Western University - Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 9512a – Finite Element Method (Theory and Applications)
Course Outline – Fall 2021

Objectives:

This course is designed to achieve the following objectives:

- Apprise the students about the basic theory of finite element method in linear analysis.
- Understand modelling aspects and techniques for 1-D, 2-D and 3-D problems.
- Learn about modelling of simple and complex structural systems, develop their mathematical and computational models and analyze the results.
- Learn how to model structures using professional programs like SAP2000, ETABS, and ANSYS.

Prerequisite:

Bachelor's degree in Structural Engineering.

Corequisite:

None

Antirequisite:

None

Topics:

Topic #	Description	Learning Activities	Tentative timeline
1	Introduction to the finite element method (FEM)		
	Lecture 1: Background – Chapter 1 - What is FEM - Applications of FEM - Basic types of elements - Degrees of freedom Lecture 2: Chapter 1 (cont.) - Review of basic equations for bar and beam problems.	• Lecture will be delivered in person • Recorded lectures will be posted to course OWL site for accessibility considerations. • Reading material (Course notes – Chapter 1) will be posted to OWL as well.	Weeks 1-2
	Lecture 3: Chapter 2 - Principle of minimum potential energy and approximate analysis.	• Lecture will be delivered in person • Recorded lectures will be posted to course OWL site for accessibility considerations. • Reading material (Course notes – Chapter 2) will be posted to OWL as well. • Live help session (office hour)	Week 3

Topic #	Description	Learning Activities	Tentative timeline
2	Finite element formulation and application of bar elements (uni-dimensional element)		
	Lecture 4: Chapter 3 - Learn about the displacement field and shape functions used in the formulation of a bar element. - Derive the stiffness matrix as well as load vector due to various load conditions acting on a bar element. - Develop numerical models for uni-dimensional problems using SAP2000.	• Lecture will be delivered in person • Recorded lectures will be posted to course OWL site for accessibility considerations. • Reading material (Course notes – Chapter 3) will be posted to OWL as well. • Live help session (office hour)	Week 4
3	Finite element formulation and application of plane trusses		
	Lecture 5: Chapter 4 - Derive the stiffness matrix as well as load vector due to various load conditions acting on a plane truss. - Learn about transformation matrix and relationship between local and global systems. - Develop numerical models for plane truss problems using SAP2000.	• Lecture will be delivered in person • Recorded lectures will be posted to course OWL site for accessibility considerations. • Reading material (Course notes – Chapter 4) will be posted to OWL as well. • Live help session (office hour)	Week 5
4	Finite element formulation and application of beam elements		
	Lecture 6: Chapter 5 - Learn about the displacement field and shape functions used in the formulation of a beam element. - Derive the stiffness matrix as well as load vector due to various load conditions acting on a beam element. - Develop numerical models for beam and plane frame problems using SAP2000.	• Lecture will be delivered in person • Recorded lectures will be posted to course OWL site for accessibility considerations. • Reading material (Course notes – Chapter 5) will be posted to OWL as well. • Live help session (office hour)	Week 6
5	Introduction to theory of elasticity		
	Lecture 7: Chapter 6 - This section will enable the student to understand the basic equilibrium and kinematic equations, the constitutive relations as well as the potential energy expression for 2-D plane stress and plane strain elasticity problems.	• Lecture will be delivered in person • Recorded lectures will be posted to course OWL site for accessibility considerations. • Reading material (Course notes – Chapter 6) will be posted to OWL as well. • Live help session (office hour)	Week 7

