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

CEE 3343b – FINITE ELEMENT METHODS & APPL. - Course Outline 2015/16

This course introduces the basis of the finite element method and its application in solving engineering problems. It also covers different approximate methods for structural analysis, especially frame and shear walls structures under the effect of lateral loads. The objectives are for the student to be able to:

- Apply knowledge of mathematics to understand the basic concepts of the finite element method;
- Model, analyse, and solve engineering problems using the finite element method;
- Use finite element digital computer programs;
- Improve communication skills by documenting modelling assumptions and results of the analysis in coherent and legible analyses calculations;
- Recognize the need for life-long learning to keep abreast of new numerical analysis methods, and to enhance one's abilities as an analyst.
- Understand and quantify the behaviour of buildings with lateral resisting system consisting of both shear wall and frame elements.
- Develop computer models to analyse buildings with various types of lateral resisting systems.
- Idealize bridges using three dimensional computer modelling.

Calendar Copy:

This course starts by introducing the finite element method including equilibrium through the principle of minimum potential energy, assembly of stiffness matrices and the imposition of boundary conditions, and applications of the Raleigh-Ritz method. This is followed by topics covering approximate analysis methods for; frames, shear walls, and coupled frame-shear wall buildings under lateral loads. Also computer simulation and modelling of buildings and bridges are covered in this course. (0.5 Course)

Contact Hours:

3 lecture hours per week; 3 tutorial/laboratory hours per week; (recommended additional personal study 4 hours). Attendance at the tutorial session is mandatory. Some of the tutorials will be held in the PC computer lab.
Attendance at the tutorial/laboratory session is **mandatory**

Prequisites: CEE2221b, CEE 3340A/B

Corequisites: None

Antirequisite: None

Note: It is the **student's responsibility** to ensure that all Prerequisite and Corequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also the **student's responsibility** to ensure that they have not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards their degree if they violate the Prerequisite, Corequisite or Antirequisite conditions.

Instructor:

Dr. Ayman El Ansary, P. Eng., SEB 3090, email: aelansa@uwo.ca. *Administrative Support:* Room 3005

Textbook:

Prepared class notes should be brought to each class, and may be downloaded from the course website (http://owl.uwo.ca).

Other References:

A First Course in the Finite Element Method, D.L. Logan, 2nd Ed., PWS Kent Publ. Co., Boston, 1992.
Introduction to Finite elements in Engineering, T.R. Chandruptla and a.D. Beleguner, 2nd Ed., Prentice Hall., NJ, 1992.
Stafford Smith, B. and Coull A. (1991) Tall building structures: analysis and design, New York; Toronto: Wiley Inter Science.
The above references will be put on reserve for a maximum of 2 hours borrowing in the Taylor Library.

Computing:

Most of the assignments will involve computer modeling of structures using the commercial program SAP2000. The full-version of the program is available at the PC lab in the Engineering building. Copies of the educational version, having a limited number of nodes, will be available for 1 day borrowing in Taylor's library. The students are encouraged to install the educational version on their own computers.

Units:

SI units will be used in lectures and examinations

Specific Learning Objectives:

Part I

1. Introduction to the Finite Element Method. At the end of this section, the student should be able to:
   a) Know the history of development and the engineering applications of the Finite Element Method;
   b) Identify the Basic Equations and various Boundary conditions applied in beam and uni-axial problems.

2. Potential Energy and Approximate Analysis. At the end of this section, the student should be able to:
   a) Develop the expressions for strain energy, work done and potential energy for beam and bar problems
   b) Understand and apply the concept of minimum potential energy.
   c) Understand the Rayleigh-Ritz Method as an Introduction to the Finite Element Method.

3. Finite Element Formulation and Application of Bar Elements. At the end of this section, the student should be able to:
   a) Recognize the displacement field and shape functions used in the formulation of a bar finite element.
   b) Derive the stiffness matrix as well as load vector due to various load conditions acting on a bar element.
   c) Perform a finite element analysis for a complete bar problem in order to evaluate displacements and stresses along the length of the bar.
   d) Judge on the accuracy of a specific bar element mesh used to solve a certain bar problem.

