CE 412 – 01 ADVANCED STRUCTURAL ANALYSIS

The objective of CE 412 is to develop the ability to model, analyze, and interpret the behavior of statically determinate and indeterminate trusses, beams, and frames using classical methods and modern matrix methods. These methods are used to calculate the forces and displacements in structures caused by loads, support settlements, temperature effects, fabrication errors, and flexible connections. Stiffness methods, or matrix methods, form the basis for modern structural analysis software. Issues concerning structural modeling and the analysis of large structures using computer programs will be discussed. Students are required to demonstrate proficiency in the analysis of statically determinate structures, including deflection calculations using classical direct integration, conjugate beam, and virtual work methods; analysis of statically indeterminate structures using energy methods, force methods, slope deflection, and moment distribution; and analysis of structural systems using the modern stiffness method. By learning to perform structural analysis using both classical and modern methods, students can gain a solid understanding of structural behavior, continue on and take a course in finite element analysis, and gain an appreciation/enthusiasm for the field of structural engineering.

Prerequisite: The ability to calculate axial forces, shear forces, and moments and deflections for statically determinate beams and frames. This course builds on structural analysis knowledge learned in CE 311 and ES 230.

Professor: Dr. Anne Raich 322 ACE raicha@lafayette.edu
330-5590 http://ww2.lafayette.edu/~raicha

Lecture: TTh 11:00 a.m. – 12:15 p.m., AEC 327
Office Hours: Th 2:00 p.m. – 4:30 p.m. and MW 3:00 p.m. – 4:00 p.m.

Textbook: No text is required; you may use any structural analysis book
Recommended Texts:
1st Half of Course: Leet and Uang, Fundamentals of Structural Analysis, 2nd ed., McGraw Hill, 2005
R. Hibbeler, *Structural Analysis*, 5th ed., Prentice Hall, 2002

2nd Half of Course R.L. Sack, *Matrix Structural Analysis*, Waveland Press, 1994
McGuire, Gallagher, Ziemian, *Matrix Structural Analysis*, 2nd ed., John Wiley, 2000

Exam I: Wednesday, March 1, 2005 (Evening Exam – 7:00 pm to 9:00 pm)
Exam II: Wednesday, April 12, 2005 (Evening Exam – 7:00 pm to 9:00 pm)
Final Exam: T.B.A.
Note: For all exams you will be able to bring one page of handwritten notes (one-side only). The use of other notes or books during the exam will not be permitted, unless provided by the instructor. The final exam is comprehensive.

Grade Distribution: Homework: 20% Exam I: 20% Final Exam: 30%
Analysis Project: 10% Exam II: 20%

Final Grading Scale: A ≥ 94; 94 > A- ≥ 90; 90 > B+ ≥ 87; 87 > B ≥ 84; 84 > B- ≥ 80; 80 > C+ ≥ 77; 77 > C ≥ 74; 74 > C- ≥ 70; ; 70 > D ≥ 65; F < 65

Expected Workload:
This course will have, in general, weekly assignments. The homework will become longer toward the end of the semester, since these homework assignments will involve obtaining results through both hand calculations and computer analysis. The main purpose of the homework is to help you learn to apply a variety of structural analysis methods, and therefore it is important to apply and compare the various methods and determine their strengths and weaknesses. You should expect to spend 9 to 12 hours each week solving homework problems, including reworking problems that you have trouble with (recommended because often these types of problems appear on the exams). Some homework will involve problems that require the use of SAP 2000 and Matlab for analysis, and more details will be provided with these assignments.

Attendance and Participation:
Regular and on-time class attendance *is required,* although no grade is assigned for attendance**.** Class participation is expected and provides an opportunity to ask *your* questions, which serve the class at large in learning the course material more thoroughly. You are responsible for all material covered in class, even if absent for authorized activities.

"I hate vacations. If you can build buildings, why sit on the beach?" – Philip Johnson

Academic Integrity Statement**:** "Students are expected to be honorable, ethical, and mature in every regard"
No form of scholastic misconduct will be tolerated. Academic dishonesty includes cheating, fabrication, falsification, multiple submissions, plagiarism, complicity, copying homework, etc. It is the student's responsibility to comply with the *Lafayette College Student Handbook* (http://www.lafayette.edu/student_life/download_handbook.html) and to be familiar with the *Principles of Intellectual Honesty* (http://www.lafayette.edu/academics/honesty.pdf). Violations will be handled in accordance with the Procedural Standards in Disciplinary Proceedings outlined in the *Student Handbook*.

