DESCRIPTION
This course introduces the basis of the finite element method and its application in solving engineering problems, mainly structural applications. The course is designed to achieve the following objectives:

- Apply mathematical knowledge to understand the basic theory of the 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.
- Understand preprocessing steps, solver (solution step), postprocessing steps, and model validation.
- Learn how to model different structural systems using commercial programs like SAP2000, ETABS, and ANSYS.

ENROLLMENT RESTRICTIONS
Enrollment in this course is restricted to graduate students with bachelor’s degree in Civil Engineering, as well as any student who has obtained permission to enroll in this course from the course instructor as well as the Graduate Chair (or equivalent) from the student's home program.

PREREQUISITE
Bachelor’s degree in Civil Engineering.

INSTRUCTOR CONTACT INFORMATION
- Course instructor: Dr. Ayman El Ansary, P.Eng.
- Email address: ayman.elansary@uwo.ca
- Office: Spencer Engineering Building (SEB 3080)
- Lecture hours: 3 hours lecture per week
- Office hours: Weekly office hours will be held either in person or via Zoom
- Administrative Support: SEB 3118

COURSE FORMAT
This course will be delivered in-person.
<table>
<thead>
<tr>
<th>Topic #</th>
<th>Description</th>
<th>Learning Activities</th>
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</table>
| 1       | Introduction to the finite element method (FEM) | • Lecture 1: Three (3) hours in-person class  
• Lecture 2: Three (3) hours in-person class  
• Reading material (Course notes – Chapter 1) will be posted on the course site OWL.  
• Help session (office hour) |
|         | 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 3: Chapter 2  
- Principle of minimum potential energy and approximate analysis. | • Lecture 3: Three (3) hours in-person class  
• Reading material (Course notes – Chapter 2) will be posted on the course site OWL.  
• Help session (office hour) |
| 2       | Finite element formulation and application of bar elements (uni-dimensional element) | |
|         | Lecture 4: Chapter 3  
- Displacement field and shape functions used in the formulation of a bar element.  
- Derive the stiffness matrix as well as the load vector due to various load conditions acting on a bar element.  
- Develop numerical models for uni-dimensional problems using SAP2000. | • Lecture 4: Three (3) hours in-person class  
• Reading material (Course notes – Chapter 3) will be posted on the course site OWL.  
• Help session (office hour) |
| 3       | Finite element formulation and application of plane trusses | • Lecture 5: Three (3) hours in-person class  
• Reading material (Course notes – Chapter 4) will be posted on the course site OWL.  
• Help session (office hour) |
|         | Lecture 5: Chapter 4  
- Concept of transformation of vectors in two different coordinate systems in the plane  
- Learn about the transformation matrix and the relationship between local and global systems.  
- Derive the stiffness matrix for a bar arbitrarily oriented in the plane.  
- Develop numerical models for plane truss problems using SAP2000. | |
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| 4      | Finite element formulation and application of beam elements | - Lecture 6: Three (3) hours in-person class  
- Reading material (Course notes – Chapter 5) will be posted on the course site OWL.  
- Help session (office hour) |
| 5      | Introduction to the Theory of Elasticity | - Lecture 7: Three (3) hours in-person class  
- Reading material (Course notes – Chapter 6) will be posted on the course site OWL.  
- Help session (office hour) |
| 6      | Introduction to various types of 2-D elements | - Lecture 8: Three (3) hours in-person class  
- Reading material (Chapter 7) will be posted on the course site OWL.  
- Help session (office hour) |
| 7      | Practical consideration in modelling and introduction to 3-D modelling using SAP2000 | - Lecture 9: Three (3) hours in-person class  
- Reading material (Chapter 8) will be posted on the course site OWL.  
- Lecture 10: Three (3) hours in-person class  
- Reading material (Chapter 9) will be posted on the course site OWL.  
- Help session (office hour) |
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| 8       | Introduction to 3-D modeling using ETABS | Lecture 11: Three (3) hours in-person class  
Reading material (Course notes – Chapter 10) will be posted on the course site OWL.  
Lecture 12: Three (3) hours in-person class  
Help session (office hour)  
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.) |

**SPECIFIC LEARNING OUTCOMES**

<table>
<thead>
<tr>
<th>Degree Level Expectation</th>
<th>Weight</th>
<th>Assessment Tools</th>
<th>Outcomes</th>
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| Depth and breadth of knowledge    | 30%    | • Assignments    | • 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%    | • Final Project  | • Ability to conduct a 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    | • Ability to apply knowledge in a rational way to analyze a particular problem  
• Ability to use a coherent approach to design a particular engineering system using existing design tools |
| Professional capacity / autonomy  | 10%    | • Final Project  | • 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%    | • Final Project  | • Ability to communicate (oral and/or written) ideas, issues, results, and conclusions clearly and effectively |
| Awareness of limits of knowledge  | 10%    | • Final Project  | • Awareness of the need for assumptions in complex scientific analyses and their consequences  
• Understanding of the difference between theoretical and empirical approaches  
• Ability to acknowledge analytical limitations due to the complexity of practical problems |
COURSE MATERIAL
Prepared class notes will be made available through the course website on OWL at http://owl.uwo.ca/, along with other useful reference material and data for assignments.

