

**WESTERN UNIVERSITY - FACULTY OF ENGINEERING**  
**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING**

**CEE3384b – Finite element methods in engineering**  
**Course outline - winter of 2014**

This course introduces the basis of the finite element method and its application in solving engineering problems. 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 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.

**Prerequisites:**

CEE2221b

**Corequisites:**

None.

**Antirequisites:**

None.

**Contact hours:**

2 lecture hrs/wk; 2 laboratory/tutorial hrs/wk

**Instructor:**

Dr. Girma T. Bitsuamlak, BLWTL Room 105, Ext. 88028; email: gbitsuam@uwo.ca  
Admin. Asst.: Room 3005, Ext. 82139.

**Textbook:**

Prepared class notes (Version 1.4) should be purchased from the UWO Book Store, UCC and brought to all lectures and tutorial/lab sessions.

**References:**

*A first course in the finite element method*, D.L. Logan, 2<sup>nd</sup> Ed., PWS Kent Publ. Co., Boston, 1992.  
*Introduction to finite elements in engineering*, T.R. Chandrupatla and A.D. Belegundu, 2<sup>nd</sup> Ed., Prentice Hall, NJ, 1997.

**Laboratory:**

A number of tutorials will be held at the engineering PC lab.

**Computing:**

A number of assignments will involve computer modelling of structures using the commercial program SAP2000. The full-version of the program is available at the PC labs in the engineering building. Copies of the educational version 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.

**General Learning Objectives**

Knowledge base	T	Individual work	E	Ethics and equity	-
Problem analysis	T	Team work	-	Economics and project management	-
Investigation	-	Communication	-	Life-long learning	-
Design	I	Professionalism	I		
Engineering tools	T	Impact on society	-		

**Specific Learning Objectives:**

1. Introduction to the finite element method: This section will enable the student to:
  - a) Know the history of development and the engineering applications of the finite element method;
  - b) Know the basic equations and various boundary conditions applied in beam and uni-axial problems.
2. Potential energy and approximate analysis. This section will enable the student 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. This section will enable the student 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. 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.
5. Shape functions for 2-D problems. This section will enable the student 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. This section will enable the student 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 modelling. This section will enable the student 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.

8. Isoparametric 2-D elements. This section will enable the student to:
  - a) Understand the concepts and advantages of isoparametric elements.
  - b) Understand a general formulation for stiffness matrix and load vector that can be applied to any isoparametric 2-D element.
  
9. Finite element formulation of the four node isoparametric element. This section will enable the student to:
  - a) Derive the stiffness matrix as well as the load vector due to various load conditions acting on a four node isoparametric 2-D element.
  - b) Understand the “Gauss Quadrature” method as a numerical integration scheme used in the finite element method.
  - c) Apply the Gauss Quadrature method in evaluating the stiffness matrix and the load vector for a four node isoparametric element.
  
10. Steady state field problems. This section will enable the student to:
  - a) Recognize that different problems in various engineering fields can be solved using the same type of finite elements.
  - b) Layout the formulation which can be used to solve a general 1-D and 2-D field problem.
  - c) Solve 1-D heat transfer and 2-D potential fluid problems using the finite element method.

**Evaluation:**

The final course mark will be determined as follows:

Final examination	60%
Assignments	20%
Quizzes	<u>20%</u>
Total	100%

**\*Students must pass the final examination to pass this course.** (Students who fail the final examination will be assigned the aggregate mark or 48%, whichever is smaller).

**Quizzes and Examination**

Two quizzes will be scheduled during the course.

The quizzes and the final examination will be OPEN BOOK.

**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 final examinations 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.

**Assignments:**

Each student must turn the solution of the assignment at 11:00 AM Wednesday morning in locker 69, second floor, Engineering Building. Late assignment will be accepted till 5:00 pm on Thursday 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.

A number of assignments might consist of two parts with the first part due for submission at the end of the tutorial. The second part is due at 11:00 AM Wednesday in Locker 69 as stated above.

**Cheating:**

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

**Attendance:**

Any students who, in the opinion of the instructor, is absent too frequently from class or laboratory periods in any course, 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 examination in the course.

**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.

**Sickness or 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.

**Notice:**

Students are responsible for regularly checking their e-mail, the course website and notices posted outside the Civil and Environmental Engineering Departmental Office.

**Consultation:**

Students are encouraged to discuss problems with the teaching assistant(s) and/or instructor in tutorial sessions. Other individual consultation can be arranged by appointment with the teaching assistant(s) or instructor.

CEAB Course Breakdown:

Engineering Science = 100%; 38.2 AU's.

Average Grade/Failure Rate: N/A/

The document "*INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED*" is attached and is part of this 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 IF YOU ARE IN FIRST YEAR) 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 2013 UWO ACADEMIC CALENDAR).

**A. GENERAL REGULATIONS & PROCEDURES**

1. CHECK THE COURSE OUTLINE TO SEE IF THE INSTRUCTOR HAS A POLICY FOR MISSED TESTS, EXAMINATIONS, LATE ASSIGNMENTS OR ATTENDANCE.
2. BRING YOUR REQUEST FOR ACADEMIC ACCOMMODATION TO THE ATTENTION OF THE CHAIR OF YOUR DEPARTMENT (OR THE UNDERGRADUATE SERVICES OFFICE IF YOU ARE IN FIRST YEAR) PRIOR TO THE SCHEDULED TIME OF THE TEST OR FINAL EXAMINATION OR DUE DATE OF THE ASSIGNMENT. IF YOU ARE UNABLE TO CONTACT THE RELEVANT PERSON, LEAVE A MESSAGE WITH THE APPROPRIATE DEPARTMENT (OR WITH THE UNDERGRADUATE SERVICES OFFICE, IF YOU ARE IN FIRST YEAR). THE ADDRESSES, TELEPHONE AND FAX NUMBERS ARE GIVEN AT THE END OF THESE INSTRUCTIONS. DOCUMENTATION MUST BE PROVIDED AS SOON AS POSSIBLE.
3. 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 unable to write a term test, inform your instructor and the Chair of your Department (or the Undergraduate Services Office if you are in first year) prior to the scheduled date of the test. If the instructor is not available, leave a message for him/her at the department office and inform the Chair of the Department (or the Undergraduate Services Office if you are in first year).
2. Be prepared to provide supporting documentation to the Chair and the Undergraduate Services Office (see next page for information on documentation).
3. Discuss with the instructor if and when the test can be rescheduled. **N.B.** The approval of the Chair (or the Undergraduate Services Office if you are in first year) 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 (please spell your full name).
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.

### **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.

### **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 the counsellors in the Undergraduate Services Office if you are in first year.

### **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 if you are in first year). **This note must contain the following information: severity of illness, effect on academic studies and duration of absence.**

**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).

### **ACADEMIC CONCERNS**

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).

**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.**

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 2013 Western Academic Calendar available at [www.westerncalendar.uwo.ca](http://www.westerncalendar.uwo.ca).

Absences Due to Illness: <http://www.westerncalendar.uwo.ca/2013/pg117.html>

Academic Accommodations for Students with Disabilities: <http://www.westerncalendar.uwo.ca/2013/pg118.html>

Academic Accommodations for Religious or Holy Days: <http://www.westerncalendar.uwo.ca/2013/pg119.html>

Course Withdrawals: <http://www.westerncalendar.uwo.ca/2013/pg157.html>

Examinations: <http://www.westerncalendar.uwo.ca/2013/pg129.html>

Scheduling of Term Assignments: <http://www.westerncalendar.uwo.ca/2013/pg97.html>

Scholastic Offences: <http://www.westerncalendar.uwo.ca/2013/pg113.html>

**Engineering Academic Regulations:** <http://www.westerncalendar.uwo.ca/2013/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, 2013
Full courses and full-year half courses (i.e. "E", "Y" or no suffix):	November 30, 2013
Second term half or second term full course (i.e. "B" or "G"):	March 7, 2014

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) 661-4412	fax: (519) 661-3020