4. Introduction to Theory of Elasticity. At the end of this section, the student should be able to:
   a) 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.

5. Shape Functions for 2-D Problems. After completion of this section, the student should be able to:
   a) Recognize various types of elements used to solve 2-D plane problems.
   b) Recognize the natural coordinate systems, the shape functions used in various 2-D plane elements.
   c) Evaluate the Jacobian expression for various 2-D plane elements.

6. Finite Element Formulation and Application by Constant Stress Triangular (CST) Element. After completion of this section, the student should be able to:
   a) Derive the stiffness matrix as well as the load vector due to various load conditions acting on a CST element.
   b) Know how to handle the effect of inclined boundaries.
   c) Perform finite element analysis of 2-D problems using CST elements.

7. Practical Consideration in Modeling. After completion of this section, the student should be able to:
   a) Recognize some basic considerations when laying out a finite element mesh including element size and grading.
   b) Know how to number a finite element mesh in order to optimize the computer storage and the running time.

Part II

1. Lateral Systems for Tall Building Structures. At the end of this section, the student should be able to:
   a. Recognize different types of structural system used to provide the lateral resistance of tall building structures.
   b. Identify the suitable system for various ranges of building heights.

2. Approximate analysis for frame under lateral loads. At the end of this section, the student should be able to:
   a. Evaluate the properties of an equivalent shear and bending beam models that can be used to estimate the deflection of the frame.
   b. Develop computer model for the lateral analysis of frame structures.

3. Response of shear wall structures. At the end of this section, the student should able to:
   a. Idealise the structural response including torsion effect of unsymmetrical structures
   b. Apply equation of equilibrium to calculate the bending moment and shear forces for walls

4. Behaviour of coupled shear wall elements. At the end of this section, the student should able to:
   a. Understand the behaviour of shear walls connected by rigid lintel beams.
   b. Analyse coupled shear walls using the continuum approximate approach
   c. Develop computer model for the lateral analysis of coupled shear wall systems

5. Behaviour of coupled frame-shear wall systems. At the end of this section, the student should be able to:
    a. Understand the interaction behaviour between frame and shear wall subjected to lateral load
    b. Describe the benefit of combining frame and shear wall for tall buildings.
    c. Analyze coupled frame-shear wall structures using the continuum approximate approach.
    d. Develop computer model for the lateral analysis of coupled frame- shear wall systems

6. Computer modelling of bridges. At the end of this section, the student should able to:
    a. Idealize different types of bridges for evaluation of internal forces using both two and three dimensional computer models.

Instructor may expand on material presented in the course as appropriate.

General Learning Objectives

E=Evaluate, T=Teach, I=Introduce (*Advanced Level*)

Knowledge Base	E	Engineering Tools	E	Impact on Society	-
Problem Analysis	E	Team Work	T	Ethics and Equity	-
Investigation	-	Communication	-	Economics and Project Management	-
Design	-	Professionalism	I	Life-Long Learning	-

Evaluation:

The final course mark will be determined as follows:

Final examination:	50%
Assignments	30%
Quizzes:	20%

Total	100%

Note: **(a) Students must pass the final examination to pass this course**. Students who fail the final examination will be assigned the aggregate mark, as determined above, or 48%, whichever is less.

(b) Students who have failed this course previously must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted.

(c) Should any of the quizzes conflicts with a religious holiday that a student wishes to observe, the student must inform the instructor of the conflict no later than two weeks before the scheduled test.
(For further information on Accommodations for Religious Holidays see http://www.uwo.ca/univsec/handbook/appeals/accommodation_religious.pdf)

1. Quizzes and Examinations:

Two 60 minutes quizzes will be scheduled during tutorial periods, on Thursdays February 11th and March 24th. The quizzes and the final examination are OPEN BOOK.