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

REFERENCES


COMPUTING
Several assignments will involve computer modelling of structures using the commercial programs SAP2000V19 and ETABS V19. The full version of these programs is available at the PC lab in the Engineering building. Remote access to the computer lab and the software license server will be provided. Instructions on how to remotely access the software license will be posted on the course OWL site. In addition, a few assignments will involve numerical simulations using the commercial software ANSYS Workbench 2024 R2. A free student license can be downloaded through this link: [Download Ansys Student | Workbench-based Simulation Tools](#)

Terms of use: Free student downloads are for educational use only and may only be used for self-learning, student instruction, student projects, and student demonstrations.

UNITS
SI units will be used in lectures and examinations.

ASSESSMENT

<table>
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<tr>
<th>Assessment Type</th>
<th>Material Covered</th>
<th>Tentative Due Date*</th>
<th>Weight</th>
</tr>
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<tbody>
<tr>
<td>Homework Assignments (six)</td>
<td>Topics 1, 2, 3, 4, 5, 6, 7</td>
<td>Check course calendar</td>
<td>30%</td>
</tr>
<tr>
<td>Participation</td>
<td>In-person and posted questions in course OWL site “Forums”</td>
<td>Weekly Activity</td>
<td>5%</td>
</tr>
<tr>
<td>Final Project</td>
<td>Topic 8</td>
<td>Dec. 16th, 2024</td>
<td>30%</td>
</tr>
<tr>
<td>Final Exam (Open Book)</td>
<td>Topics 1 - 8</td>
<td>Dec. 6th, 2024</td>
<td>35%</td>
</tr>
<tr>
<td>Oral Exam</td>
<td>Final Project</td>
<td>Dec. 18th &amp; 19th</td>
<td>50% of the project’s weight</td>
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* 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”: Weekly forums will be posted on the course OWL site. Each week students are expected to interact with the course content, and each other by posting questions/responding to existing questions on OWL “Forums”. The minimum expectation regarding this participation activity is at least one posting per week. Group discussion using “Forums” regarding course material, and topics covered in lectures is permitted.
• Final Project: Students will be divided into groups (2 members per group). Collaboration between only group members is permitted. Only one final project report is required from each group.

Activities in which students must work alone (collaboration is not permitted):
• Homework Assignments
• Final Project
• Final Exam

USE OF ENGLISH
In accordance with Senate and Faculty Policy, students may be penalized 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.

STATEMENT ON THE USE OF GENERATIVE ARTIFICIAL INTELLIGENCE
The considerations for using generative Artificial Intelligence (AI) in graduate work should be acknowledged in the submission and should align with the guidance on generative AI use for Western University. Please refer to the published Provisional Guidance for the Use of Generative AI in Graduate Studies at Western University.

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 the information above and ask the 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 at the following website: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

CONDUCT
Students are expected to follow proper etiquette to maintain an appropriate and respectful academic environment. Any student who, in the opinion of the instructor, is not appropriately participating in course activities and/or is not following the rules and responsibilities associated with the course
activities, will be reported to the Associate Dean (Graduate) (after due warning has been given). On
the 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 as
appropriate.

HEALTH/WELLNESS SERVICES
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 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. Faculty of Engineering has a Student Wellness
Counsellor. To schedule an appointment with the counselor, contact Kristen Edwards
(khunt29@uwo.ca) via confidential email and you will be contacted by our intake office within 48
hours to schedule an appointment.
Students who are in emotional/mental distress should refer to Mental Health@Western:
http://www.uwo.ca/uwocom/mentalhealth/ for a complete list of options about how to obtain help.

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.
Students who are not able to meet certain academic responsibilities due to medical, compassionate,
or other legitimate reason(s), could request for academic consideration. The Graduate Academic
Accommodation Policy and Procedure details are available at:
https://www.eng.uwo.ca/graduate/current-students/academic-support-and-accommodations/index.html

ACCESSIBLE EDUCATION WESTERN (AEW)
Western is committed to achieving barrier-free accessibility for all its members, including graduate
students. As part of this commitment, Western provides a variety of services devoted to promoting,
advocating, and accommodating persons with disabilities in their respective graduate program.
Graduate students with disabilities (for example, chronic illnesses, mental health conditions,
mobility impairments) are strongly encouraged to register with Accessible Education Western
(AEW): http://academicsupport.uwo.ca/accessible_education/index.html

AEW is a confidential service designed to support graduate and undergraduate students through their
academic program. With the appropriate documentation, the student will work with both AEW and
their graduate programs (normally their Graduate Chair and/or Course instructor) to ensure that
appropriate academic accommodations to program requirements are arranged. These
accommodations include individual counseling, alternative formatted literature, accessible campus
transportation, learning strategy instruction, writing exams, and assistive technology instruction.