Modern Methods of Structural Analysis (Undergraduate: CIV ENG 4K04)
Course Outline, Fall 2018

Teaching Staff
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Office Hours: appointments preferred, but drop-ins accepted when possible

Teaching Assistants:
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Office Hours: Thursdays at 11:30 in JHE 329A (watch the course website for a possible change in location)

Communication
Lectures: Mondays, Wednesdays, and Thursdays 10:30-11:20 in MDCL 1309
Tutorials: Tuesdays 8:30-10:20 in HH 104
Website: On Avenue to Learn (http://avenue.mcmaster.ca). Please sign up immediately because important information and course documents will be posted there. It is your responsibility to check the course website regularly.
Email: You can expect a response from TAs within 1 business day, or from the instructor within 3 business days.

Academic Accommodation of Students with Disabilities
Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Student Accessibility Services can be contacted by phone 905-525-9140 ext. 28652 or e-mail sas@mcmaster.ca. For further information, consult McMaster University’s Academic Accommodation of Students with Disabilities policy.

Academic Accommodation for Religious, Indigenous or Spiritual Observances (RISO)
Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students requiring a RISO accommodation should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar’s Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Course Overview
Learning Outcomes
When you have successfully completed this course, you will have increased your knowledge base for engineering so that you will be able to:

• use exact and approximate hand methods to estimate the forces and displacements associated with trusses, beams, and frames [CEAB Indicators 1.3 and 1.4]
• use the method of virtual work to calculate the displacements of structures [1.4]
• create and use influence lines to identify critical loading locations in beams [1.4]
• use matrix methods (i.e. the direct stiffness method) to calculate the forces and deflections in planar trusses, beams, and frames under a variety of loading conditions, including geometric nonlinearities [1.4]
• use SAP2000 to facilitate these calculations [5.2]
• describe the fundamental assumptions of finite element analysis and identify situations that require it [1.4]
With this knowledge base, you will be able to:

- select a structural analysis technique, whether simple or sophisticated, that is appropriate for the complexity of the problem and the resources available [2.2, 3.2, and 5.1]
- critically examine the results of one analysis method using insights from other methods [2.3 and 3.3]
- identify the assumptions and limitations that are inherent in particular analysis methods [2.1 and 2.3]

**Course Outline and Approximate Schedule**

<table>
<thead>
<tr>
<th>Week</th>
<th>Lecture Topics (topics and dates subject to change without notice)</th>
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</thead>
<tbody>
<tr>
<td>September 3</td>
<td>Trusses: Hand Calculation Methods</td>
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<tr>
<td>September 10</td>
<td>Trusses: Approximate Methods</td>
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<tr>
<td>September 17</td>
<td>Trusses: The Method of Virtual Work</td>
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<tr>
<td>September 24</td>
<td>Trusses: The Direct Stiffness Method</td>
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<tr>
<td>October 1</td>
<td>Trusses: Large and Complex Problems</td>
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<td><strong>October 8</strong></td>
<td><strong>Midterm Recess: No Lectures or Tutorial</strong></td>
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<td>October 15</td>
<td>Beams and Frames: Estimating by Inspection</td>
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<tr>
<td>October 22</td>
<td>Beams and Frames: Approximate Methods</td>
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<tr>
<td>October 29</td>
<td>Beams and Frames: The Method of Virtual Work</td>
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<td>November 5</td>
<td>Beams: Influence Lines</td>
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<td>November 12</td>
<td>Beams: The Direct Stiffness Method</td>
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<td>November 19</td>
<td>Beams and Frames: The Direct Stiffness Method, Elastic Stability</td>
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<tr>
<td>November 26</td>
<td>Introduction to Finite Element Analysis</td>
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<tr>
<td>December 3</td>
<td>Big Problems</td>
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analyzing real structures

simplicity | accuracy

trusses
approximate methods
energy methods
matrix methods & analysis software

beams & frames
approximate methods
energy methods
influence lines
matrix methods & analysis software

solids
finite element method
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This course is about analyzing real structures, a process that always involves simplifying the problem to a level that allows the forces and displacements to be solved with an acceptable level of accuracy. To study this, we will examine several different analysis techniques, as outlined in the figure and table above.

In the first part of the course, we will focus on methods of analysis for trusses, including approximate methods, energy methods (particularly the method of virtual work), and the matrix methods (i.e. the direct stiffness method) that are at the core of most modern structural analysis software packages (e.g. SAP2000).

The second part of the course will apply similar methods to beams and frames. In addition, we will discuss how to use influence lines to identify critical loading cases for beams.

As time permits, we will conclude the course by extending our discussion of matrix stiffness methods to elastic stability analysis and to finite element analysis using planar area elements.

Throughout the course, we will discuss tools for quickly estimating the solution to common problems in structural analysis. Comparing these simple estimates with the results of more complex models will enable us to identify errors in the more complex models, and to identify the limitations of the simple estimates.

**Extreme Circumstances and Other Modifications**

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

In addition, the instructor may adjust the lecture and assessment schedule during the term. If this happens, the class will be given reasonable notice, an explanation, and an opportunity to comment, although the instructor will not necessarily make changes in response to comments received. It is your responsibility to stay informed of changes by attending all lectures and by checking the course website regularly.

**Required Background:** Structural Analysis (CIV ENG 3G03 or 3G04)

**Graduate Attributes and CEAB Indicators**

Through this course, you will develop in the following graduate attributes and indicators:

1. A knowledge base for engineering (Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.)
   1.3 Competence in Engineering Fundamentals
   1.4 Competence in Specialized Engineering knowledge

2. Problem analysis (An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.)
   2.1 Demonstrates an ability to identify reasonable assumptions (including identification of uncertainties and imprecise information) that could or should be made before a solution path is proposed.
   2.2 Demonstrates an ability to identify a range of suitable engineering fundamentals (including mathematical techniques) that would be potentially useful for analyzing a technical problem.
   2.3 Obtains substantiated conclusions as a result of a problem solution including recognizing the limitations of the solutions.

