ENCE 353: Introduction to Structural Analysis

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Notes from Class

GOALS

The class is an introduction to the basic tools of structural analysis and design.

Topics will include: Design loads. Equilibrium of external and internal forces. Shear and moment diagrams in beams and frames. Truss analysis. Influence line diagrams. The slope-deflection method and method of consistent deformation. Matrix stiffness methods for beams, frames and trusses.

COURSE OUTLINE - SPRING SEMESTER, 2020

The topics will be as follows:

- **Introduction** (4 classes)
  - Overview of structural analysis and structural design.
  - Structural loads and structural design.
  - Quick review of statics, free body diagrams, equations of equilibrium.
  - Stability and determinacy.

- **Statically Determinate Trusses** (4 classes)
  - Types and classification of trusses.
  - Method of joints, method of sections.

    - Compound trusses.

- **Statically Determinate Beams and Frames** (6 classes)
    - Internal forces: shear and bending moment diagram for a beam.
    - Shear and moment diagrams for a frame.
    - Principle of Superposition
    - Qualitative drawing of deflection shape for a structure under applied loads.

- **Cables and Arches** (4 classes)
    - Boundary conditions for arches.
    - Three-hinged arch structures.
    - Analysis of circular and parabolic arch structures.
    - Cables subject to uniformly distributed loads.
    - Simplified analysis of suspension structures.

- **Influence Lines for Statically Determinate Structures** (4 classes)
    - Muller-Breslau Principle and general procedure for obtaining influence lines.
    - Qualitative influence lines for beams and frames.
    - Live-load patterns; determination of maximum response by influence lines.

- **Deflection of Structures** (6 classes)
    - Differential equations and moment area method.
    - Principle of virtual work.
    - Method of virtual work to determine deflections.

- **Method of Consistent Deformations (Force Method)** (6 classes)
    - General procedure.
    - Effects of support settlement (movement), temperature change, and fabrication errors.

- **Slope-Deflection Equations (Displacement Method)** (6 classes)
    - General procedure for displacement method.
    - Differences between the force and displacement methods.
    - Slope-deflection equations and sign conventions.
    - Analysis of simple structures with the slope-deflection equations.

There will be in-class problems, homework, two midterm exams and one final exam (see details below).

COURSE PREREQUISITES

- A knowledge of engineering mathematics (e.g., calculus, linear algebra, differential equations).
- ENES220, MATH246 and permission of department.
- Restricted to students in the College of Engineering.

TIME AND LOCATION OF CLASS/OFFICE HOURS

- **Class.** M,W,F 9.00 am - 9.50 am,
  EGR, Rm 0108
- **Office Hours.** Mark Austin, M,W,F 10-11 am in Rm 2261 AV Williams.
  Otherwise, by appointment. For a quick response, send me an e-mail (austin "at" umd.edu).
- **Teaching Assistant.** TBD (E-mail: xxxxx "at" yyyy)
  Office hours. Monday, 1.30 -- 3 pm, ENGR 1166, Glenn L. Martin Hall.

CLASS TEXT AND RESOURCES

- Hibbeler R.C., Structural Analysis, 8th Edition, Prentice-Hall, 2012.
- Lecture slides and support material will be posted on the ``notes from class'' web page.
- Pictures of the ``white board content'' will be posted to the ``notes from class'' web page after class.

Note.

- If you have a copy of Hibbeler that is not the 8th Edition, don't worry.
  To avoid confusion in the assignment of homework problems, we will distribute copies of the questions to be solved.

COURSE ASSESSMENT AND EXAM SCHEDULE

Coure assessment will be as follows:

- In-class problems and homework (20%).
- Midterm 1 (20%): March XX,
  The exam will be open book and open notes.
  Three questions covering computation of indeterminacy, support reactions,
  shear and bending moment diagrams, tensile and compressive element-level forces.
- Midterm 2 (20%): April XX,
  The exam will be open book and open notes.
  Three questions covering: (1) computation of displacements via integration of
  beam differential equations and/or moment area, and (2) arches and cables.
  Virtual work will not be on the exam.
- Final (40%): May XX, 8--10 am in our regular classroom.
  Format: 2 hrs long plus 5 minutes to read the paper.
  The exam will be open book and open notes.
  Six questions: Question 1 is compulsory. Do three of the remaining five questions.
  Topics include: Moment area, virtual forces, virtual displacements, force method,
  analysis of cables and arches, bending moments and bending moment diagrams, flexibility matrices.

Note.

- The midterm exams will spaced approximately one month apart.
  Midterm 1 will be during the second or third week of October and will be scheduled to

minimize conflicts.
Midterm 2 will be on the Monday before Thanksgiving.

- There will be no midterm or final make-up exams.
- Students may drop the lower midterm score if they do better in the final (i.e., the final exam can count for up to 60% of the overall grade).
- The boundary between a B grade and an A grade will be 80%.
  The boundary between D/F grades and a C grade will be 50%.
  No extra credit will be allowed.
- Accommodation for students with disabilities will be made.
- Homework must be completed on engineering paper. Write on one side only.
- We encourage students to work together on solutions to the in-class problems and homework problems.
  However, each student must hand in their own homework and will be held accountable for understanding the concepts employed in the problem solutions.
- At the end of the semester, please participate in the evaluation of courses through CourseEvalUM.
  Your feedback is confidential and an important means of improving the course in future semesters.

Developed in August 2011 by Mark Austin
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