

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

CEE 4491A – Structural Dynamics II – Course Outline Fall 2018

This course provides an introduction to the calculation of dynamic effects for multi-degree of freedom structures, including the response of such structures to random, time-varying loads due to wind and earthquakes. Code approaches to the calculation of these loads, and how these are implemented in the National Building Code of Canada (NBCC) are also reviewed. The general objectives of the course are for the student to become able to:

- calculate the mass and stiffness matrices for multi-degree of freedom structures, before determining the corresponding natural frequencies and mode shapes using eigenvalues and eigenvectors respectively;
- apply the principles of modal analysis to describe the response of multi-degree of freedom structures to both free and forced undamped and damped vibration;
- determine the response of multi-degree of freedom structures to ground motion using either recorded ground motion time histories, or response spectrum concepts;
- calculate the dynamic response of a structure to earthquake loads using an appropriate method from the NBCC; and
- calculate the dynamic response of a simple single-degree of freedom structure to wind loads using either direct methods or the NBCC approach.

Calendar Copy:

An introduction to the dynamic analysis of multi-degree of freedom structures. Topics include: calculation of mass and stiffness matrices, determination of natural frequencies and mode shapes using eigenvalues and eigenvectors, modal analysis, free and forced vibration of undamped and damped structures, dynamic response to earthquake and wind loads, and fatigue. (0.5 course)

Contact Hours:

3 lecture hours/week; 2 tutorial hours/week; (recommended additional personal study - 3 hours).

Attendance at the tutorial/laboratory session is **mandatory**

Prerequisites: CEE 3344A/B

Corequisites:

Antirequisite: the former CEE 4490

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 Craig Miller, P.Eng.; 3C+ 4480; e-mail: cmiller@eng.uwo.ca. *Administrative Support:* SEB 3005

Textbook:

Dynamics of Structures, Fourth Edition, by Anil K. Chopra, Prentice Hall, 2012.

Prepared class notes should be brought to each class, and may be downloaded from the course OWL site at <http://owl.uwo.ca/>

Computing:

Students will be required to use portable computers during lectures and tutorials. Assignments may require the use of additional software available through site licences held by the University of Western Ontario, and in particular the use of the numerical computing environment software MATLAB.

Units:

SI units will be used in lectures and examinations

Specific Learning Objectives:

1. Introduction
 - a) Understand and review the basic principles governing the response of single degree of freedom systems, including the effects of stiffness, damping, and forced vibration
2. Free Vibration of Multi-degree of Freedom Systems
 - a) Derive the mass and stiffness matrices for multi-degree of freedom (MDOF) structures
 - b) Condense the stiffness matrix for MDOF structures acting in shear and rotation to the equivalent system acting in shear only
 - c) Solve the resulting equations of motion for free vibration to calculate the corresponding natural frequencies and mode shapes using eigenvalues and eigenvectors respectively
3. Forced Vibration of Multi-degree of Freedom Systems
 - a) Calculate the generalized mass, stiffness, and force matrices for MDOF structures undergoing harmonic forced vibration
 - b) Solve for the response of MDOF structures undergoing harmonic undamped or damped forced vibration using modal analysis and the principle of superposition
4. Ground Motion and the Response of Multi-degree of Freedom Systems
 - a) Understand the effects of earthquakes, and the factors that affect ground motion that are relevant to the response of MDOF structures
 - b) Understand when to use the dynamic and quasi-static approaches presented in the NBCC
 - c) Determine the response of SDOF structures to ground motion using the NBCC quasi-static approach
 - d) Determine the response of MDOF structures to ground motion using recorded ground motion time histories and numerical methods
 - e) Determine the response of MDOF structures to ground motion using response spectrum concepts for either specific events or the NBCC design response spectrum approach

5. Dynamic Approaches to Wind Loads

- a) Describe the underlying theory behind the dynamic approach to wind loads, and importance of the resonant response in the calculation of wind loads on several classes of structure, including tall buildings and long-span bridges
- b) Calculate the dynamic response of a simple single-degree of freedom structure to wind loads using either direct methods or the NBCC approach.

The instructor may expand on material presented in the course as appropriate.

General Learning Objectives:

E = Evaluate, T = Teach, I = Introduce

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

Evaluation:

The final course mark will be determined as follows:

Assignments:	25%
Quiz:	15%
Final exam:	<u>60%</u>
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 assignments or exams conflict 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:

A 60 minute **CLOSED BOOK** quiz will be scheduled during the first hour of the lecture on Wednesday, October 31. The final examination will be **CLOSED BOOK**, approved handheld non-programmable calculators are allowed, but NO other external sources of information, including books, notes or crib sheets, are permitted. Please consult the list of acceptable calculators for closed book exams posted on the bulletin board across from the Department of Civil and Environmental Engineering Office to be sure your calculator is on it! **Part marks may not be awarded for some of the problems on the final exam.**

2. Assignments

Assignments will be due at either the start or the end of the tutorial period, as directed by the course instructor. Some assignments may also require electronic submission of supporting files through the course OWL site by the given due date and time for the assignment. Please note that assignments can only be handed in during the tutorial period, or through the course OWL site, where required, this course does not use lockers to collect assignments. Late assignments will receive a grade of zero. 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:

25% Math; 75% Engineering Science.
AUs: Total 48; Math 12; Engineering Science 36.

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 relief 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 relief will be considered. Different regulations apply to term tests, final examinations and late assignments. Please read the instructions carefully.

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 examination that is worth LESS THAN 10% of your mark, you should report to your department office to request relief. If your course work is MORE THAN 10% of your final grade, you will report to the Undergraduate Services Office, SEB 2097.
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 LESS THAN 10% of your mark, you should report to your department office to request relief. If the test is worth MORE THAN 10% of your final grade you will report to the Undergraduate Services Office, SEB 2097 to request relief.
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.

PLEASE NOTE: 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 Assistant Dean, First Year Studies, 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, Undergraduate Studies. 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, Undergraduate Studies.

E. SHORT ABSENCES

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory 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 your academic counsellor in the Undergraduate Services Office.

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 doctor's 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 2018 Western Academic Calendar available at www.westerncalendar.uwo.ca.

Absences Due to Illness:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_12

Academic Accommodations for Students with Disabilities:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_10

Academic Accommodations for Religious or Holy Days:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_16

Course Withdrawals:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page_75

Examinations:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID=#Page_75

Scheduling of Term Assignments:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading_78

Scholastic Offences:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_20

Student Medical Certificate: <https://www.eng.uwo.ca/files/undergraduate/forms/smc.pdf>

Engineering Academic Regulations:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page_86

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.

Add Deadlines:

First term half course (i.e. “A” or “F”)	September 14, 2018
Full courses and full-year half course (i.e. “E”, “Y” or no suffix)	September 14, 2018
Second term half course (i.e. “B” or “G”)	January 15, 2019

Drop Deadlines:

First term half course (i.e. “A” or “F”)	November 12, 2018
Full courses and full-year half courses (i.e. “E”, “Y” or no suffix)	November 30, 2018
Second term half or second term full course (i.e. “B” or “G”)	March 7, 2019

Contact Information:

Undergraduate Services Office:	SEB 2097	Telephone: (519) 661-2130	E-mail: engugrad@uwo.ca
Dept. of Chemical and Biochemical Engineering & Green Process Engineering:	TEB 477	Telephone: (519) 661-2131	E-mail: cbeugrad@uwo.ca
Dept. of Civil and Environmental Engineering:	SEB 3005	Telephone: (519) 661-2139	E-mail: civil@uwo.ca
Dept. of Electrical and Computer Engineering, Software Engineering & Mechatronics Engineering:	TEB 279	Telephone: (519) 661-3758	Email: eeugrad@uwo.ca
Dept. of Mechanical and Materials Engineering:	SEB 3002	Telephone: (519) 661-4122	E-mail: mmeundergraduate@uwo.ca