CIVE 4201A Finite Element Methods in Civil Engineering – Course Syllabus

1 Teaching Team

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Teaching Assistants (TA)		To be updated	

2 Course Description and Requirements

2.1 Schedule

For current information on the location, date and time of the classes and PA sessions, see Course Search - Carleton University.

2.2 Course Description

Introduction to the theory and application of finite element methods. The relationship with virtual work, Rayleigh-Ritz, system of linear equations, polynomial interpolation, numerical integration, and theory of elasticity is explored. Isoparametric formulations of structural and plane elements are examined. Geotechnical and nonlinear problems are introduced.

2.3 Precluded Courses

Also offered at the graduate level, with different requirements, as CIVE 5103, for which additional credit is precluded.

2.4 Prerequisites and Recommended Knowledge

Fourth-year status in engineering.

2.5 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,

[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.

- 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).

2.6 Textbook(s), References and Resources

The recommended 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). A copy of the 5th Edition is held at the through the Carleton University MacOdrum library reserve desk.

Supporting resources are also provided, including course guidance notes that provide supplemental content and illustrative examples. The Matlab programming language will also be used to achieve learning goals in the application of the FEM.

Additional online resources are available through the Carleton University MacOdrum library. There is no preference for the electronic resources highlighted, which are presented in alphabetical order. The options are provided for you to choose the resource that best matches your learning style.

- Boulbes, Raphael Jean. Troubleshooting Finite-Element Modeling with Abaqus: With Application in Structural Engineering Analysis. Cham: Springer International Publishing AG, 2019.
- Das, Shuvra. An Introduction to Finite Element Analysis Using MATLAB Tools. 1st ed. 2023., Springer, 2023, https://doi.org/10.1007/978-3-031-17540-4.
- 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.
- Khennane, Amar. Introduction to Finite Element Analysis Using MATLAB and Abaqus. Boca Raton: Taylor & Francis, 2013.
- Kim, Nam H., et al. Introduction to Finite Element Analysis and Design. Second edition., John Wiley & Sons, 2018.

- Liu, G. R., and S. S. Quek. The Finite Element Method : A Practical Course. Second edition., Butterworth-Heinemann, 2014.
- Zienkiewicz, O. C., and Richard Lawrence Taylor. The Finite Element Method for Solid and Structural Mechanics. 6th ed., Elsevier Butterworth-Heinemann, 2005.
- Zienkiewicz, O. C., et al. The Finite Element Method Its Basis and Fundamentals. 6th ed., Elsevier Butterworth-Heinemann, 2005.

The following communications focused resources are identified:

- M. Alley, The Craft of Scientific Presentations: Critical Steps to Succeed and Critical Errors to Avoid. Boca Raton, FL USA: 2nd Edition, Springer, 2013.
- Michael Alley, Website, Penn State, Writing as an Engineering or Scientist
- Michael Alley, Website, Penn State, Assertion-Evidence
- Laplante, P. (2018). Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals. Boca Raton, FL USA: 2nd Edition, CRC Press, eBook ISBN 9780429467394, 2018.

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

2.7 Lecture Topics and Tentative Plan

2.7.1 Fall Term

Fall Term Starts September 4, 2024 (04/09/24) – Classes from 1605-1755 in AT 302		
Lec #	**Week of**	**Topic**
1	2/09	Introduction to numerical and finite element methods (FEM)
2	9/09	Foundational mathematical concepts [PA1]
3	16/09	1D bar and truss FEM
4	23/09	2D and 3D truss FEM [PA2]
5	30/09	Beam (structural) FEM
6	7/10	Thermal stress analysis [PA3]
7	14/10	2D plane stress & plane strain FEM
Fall Term Break: October 21-25, 2024		
8	28/10	Introduction to structural dynamics FEM [PA4]
9	4/11	FEM applications in structural dynamics
10	11/11	Introduction to geotechnical engineering FEM [PA5]
11	18/11	FEM applications in geotechnical engineering
12	25/11	Special topics in FEM [PA6]
13	2/12	Review
Fall Term Ends December 6, 2024		

2.8 Evaluation and Marking Scheme

2.8.1 Term Assessment

Assessment Element	Description [Evaluator]	Weight
Assignments	5 assignments (aligned with the first 5 PA sessions).	40%
Comprehension Activities	5 in-class assessments (open book & notes quiz) held during the PA session weeks.	10%
Final Exam	Closed book. Formula sheet provided. 3-hour exam.	50%

2.8.2 Final Examination

The date and room for the final examination will be set by Examination Services. The final examination is for evaluation purposes and will not be returned to students.