Topic #	Description	Learning Activities	Tentative timeline
6	Introduction to various types of 2-D elements		
	Lecture 8: Chapter 7 - Recognize various types of elements used to solve 2-D plane problems. - Develop numerical models to solve plane stress and plan strain problems using SAP2000 and ANSYS.	• Lecture will be delivered in person • Recorded lectures will be posted to course OWL site for accessibility considerations. • Reading material (Course notes – Chapter 7) will be posted to OWL as well. • Live help session (office hour)	Week 8
7	Practical consideration in modelling and introduction to 3-D modelling using SAP2000		
	Lecture 9: Chapter 8 - In this section, general guidelines for finite element modelling are presented Lecture 10: Chapter 9 - Use the commercial program Sap2000 to develop a three-dimensional computer model to idealize a cable-stayed bridge for the evaluation of internal forces.	• Lecture will be delivered in person • Recorded lectures will be posted to course OWL site for accessibility considerations. • Reading material (Course notes – Chapter 8 and 9) will be posted to OWL as well. • Live help session (office hour)	Weeks 9-10
8	Introduction to 3-D modelling using ETABS		
	Lecture 11: Chapter 10 - Use the program ETABS to develop three-dimensional computer models to idealize high-rise buildings under different types of loading. Lecture 12: Chapter 10 (cont.)	• Lecture will be delivered in person • Recorded lectures will be posted to course OWL site for accessibility considerations. • Reading material (Course notes – Chapter 10) will be posted to OWL as well. • Live help session (office hour)	Weeks 11-12

Specific Learning Outcomes

Degree Level Expectation	Weight	Assessment Tools	Outcomes
Depth and breadth of knowledge	30%	• Assignments • Projects I & II • Final Examination	• Understanding of advanced concepts and theories • Awareness of important current problems in the field of study • Understanding of computational and/or empirical methodologies to solve related problems
Research & scholarship	10%	• Project II	• Ability to conduct critical evaluation of current advancements in the field of specialization • Ability to conduct coherent and thorough analyses of complex problems using established techniques/principles and judgment
Application of knowledge	30%	• Assignments • Projects I & II • Final Examination	• Ability to apply knowledge in a rational way to analyze a particular problem • Ability to use coherent approach to design a particular engineering system using existing design tools
Professional capacity / autonomy	10%	• Project II	• Awareness of academic integrity • Ability to implement established procedures and practices in the coursework • Defends own ideas and conclusions • Integrates reflection into his/her learning process
Communication skills	10%	• Project II	• Ability to communicate (oral and/or written) ideas, issues, results and conclusions clearly and effectively
Awareness of limits of knowledge	10%	• Project II	• Awareness of the need of assumptions in complex scientific analyses and their consequences • Understanding of the difference between theoretical and empirical approaches • Ability to acknowledge analytical limitation due to complexity of practical problems

Contact information:

Course instructors:

Sec. 001: Thursday, 4:30 pm-7:30 pm, Dr. Khaled El Sawy, SEB-1200, email: kelsawy2@uwo.ca

Sec. 002: Friday, 9:30 am-12:30 pm, Mohamed AbuGazia, AHB-2B04, email: mabugazi@uwo.ca

Contact policy:

- Contact instructors via email (above) or through messages in OWL
- Weekly Office hours are held via Zoom
- A general FAQ section on the 'forums' section of OWL will be used for students to post course-related questions so that all have the same information.

Contact Hours:

3 hours lecture per week – Sec. 001: Thursday, 4:30 pm-7:30 pm, Sec. 002: Friday, 9:30 am-12:30 pm, (personal study – 9 hours per week).

Course Materials:

Prepared class notes will be made available through the course website on OWL at http://owl.uwo.ca/, alongwith other useful reference material and data for assignments.

Special circumstances:

In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, all remaining course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any remaining assessments will also be conducted online at the discretion of the course instructor"

Other References:

1) *A First Course in the Finite Element Method, D.L. Logan, 2nd Ed., PWS Kent Publ. Co., Boston, 1992.*
2) *Introduction to Finite elements in Engineering, T.R. Chandruptla and A.D. Beleguner, 2nd Ed., Prentice Hall., NJ, 1992.*

Computing:

Several assignments will involve computer modelling of structures using the commercial programs SAP2000 V19 and ETABS V16. The full version of the programs is available at the PC lab in the Engineering building. Remote access to the computer lab and the software license serves will be provided. Instructions on how to remotely access the software license will be posted on course OWL site. In addition, few assignments will involve numerical simulations using the commercial software ANSYS Workbench V19.2. A free student license can be downloaded through this link:
https://www.ansys.com/academic/free-student-products

