CIVE 4201A FEM in Civil Engineering – Course Syllabus

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Overview and Learning Outcomes

This course introduces the finite element methods (FEM) for applications in civil engineering. Upon successful completion of this course, the student will be able to:

- acquire knowledge on the theory and application of Finite Element Methods (FEM) in Civil Engineering for the analysis of linear, elastic systems,
- develop modelling skills for the idealization and formulation of Civil Engineering problems using FEM,
- apply FE modelling procedures to solve practical Civil Engineering problems, and develop critical thinking skills to assess the quality of the numerical predictions (i.e., understand the benefits, constraints, and limitations of the FEM),
- develop other technical skills (e.g., software programming) and personal attributes (e.g., work effectively within a team environment), and
- understand the relationship between numerical simulations and professional engineering practice (e.g., competence, supporting design and decision making, public safety).

Textbook and Resources

The course textbook is "A First Course in the Finite Element Method", Enhanced Edition, SI Version by D.L. Logan (ISBN-10: 0357676432; ISBN-13: 9780357676431). Course notes, where needed, will provide supplemental content and illustrative examples. The Matlab programming language will also be used to achieve learning goals in the application of the FEM.

The FE modelling software package Abaqus™ will be used to develop the numerical modeling procedures, simulate the civil engineering problem, and generate the numerical predictions. The

[1] Electronic correspondence should be limited to the scheduling of meetings or providing information (e.g., absence from course work). General questions on course content will not be answered by e-mail.

Abaqus student version and other resources (e.g., installation instructions, tutorials and workshops, links for study resources) can be obtained through https://academy.3ds.com/en/software/abaqus-student-edition. Create an account with Simulia, download and install this program onto your computer for use in the course. Learning will be imparted through the lectures, laboratories and assignments.

Other online resources available through the Carleton University library include:

- Khennane, Amar. Introduction to Finite Element Analysis Using MATLAB and Abaqus. Boca Raton: Taylor & Francis, 2013.
- Hejazi, Farzad, and Hojjat Mohammadi Esfahani. Solving Complex Problems for Structures and Bridges Using ABAQUS Finite Element Package. First edition. Milton: CRC Press, 2021. Web.
- Boulbes, Raphael Jean. Troubleshooting Finite-Element Modeling with Abaqus: With Application in Structural Engineering Analysis. Cham: Springer International Publishing AG, 2019.

Lecture Progression

The planned lecture progression (week #, week start date and lecture content) is summarized in the Table 1, which may be adjusted during the term in response to unforeseen events or constraints. Prior to the lectures, students should enhance their learning opportunities by taking notes during class, being actively engaged in the course and reviewing the assigned course notes and resources. The lectures will highlight the key theoretical concepts and illustrate application of FEM through worked examples. The course material, available for download from Brightspace, is intended to facilitate learning and complement the lectures.

The general topics addressed during this course:

Introduction

- Introduction to numerical methods
- Approach to finite element modelling

Modelling Concepts for Linear Elastic Finite Element Analysis (FEA)

- Element type, order and performance (topology and convergence study)
- Materials, loads and boundary conditions
- Errors and common mistakes
- Analysis and interpretation of results

Structural Analysis

- Matrix or stiffness methods
- Bars (1D) and truss (2D plane, 3D space) systems
- Beams and frames
- Thermal stress analysis
- Modal analysis and structural dynamics

Plane Continuum Analysis

- Plane stress and plane strain analysis
- Stress concentrations

Geotechnical Engineering

- Solving geotechnical problems using finite element methods
- Modelling considerations and applications to engineering problems

Special Topics

- Introduction to sources of nonlinearity, modelling considerations and applications
- Reflective symmetry and axisymmetric problems
- Overview of special elements

Table 1. Lecture Progression	
Week # – Start Date	**Content**
1 – Sep. 5	Introduction to numerical methods
2 – Sep. 12	Foundational mathematical concepts
3 – Sep. 19	FEM procedures for the 1D truss or bar (structural) element [PA1]
4 – Sep. 26	Extension of FEM procedures for the 2D and 3D truss (bar) element
5 – Oct. 3	FEM procedures for beam (structural) elements [PA2]
6 – Oct. 10	FEM procedures for thermal stress analysis
7 – Oct. 17	FEM procedures for the 2D plane stress & plane strain elements [PA3]
8 – Oct. 24	Fall Break
9 – Oct. 31	FE applications in geotechnical engineering
10 – Nov. 7	FE applications in geotechnical engineering [PA4]
11 – Nov. 14	Practical analysis and interpretation of results
12 – Nov. 21	FE applications in structural dynamics [PA5]
13 – Nov. 28	FE applications in structural dynamics
14 – Dec. 5	Special topics in continuum FEM

Course Evaluation

The course evaluation will comprise assignments, comprehension activities and a final exam. The evaluation scheme is presented in Table 2.