The duration of the final examination will be 3 hours. A formula sheet will be provided in the final examination. In addition to the general examination regulations , the exam conditions will be closed book and closed notes with the use of non-programmable calculators allowed.

The weight of the final examination is 50% of the total grade.

2.8.3 Final Examination Format and e-Proctoring Statement

There is no electronic format (e.g., solutions using FE software) for the final examination. The final examination is in-person with no e-Proctoring.

2.8.4 Additional Evaluation Requirements

There are no additional evaluation requirements.

2.8.5 Deferred Final Examination

Students who are unable to write the final examination because of extenuating circumstances, as defined in the Academic Consideration Policy, may apply for accommodation by contacting the Registrar's office. Consult the Section 4.3 of the University Calendar.

2.9 Deferred Term Work and Self-declaration

Students who claim extenuating circumstances defined in the Academic Consideration Policy, as a reason for missed term work are held responsible for immediately informing the instructor concerned and for making alternate arrangements with the instructor and in all cases. This must

occur no later than three (3) days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. Consult Section 4.4 of the University Calendar.

2.10 Academic dates

Students should be aware of the academic dates (e.g., last day for academic withdrawal) posted on the Registrar's office web site.

2.11 Graduate Attributes

For engineering elective courses there are no graduate attributes collected or assessed.

3 Academic Integrity and Plagiarism

The Carleton University Academic Integrity Policy addresses the 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).

Consult the Faculty of Engineering and Design information page about the Academic Integrity policy and our procedures. Violations of the Academic Integrity Policy will result in the assignment of a penalty such as reduced grades, the assignment of an F in a course, a suspension or expulsion.

One of the main objectives of the Academic Integrity Policy is to ensure that **the work you submit is your own**. As a result, it is important to write your own solutions when studying and preparing with other students and to avoid plagiarism in your submissions. The University Academic Integrity Policy defines plagiarism as "presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own." This includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source. Some examples of violations of the policy include, but are not limited to:

- any submission prepared in whole or in part, by someone else,
- using another's data or research findings without appropriate acknowledgement,
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own, and
- failing to acknowledge sources of information by not including proper citations when using another's work and/or failing to use quotations marks.

4 Copyright

All course materials (e.g., course outline, posted resources, lectures slides, notes, videos assignments, quizzes, exams, and corresponding solutions) are provided under copyright© for personal use (academic study) only. Reproduction, distribution, or transmittal of course materials by any means, without explicit documentation expressing allowance from the copyright holder is a violation of copyright law. This action is an academic offence of the Academic Integrity Policy of Carleton University and Code of Conduct (Category 2 Offence). If you have any questions about fair dealing and your rights to use work for educational purposes, please contact copyright@carleton.ca.

5 Learning and Working Environment

The University and all members of the University community share responsibility for ensuring that the University's educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the Department of Equity and Inclusive Communities at equity@carleton.ca. We will strive to create an environment of mutual respect for all through equity, diversity, and inclusion within this course. The space which we work in will be safe for everyone. Please be considerate of everyone's personal beliefs, choices, and opinions.

6 Academic Accommodations

6.1.1 Overview

Carleton University is committed to providing access to the educational experience that promotes 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.

6.1.2 Academic Accommodations for Students with Disabilities:

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 .

You should request your academic accommodations in the Ventus Student Portal, for each course at the beginning of every term. For in-term tests or midterms, please request accommodations at least two (2) weeks before the first test or midterm. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).

6.1.3 Accommodation for Student Activities

Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see the Senate Policy on Accommodation for Student Activities (PDF).

6.1.4 Pregnancy Obligation

Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please review the Student Guide to Academic Accommodation (PDF).

6.1.5 Religious Obligation

Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please review the Student Guide to Academic Accommodation (PDF).

6.1.6 Survivors of Sexual Violence

As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit the Sexual Violence Prevention & Survivor Support.

7 Engineering Academic Advising

The Engineering Academic Support Service assists undergraduate engineering students with course selection, registration, and learning support from first year through to graduation. The

Department of Civil and Environmental Engineering (CEE) also has Academic Advisors that you may need to contact.

