second floor of EG (in front of the elevator). Solutions will be posted on the website on the following Monday at 6.30pm. Late homework is not accepted and will not be graded. Nonetheless, one opportunity is provided to each student to turn in ONE late assignment and receive full credit for it. This is meant to provide a "stress-release valve" when things get hectic in the quarter. In any case, this late assignment needs to be turned in BEFORE the solution is posted, i.e. before the following Monday at 6.30pm. No other exception will be granted.

Working together is strongly encouraged (but NOT copying each other). Identical homework assignments from two students will be considered cheating and not tolerated.

Some homework assignments might require the use of computational resources (primarily ABAQUS and/or MATLAB) available in the computer lab as noted above.

These factors ALL contribute to the grade:

- Conceptually sound problem-solving approach.
- Numerical accuracy of results.
- Neatness of the presentation and description of the procedure.

Please, format your homework in a clear way. The TAs don't have to make effort in interpreting or guessing your thinking process. All the fundamental steps of your derivations need to be clearly stated. Illegible homework will not be graded.
A correct solution obtained with a wrong or unclear methodology will be given no credit. Conversely, numerical mistakes associated with sound and reasonable approaches will result in partial credit.

Midterm and final examinations

There will be one midterm and one final examination. The final examination has been set by the registrar's office on Thursday, March 17, 2011, 4-6pm. The midterm will be tentatively at the end of the 5th week of class. The exact date will be announced in class. The midterm will take place in class at normal lecture time.
Midterm and final are closed-book exams. However, students are allowed to bring ONE 3"X5" card with any writing on it (front and back) at the midterm. Two cards are allowed during the final exam. Standard scientific calculators can be used during midterm and final exam.
The same grading approach that was described for homework applies to midterm and final exam: all the derivations need to be clearly shown. Correct but unjustified answers will receive no credit. Neatness is required.