Class		Date	Tentative Topic (Subject to Change)
1	T	1/24	Introduction/ Review of Deflection Calculations using Direct Integration
2	R	1/26	Deflections – Direct Integration/Moment-Area Method
3	T	1/31	Deflections - Conjugate Beam
4	R	2/2	Deflections - Virtual Work for Trusses
5	T	2/7	Deflections - Virtual Work for Beams and Frames
6	R	2/9	Deflections – Special Considerations
7	T	2/14	Force Methods of Analysis - Beams
8	R	2/16	Force Methods of Analysis – Frames
9	T	2/21	NO CLASS
10	R	2/23	Force Methods of Analysis – Trusses
11	T	2/28	Slope Deflection
	W	3/1	Exam 1 – Evening Exam
12	R	3/2	Moment Distribution
13	T	3/7	Moment Distribution
14	R	3/9	Moment Distribution
3/14 & 3/16			Spring Break Week
15	T	3/21	Displacement Methods
16	R	3/23	Stiffness Method – Trusses
17	T	3/28	Stiffness Method – Trusses
18	R	3/30	Stiffness Method – Beams
19	T	4/4	Stiffness Method – Beams
20	R	4/6	Modeling of Structural Systems
21	T	4/11	Special Considerations in Modeling and Analysis
	W	4/12	Exam 2 – Evening Exam
22	R	4/13	NO CLASS
23	T	4/18	Stiffness Method – Frames
24	R	4/20	Stiffness Method – Frames
25	T	4/25	Stiffness Method – Space Structures
26	R	4/27	Advanced Topics in Structural Analysis
27	T	5/2	Influence Lines
28	R	5/4	Influence Lines

ABET Outcomes:
This course focuses on ABET program outcome (a.), which involves applying math and science principles daily to perform analysis of systems including trusses, beams, and frames. Other outcomes addressed include (j.) and (k.), which involve discussing contemporary structural and mechanical systems, including bridges, buildings, and other structures, in order to highlight their impact on the design profession and society, and providing opportunities to gain proficiency in the use of engineering tools and programs through use of structural analysis software.

"It's a tremendous responsibility being an engineer. It's an imperfect process.
It's not as beautiful as science" – Les Robertson

Students with Disabilities**:** The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation or require assistance with academic concerns/accommodations, please contact the Office of the Dean of Studies (610-330-5080).

Homework Policy:

- Homework is generally assigned once a week and is collected at the beginning of the class meeting on the due date, unless otherwise specified. Late homework will be accepted **only** by making a **prior** arrangement with the instructor either during office hours or by email, subject to Lafayette College Dean's Excuse Policy outlined in section 7.3.2 of the Faculty Handbook under the heading Class Attendance.

- This class emphasizes developing professional analysis and modeling skills. All homework should be submitted on engineering paper (one side only) in a professional manner, which includes neat handwriting and organization. The detail of work you provide should allow another engineer to review your work without having to ask you any questions. When you work in a design office or elsewhere, your calculations will be checked internally by another engineer for small projects, and externally by peer review committees for large projects. In either case, easy to understand assumptions, calculations, and results are required. Therefore, neatness does count and messy, unorganized problem solutions will result in lower grades. The following should be provided in the homework:
    - Provide a brief written description of the problem being solved and the result requested.
    - Provide well-drawn sketches, free body diagrams of section cuts, approximate deflected shapes.
    - Clearly identify the analysis steps and calculations.
    - Provide a summary of your final answers and box them. Check your units!
    - Check your answers to make sure they seem reasonable, sometimes with another method.
    - Staple homework pages together before submitting homework.

- Unless otherwise stated, all homework in this class is expected to be individual work. Copying the work of others, including homework, is in violation of the College's Principles of Intellectual Honesty, which can be accessed at http://www.lafayette.edu/academics/honesty.pdf. You may discuss the homework assignments with other students. All work submitted, however, must be your own and it is your responsibility to properly acknowledge the source of ideas and facts received from others, including other students. A student who commits academic dishonesty is subject to a range of penalties, including suspension or expulsion.

- Discussions about re-grading of homework or exams are not conducted in person or by email. If you would like to request re-grading, attach a signed statement to your work that details where you feel you lost points and submit it to the professor within one week after the homework or exam has been returned.

Software Used for this Class:

Students can check their homework solutions using Matlab, SAP 2000, or any other useful program. The department computers provide access to many of these programs. As engineers you will continually be looking for new tools to learn and apply that make your life easier. Therefore, you are encouraged to try to use some of the programs to help solve the homework. Specific information on using Matlab to perform structural analysis will be discussed in-class.

Analysis Project:

During the semester, each student will select a structure (can be an existing structure or a proposed structure) and perform a detailed structural analysis, including model development, load determination, and interpretation of results. Additional details concerning project objectives and scope will be presented during the semester.