CIVE 4201 Finite Element Methods in Civil Engineering

Lectures: Thursday (each week) 1135-1425 RB 1201
Laboratory (Problem Solving): Wednesday (every 2nd week) 0835-1125 MC 5010

Objectives and Learning Outcomes

Upon successful completion of this course, the student will:

- acquire knowledge on the fundamental principles, theory and application of the Finite Element Method (FEM) for the analysis of common linear, static systems in Civil Engineering with an introduction to other advanced topics.
- develop critical thinking skills through the synthesis of engineering knowledge acquired from other technical courses and formulating problems within the FEM framework,
- solve problems through application of FE modelling procedures, to properly interpret the results and to understand how these outcomes can be integrated in the support of engineering design and decision making (i.e. understand the benefits, constraints and limitations of the FEM),
- develop auxiliary technical capabilities (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. integrity, technical competence, public safety, liabilities).

Instructor and Teaching Assistants

Instructor: Shawn Kenny, Ph.D., P.Eng., Associate Professor
Room CB 4205 (Canal Building)
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Office Hours: Wednesday & Thursday 1430-1600²

Teaching Assistant: Elham Nakhostin
Room CB 6212
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¹ E-mail can be used to schedule meetings outside the office hours. General technical questions will not be answered by e-mail, however, I welcome any discussion in person.
Course Syllabus

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 FEA

- Matrix or stiffness methods
- Bars and truss systems
- Beams, columns and frames

Continuum FEA

- Plane stress and plane strain analysis
- Stress concentrations
- Introduction to modelling problems in 3D solids and solids of revolution

Introduction to Geotechnical Engineering

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

Special Topics

- Introduction to sources of nonlinearity with modelling considerations and applications to engineering problems
- Overview of special elements

The Lecture format will be a discussion and examination of the major concepts outlined in the course syllabus through modules addressing specific topics. The Lectures will use slides, worked examples and discussion to illustrate the theory and application of finite element methods. The Lecture slides will be available for download, in PDF format on cuLearn, and are intended to facilitate learning. The slides should not be viewed as a substitute for attending class. Students are encouraged to enhance their learning experience by taking notes during class, and to engage all participants through lines of inquiry and dialogue. The Laboratory will be focused on problem solving and the application of FEM in Civil Engineering using both hand calculations and numerical simulation tools.
Method of Evaluation

Comprehension Activities 10% (5 activities)
Assignments 15% (3 assignments)
Term Exam 25% (October 20th)
Final Exam 50% (TBD)

Primary Course Resources

The required textbook for the course is:


This textbook is a valuable resource introducing the technical concepts and application of the finite element methods (FEM) for the undergraduate student. I will supplement the textbook with course notes that provide additional technical concepts and examples. The Matlab programming language will also be used to achieve learning goals in the application of the FEM.

The finite element software Abaqus will be used to develop numerical modeling procedures, simulate problems in civil engineering and interpret the predicted results. 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. The laboratory (MC 5010) will also have the Abaqus student version installed. For the labs conducted in this course, guidance notes will also be provided to demonstrate the process for building the FE model and analyzing the results. This learning will be imparted through the lectures, laboratories and assignments.

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2 The course evaluation will follow the current version of the University Calendar with respect to Course Evaluation governed by the Academic Regulations – except as noted in this course outline.

3 These activities will be held periodically during the term to assess comprehension of course material, which may include in-class quiz or take home material.

4 Assignments will not be accepted after the due date.

5 The term exam format will be closed book with a formula sheet provided. Only non-programmable calculators are allowed. A deferral of the term will be granted if you notify the instructor prior to the term and subsequently provide documentation on the extenuating circumstances.

6 The final exam format will be closed book with a formula sheet provided. Only non-programmable calculators are allowed. The final exam will not be returned to the student.
Supplementary Resources

There are useful textbook resources in the Carleton University library (http://www.library.carleton.ca) including:


Other learning tools and resources are available within the Carleton University library system and through Internet search engines (e.g. use the search term “introduction to finite element methods”), which range from introductory treatments of the subject matter to detailed examination of specific applications. If you require guidance on other resources please contact the instructor.

Academic Regulations, Policies and Support Services

The following electronic resources provide information on academic regulations, policy and support services.

- Regulations: http://calendar.carleton.ca/undergrad/regulations/academicregulationsandrequirementsforthebachelorofengineeringdegree/
- Integrity: http://carleton.ca/studentaffairs/academic-integrity/
- Academic Support Services: http://www.carleton.ca/academics/support/
- General: http://www.carleton.ca/studentaffairs/

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7 See for example http://www.colorado.edu/engineering/CAS/courses.d/IFEM.d/Home.html