3. Investigation (An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.)
   3.2 Selects appropriate model and methods and identifies assumptions and constraints.
   3.3 Estimates outcomes, uncertainties and determines appropriate data to collect.
5. Use of engineering tools (An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.)

5.1 Evaluates and selects appropriate modern tools.

5.2 Demonstrates an ability to use modern/state of the art tools.

Recommended References

Computers and Structures, Inc. 2014. SAP2000 v17. This software is installed on the computers in JHE 201, and a request has been made to CSI to make a student version available through the course website.

Assessment
Components (the mark breakdown is NOT the same as for the graduate class 6K04)

Final Exam (Date TBA) 50%
- One Handwritten Double-Sided Crib Sheet Permitted
- McMaster Standard Calculator (Casio fx-991 MS or MS Plus) only

Term Test (October 18, 10:30-12:20, location to be announced) 25%
- One Handwritten Double-Sided Crib Sheet Permitted
- McMaster Standard Calculator (Casio fx-991 MS or MS Plus) only

Assignments 25%
- There will be assignments approximately weekly during the term. Your lowest assignment grade will be omitted when calculating your total grade for assignments.

The final percentage grade will be converted to a letter grade using the scale specified in the McMaster calendar (http://academiccalendars.mcmaster.ca/index.php under General Academic Regulations).

Late Submissions
If an assignment will be accepted after the regular deadline, the deadline for late submissions will be listed on the assignment. A deduction of 20% will apply (e.g. a student who scores 80% on the assignment will receive 60% if it is submitted late).

Discussions of Feedback
You are encouraged to discuss the feedback that you receive on any assessment with your TAs or the course instructor. If you believe that you have received an incorrect grade on any piece of assessment, you must return that piece to the person who marked it, together with a written explanation of why you believe the grade was incorrect, within one week of the day that the assessment was returned. This may result in the grade increasing, decreasing, or remaining the same.

Requests for Relief for Missed Academic Term Work
In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar “Requests for Relief for Missed Academic Term Work.” In accordance with university policy, the McMaster Student Absence Form (MSAF) will only be accepted if you email the course instructor within one week after the due date of the assignment. The accommodation will normally be an extension of the deadline (i.e. waiving the late penalty), but the assignment must still be submitted to avoid a grade of 0. When accommodations are

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1 For each student, a non-zero midterm exam grade will be replaced with the final exam grade if it is to that student’s benefit.
made, they will be confirmed by email from the course instructor; any grades that are missing on the course website will be counted as zero when calculating your final grade unless you have received email confirmation otherwise. **As the midterm exam is worth 25% of the final grade, students who miss the midterm must report to the Faculty Office; an MSAF is not sufficient.** For the midterm exam, an acceptably documented absence will normally result in the weight of the test being shifted to the final exam.

**Academic Integrity**

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the [Academic Integrity Policy](https://www.mcmaster.ca/academicintegrity/), located at www.mcmaster.ca/academicintegrity/.

The following illustrates only three forms of academic dishonesty:

- Plagiarism, e.g. the submission of work that is not one’s own or for which other credit has been obtained.
- Improper collaboration in group work.
- Copying or using unauthorized aids in tests and examinations.

In this course, most assignment questions will have a single correct answer. Discussing your solution technique with your classmates is encouraged, but copying some or all of the solution from another student (including using or modifying someone else’s spreadsheet or SAP model) is considered an example of academic dishonesty.

**Diversity and Inclusion**

Under the Ontario Human Rights Code and McMaster policy, you have a right to an environment that is free of discrimination and harassment. If you have any concerns, please do not hesitate to contact me or a human rights officer (equity.mcmaster.ca). Like many people, I am still in the process of learning about diverse perspectives and identities. If something was said in class (by anyone, including me) that made you feel uncomfortable, please talk to me about it. Anonymous feedback is always an option.

**Copyright Notice**

All slides, presentations, handouts, lecture notes, and other course materials in this course are the intellectual property of the instructor unless otherwise noted, and are protected by law under Canada’s Copyright Act. Unless a user’s right in the Copyright Act covers the particular use, students must not publish, post on a public internet site, sell, rent, or otherwise distribute any course materials without the instructor’s express permission.

**Professional Class Conduct**

My goal in every class is to provide the best possible environment for everyone in the class to become competent structural engineering professionals. In order to do this, I expect you to treat meetings of this class as you would treat meetings that with your supervisor in an engineering design office. This includes the following expectations:

- **Arrive on time.** Plan for the possibility of transport delays. But if you are late, minimize the disruption you cause by quickly and quietly finding a seat near the aisle.
- **Come prepared to work.** Expect to participate actively in every class, check the course website before coming, and bring a calculator with you.
• **Be quiet during class.** If you have a question, please raise your hand so that I can answer it for everyone.

• **Turn off all electronic devices during class, unless you are taking notes on it.** I will check.

• **Avoid eating during class.** If you must eat, choose something that you can eat quietly and that is not smelly.

• **Avoid leaving the room during class.** If you must leave, minimize your disruption by doing so quickly and quietly.

If you are disrupting the class, after a warning, I may have to ask you to leave the class and possibly to meet with the Chair of the Department if the behaviour persists.

If you are bothered by the behaviour of other students, please let me know so that I can address your concerns quickly.