Units:

SI units will be used in lectures and examinations

Assessments:

Assessment Type	Material Covered	Tentative Due Date*	Weight
Homework Assignments (five)	Topics 1, 2, 3, 4, 5, 6	Check course calendar	25%
Participation	In person and posted questions in course OWLsite "Forums"	Weekly activity	5%
Project I	Topic 7	Nov. 26th, 2021	15%
Project II	Topic 8	Dec. 13th, 2021	25%
Final Exam	Topics 1 - 8	Dec. 10th, 2021	30%
Oral Exam	Projects I & II	Dec. 16th & 17th	50% of project weight

* The shown dates are an approximate guide for students and are subject to change.

Activities in which collaboration is permitted:

- *Participation using course OWL site "Forums"*: Students are strongly encouraged to post questions/respond to posted questions on a weekly basis. Group discussion using "Forums" regarding course material and topics covered in lectures is permitted.
- *Project II*: Students will be divided into groups (2 members per group). Collaboration between ***only*** group members is permitted. One final project report is required from each group.

Activities in which students must work alone (collaboration is not permitted):

- Homework Assignments
- Project I
- Final Exam

Use of English:

In accordance with Senate and Faculty Policy, students may be penalised up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Course content

The lecture notes and online lecture videos are copyrighted to the instructor and legally protected. Do not post these videos and lecture notes on any other website or online forums. The recording of the live/synchronous sessions of the course without the permission from the instructor is prohibited. The illegal posting and sharing of the copyrighted course content could be subjected to legal actions.

Cheating, Plagiarism/Academic Offences

Academic integrity is an essential component of learning activities. Students must have a clear understanding of the course activities in which they are expected to work alone (and what working alone implies) and the activities in which they can collaborate or seek help; see information above under "Assessments" and ask instructor for clarification if needed. Any unauthorized forms of help-seeking or collaboration will be considered an academic offense. University policy states that cheating is an academic offence. If you are caught cheating, there will be no second warning. Students must write their essays and assignments in their own words. Whenever students take an idea or a passage of text from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. Academic offences are taken seriously and attended by academic penalties which may include expulsion from the program. Students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence (see Western's scholastic discipline regulations for graduate students).

Synchronous Learning Activities

In some cases, students are expected to participate in synchronous learning activities as outlined in the course syllabus and/or described by the instructor. If you have issues that will impede your ability to participate in synchronous activities, please discuss with the course instructor at the beginning of thecourse.

Conduct

Students are expected to follow proper etiquette during in-person, synchronous and asynchronous activities tomaintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in the synchronous and asynchronous learning activities and/or is not following the rules and responsibilities associated with the online learning activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). Onthe recommendation of the Department concerned, and with the permission of the Associate Dean (Graduate), the student could be debarred from completing the assessment activities in the course asappropriate.

Health/Wellness

As part of a successful graduate student experience at Western, we encourage students to make their health and wellness a priority. Western provides several health and wellness related services (remotely accessible) to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. Information regarding health- and wellness-related services available to students may be found at http://www.health.uwo.ca/.

Students seeking help regarding mental health concerns are advised to speak to someone they feel comfortable confiding in, such as their faculty supervisor, their program director (graduate chair), or other relevant administrators in their unit. Campus mental health resources may be found at
http://www.health.uwo.ca/mental_health/resources.html
https://www.uwo.ca/health/psych/index.html

Sickness

Students should immediately consult with the Instructor (for a particular course) or Associate Chair (Graduate) (for a range of courses) if they have problems that could affect their performance. The student should seek advice from the Instructor or Associate Chair (Graduate) regarding how best to deal with the problem. Failure to notify the Instructor or the Associate Chair (Graduate) immediately (or as soon as possible thereafter) will have a negative effect on any appeal. Obtaining appropriate documentation (e.g., a note from the doctor) is valuable when asking for accommodation due to illness.

Accessibility

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Accessible Education at 661-2111 x 82147 or http://academicsupport.uwo.ca/accessible_education/index.html, for any specific question regarding an accommodation.