8 Student Mental Health and Wellness

As a university student you may experience a range of mental health challenges that can significantly impact your academic success and overall well-being. Carleton's **Wellness Services Navigator** is designed to help students connect with mental health and wellness resources.

If you need to talk to someone from the department for more information and support with connecting to resources, you may contact a CEE Departmental Administrator, Academic Advisor or the Associate Chair of Undergraduate Studies.

The following list provides additional on-campus and off-campus resources:

1. **Carleton's Wellness Desk**: Located at 204A MacOdrum Library, is a space for students to learn about resources, connect with our Wellness Coordinator, and decompress during stressful times of the year. You can pop into the Wellness Desk any time during its hours of operation – no appointments necessary! https://wellness.carleton.ca/mental-health/wellness-desk/
2. **Carleton's Health and Counselling Services:** To book an appointment contact the main clinic by calling (613) 520-6674. If urgent, let the Patient Care Coordinator know or go in person to the main clinic (2500 Carleton Technology and Training Centre Building) and indicate that they are in crisis and need to speak to someone right away. https://carleton.ca/health/
3. **Residence Counselling and Wellness Service:** Counselling services specifically for students in residence. https://carleton.ca/health/residence-counselling/
4. **Therapy Dogs:** Carleton's therapy dogs are around campus with their owners (who are Carleton University staff and faculty) to comfort and provide support to help you thrive as a university student. https://carleton.ca/wellness/dogs/
5. Emergencies and Crisis and Emergency Numbers
6. **Good2Talk (1-866-925-5454):** Good2Talk is a free, confidential helpline providing professional counselling and information and referrals for mental health, addictions and well-being to post-secondary students in Ontario, 24/7/36 https://good2talk.ca/
7. **Empower Me:** Undergraduate students have access to free counselling services in the community through Empower Me, either in person, by telephone, video-counselling or e-counselling. **This free service is accessible 24/7, 365 days per year.** Call **1-844-741-6389 (toll free)** to make an appointment with a counsellor in the community. More information is available https://students.carleton.ca/services/empower-me-counselling-services/

8. **The Walk-In Counselling Clinic (off-campus community resource):** The walk-in Counselling Clinic have offices in various locations across Ottawa and the greater Champlain region that are open 7 days a week. Individuals will be assisted, with no appointment, on a first-come, first-serve basis during the Walk-in Counselling Clinic hours. The Walk-in Counselling Clinic **offers services in many languages** and is free and confidential. More information can be found at: https://walkincounselling.com/
9. **Distress Centre of Ottawa and Region**: Available 10am-11pm, 7 days/week, 365 days/year. **Distress Line:** 613-238-3311, **Crisis Line:** 613-722-6914 or 1-866-996-0991, **Text:** 343-306-5550. https://www.dcottawa.on.ca/
10. **Distress and Crisis Ontario**, Available for chat 2 pm – 2 am EST. https://www.dcontario.org/
11. **BounceBack Ontario (Toll-Free: 1-866-345-0224)** is a free skill-building program managed by the Canadian Mental Health Association (CMHA). It is designed to help adults and youth 15+ manage low mood, mild to moderate depression and anxiety, stress or worry. Delivered over the phone with a coach and through online videos, you will get access to tools that will support you on your path to mental wellness. https://bouncebackontario.ca/.

9 General Carleton University Policies

This section summarizes other 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.

9.1 Academic petition and appeal of grade

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

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 § Course Evaluation.

9.2 Additional student resources

From Intention to Action – Supports undergraduate and graduate students in the often-stressful university experience. We help students to better manage stress and improve their academic performance, by navigating the personal stressors that can often get in the way of school.

International Students – offers services and programs that contribute to positive international experiences for all Carleton students.

Peer Assisted Study Sessions – offers free, course-specific study sessions known as Peer Assisted Study Sessions (PASS). PASS is a learning enhancement program that is attached to historically challenging courses. PASS is a peer-to-peer program which provides a welcoming and supportive environment where students work through course content and learn transferable study skills that they can apply to other courses.

Student Experience Office – facilitate student-centered learning that enhances the university experience by offering transition support, leadership opportunities, and experiential learning resources to enhance university experience.

Writing Service – offers equitable access to writing support services for the Carleton community.