2. Weekly Assignments

Assignments: Solution to Part A of each assignment must be turned in by each student by the end of tutorial period. Each student must turn the solution to Part B of the assignment at 9:30 am Monday morning in locker # 65 – Spencer Engineering Building. Late assignment will be accepted till 1:00 pm on Tuesday of the week of submission and have to be submitted directly to the instructor. Late assignments will be marked out of 70% of the total mark. Extensions are to be negotiated with the course instructor, not the teaching assistants.

3. 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.

Plagiarism Checking:

The University of Western Ontario uses software for plagiarism checking. Students are required to submit their Laboratory Reports in electronic form to Turnitin.com for plagiarism checking.

Cheating:

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties that might include expulsion from the program. If you are caught cheating, there will be no second warning.

For more information on scholastic offenses, please see:
http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf

Attendance:

Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

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 Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

Conduct:

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others. Late comers may be asked to wait outside the classroom until being invited in by the Instructor. Please turn off your cell phone before coming to a class, tutorial, quiz or exam.

On the premises of the University or at a University-sponsored program, students must abide by the Student Code of Conduct: http://www.uwo.ca/univsec/board/code.pdf

Sickness and Other Problems:

Students should immediately consult with the Instructor or Department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see attached). The student should seek advice from the Instructor or Department Chair regarding how best to deal with the problem. Failure to notify the Instructor or Department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.
For more information concerning medical accommodations, please see:
http://www.uwo.ca/univsec/handbook/appeals/accommodation_medical.pdf

Notice:

Students are responsible for regularly checking their email, course website (https://owl.uwo.ca) and notices posted outside the Civil and Environmental Engineering Department Office

Consultation:

Students are encouraged to discuss problems with their teaching assistant and/or instructor in tutorial sessions. Office hours will be arranged for the students to see the instructor and teaching assistants. Other individual consultation can be arranged by appointment with the appropriate instructor.

Course breakdown:
Engineering Science = 100%

The document "INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMINT ASSIGNMENTS AS SCHEDULED" is part of this course outline.

INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED

IF, ON MEDICAL OR COMPASSIONATE GROUNDS, YOU ARE UNABLE TO WRITE TERM TESTS OR FINAL EXAMINATIONS OR COMPLETE COURSE WORK BY THE DUE DATE, YOU SHOULD FOLLOW THE INSTRUCTIONS LISTED BELOW. YOU SHOULD UNDERSTAND THAT ACADEMIC ACCOMMODATION WILL NOT BE GRANTED AUTOMATICALLY ON REQUEST. YOU MUST DEMONSTRATE TO YOUR DEPARTMENT (OR THE UNDERGRADUATE SERVICES OFFICE) THAT THERE ARE COMPELLING MEDICAL OR COMPASSIONATE GROUNDS THAT CAN BE DOCUMENTED BEFORE ACADEMIC ACCOMMODATION WILL BE CONSIDERED. DIFFERENT REGULATIONS APPLY TO TERM TESTS, FINAL EXAMINATIONS AND LATE ASSIGNMENTS. READ THE INSTRUCTIONS CAREFULLY. (SEE THE 2015 UWO ACADEMIC CALENDAR).

A. *GENERAL REGULATIONS & PROCEDURES*

1. All first year students will report to the Undergraduate Services Office, SEB 2097, for all instances.

2. If you are an upper year student and you are missing a test/assignment/lab or exam that is worth MORE THAN 10% of your final grade, you will report to the Undergraduate Services Office, SEB 2097. Otherwise, you will report to your department office to request accommodation.

3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.

4. Documentation must be provided as soon as possible. If no one is available in your Department office or the Undergraduate Services Office, leave a message clearly stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.

5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

B. *TERM TESTS*

1. If you are in first year and you are unable to write a term test, contact the Undergraduate Services Office, SEB 2097 PRIOR to the scheduled date of the test.

2. If you are an upper year student and you are unable to write a term test, inform your instructor PRIOR to the scheduled date of the test. If the instructor is not available, leave a message for him/her at the department office. If the test is worth MORE THAN 10% of your final grade you will report to the Undergraduate Services Office, SEB 2097 to request accommodation. Otherwise, you will report to your department office to request accommodation.

3. Be prepared to provide supporting documentation to the Department Chair and/or the Undergraduate Services Office (see next page for information on documentation).

4. Discuss with the instructor if and when the test can be rescheduled. **N.B.** The approval of the Chair or the Undergraduate Services Office is required when rescheduling term tests.

C. *FINAL EXAMINATIONS*

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number.

2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, sleeping in, misreading timetable and travel arrangements.

3. In order to receive permission to write a special examination, you must obtain the approval of the Chair of the Department **and** the Associate Dean and in order to apply you must sign a "Recommendation for a Special Examination Form" available in the Undergraduate Services Office. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

N.B. **It is the student's responsibility to check the date, time and location of the special examination.**

D. *LATE ASSIGNMENTS*

1. Advise the instructor if you are having problems completing the assignment on time (**prior** to the due date of the assignment).
2. Be prepared to provide documentation if requested by the instructor (see reverse side for information on documentation).
3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Associate Dean if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4. i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean. Documentation is mandatory.
   ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean.

E. ***SHORT ABSENCES***

If you miss a class due to a minor illness or other problems, check your course outlines for information regarding attendance requirements and make sure you are not missing a test or assignment. Cover any readings and arrange to borrow notes from a classmate.

F. ***EXTENDED ABSENCES***

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You may want to seek advice from the academic counsellor in your Department or Ms. Karen Murray in the Undergraduate Services Office, if you are in first year.

G. ***DOCUMENTATION***

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, **you must provide the doctor with a Student Medical Certificate** to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). **This note must contain the following information: severity of illness, effect on academic studies and duration of absence. Regular doctors notes will not be accepted; only the Student Medical Certificate will be accepted.**

In Case of Serious Illness of a Family Member: Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

In Case of a Death: Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

For Other Extenuating Circumstances: If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

Note: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).

H. ***ACADEMIC CONCERNS***

1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).

2. **You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.**

3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your academic counsellor.

Calendar References: Check these regulations in your 2015 Western Academic Calendar available at www.westerncalendar.uwo.ca.

Absences Due to Illness: http://www.westerncalendar.uwo.ca/2015/pg117.html
Academic Accommodations for Students with Disabilities: http://www.westerncalendar.uwo.ca/2015/pg118.html
Academic Accommodations for Religious or Holy Days: http://www.westerncalendar.uwo.ca/2015/pg118.html
Course Withdrawals: http://www.westerncalendar.uwo.ca/2015/pg157.html
Examinations: http://www.westerncalendar.uwo.ca/2015/pg129.html
Scheduling of Term Assignments: http://www.westerncalendar.uwo.ca/2015/pg97.html
Scholastic Offences: http://www.westerncalendar.uwo.ca/2015/pg113.html
Student Medical Certificate: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf
Engineering Academic Regulations: http://www.westerncalendar.uwo.ca/2015/pg1442.html

Note: These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

***Drop Deadlines*:**		
	First term half course (i.e. "A" or "F"):	November 5, 2015
	Full courses and full-year half courses (i.e. "E","Y" or no suffix):	November 30, 2015
	Second term half or second term full course (i.e. "B" or "G"):	March 7, 2016

Contact Information:

Undergraduate Services Office:	SEB 2097	Telephone: (519) 661-2130	Fax: (519) 661-3757
Dept. of Chemical and Biochemical Engineering & Green Process Engineering:	TEB 477	Telephone: (519) 661-2131	Fax: (519) 661-3498
Dept. of Civil and Environmental Engineering:	SEB 3005	Telephone: (519) 661-2139	Fax: (519) 661-3779
Dept. of Electrical and Computer Engineering, Software Engineering & Mechatronics Engineering:	TEB 279	Telephone: (519) 661-3758	Fax: (519) 850-2436
Dept. of Mechanical and Materials Engineering:	SEB 3002	Telephone: (519) 661-4422	Fax: (519) 661-3020