Table 2. Course Evaluation Scheme		
Element	**Description**	**Weight**
Assignments	4 assignments (aligned with the first 4 PA sessions).	40%
Comprehension Activities	5 in-class assessments (open book & notes quiz) held during the PA session weeks.	10%
Final Exam	Open book & notes. TBD. 2-hour exam.	50%

Course Policies

This section summarizes key university and course policies. As a student you must be aware of and follow the regulations of Carleton University for academic behaviour and understand your rights and responsibilities for non-academic behaviour.

Academic Integrity

The Carleton University Academic Integrity Policy addresses the7 expected behaviour of students with respect to academic integrity, which is essential to the university environment. This policy reflects the values we hold to be important in the pursuit of engagement, learning, and scholarship. Violations of this policy can have a range of repercussions and outcomes (e.g. resubmission of work, change in grade, withdrawal from course(s), suspension).

Academic Petition

For extenuating circumstances that affect your ability to meet your academic obligations, you have the option to submit a petition.

Appeal of Grade

Before initiating the Appeal of Grade process, seek resolution through communication with (1) the assigned Teaching Assistant (TA), and, if the issue remains unresolved, (2) the Primary Evaluator based on Table 3 §7 Course Evaluation.

Communications

Course materials will be distributed through the course's cuLearn page and are protected provided under copyright© for personal (academic study) use only. All electronic communications must be conducted through official Carleton university resources (e.g. email accounts, cuLearn). Professionalism is expected in all course communications. The Announcements forum on the cuLearn course page will be the primary communication tool.

Copyright on Materials

All course materials (e.g., assignments, course outline, posted notes, projects, as well as the quiz, exam and solutions) are provided under copyright© for personal (academic study) use only. Reproduction, distribution, or transmittal of course materials by any means, without explicit

documentation expressing allowance from the copyright holder, violates copyright law. A student who publicly posts or sells an instructor's work, without the instructor's express consent, may be charged with misconduct under an academic offence under the Academic Integrity Policy of Carleton University and/or Code of Conduct (Category 2 Offence), and may also face adverse legal consequences for infringement of intellectual property rights. If you have questions about fair dealing and your other rights to use works for educational purposes, please contact copyright@carleton.ca.

Academic Accommodations

Carleton University is committed to providing access to the educational experience in order to promote academic accessibility for all individuals. Academic accommodation refers to educational practices, systems and support mechanisms designed to accommodate diversity and difference. The purpose of accommodation is to enable students to perform the essential requirements of their academic programs. At no time does academic accommodation undermine or compromise the learning objectives that are established by the academic authorities of the University. The accommodations include:

- pregnancy obligation
- religious obligation,
- academic accommodation for students with disabilities,
- survivors of sexual violence, and
- accommodation of student activities.

See the following link for further information on academic accommodations:

https://students.carleton.ca/course-outline/

Additional Student Resources

Student Referral Guide
https://carleton.ca/studentsupport/wp-content/uploads/2019ReferralGuide-09-19.pdf

Carleton Online – Connect with resources to support online learning
https://carleton.ca/online/

Counselling Services – Counselling support for physical and mental health
https://carleton.ca/health/counselling-services/

International Students – Services and programs
https://carleton.ca/isso/

Paul Menton Centre – Integration of students with learning disabilities
http://www.carleton.ca/pmc/

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). Requests made within two weeks will be reviewed on a case-by-case basis. After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam (if applicable).

Mental Health & Well-Being – Available tools and resources
https://carleton.ca/wellness/

Peer Assisted Study Sessions – Supportive learning environment
https://carleton.ca/csas/pass/

Research Help Desk – Library support services
https://library.carleton.ca/contact/service-points/research-help-desk

Student Experience Office – Resources to enhance university experience
https://carleton.ca/seo/

Undergraduate Academic Support – Engineering focused resources
https://carleton.ca/engineering-design/current-students/undergrad-academic-support/

Writing Service – Support to improve writing skills
https://carleton.ca/csas/writing-services/

Covid-19 Information

It is important to remember that COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are a number of actions you can take to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you're sick, washing your hands and maintaining proper respiratory and cough etiquette.

Feeling sick? Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you must follow Carleton's symptom reporting protocols.

Masks: Carleton has paused the COVID-19 Mask Policy, but continues to strongly recommend masking when indoors, particularly if physical distancing cannot be maintained. It may become necessary to quickly reinstate the mask requirement if pandemic circumstances were to change. **Vaccines:** Further, while proof of vaccination is no longer required as of May 1 to attend campus or in-person activity, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes. Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible, and submit their booster dose information in cuScreen as soon as possible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the campus.

All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton's COVID-19 response and health and safety requirements please see the University's COVID-19 website and review the Frequently Asked Questions (FAQs). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca.