

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

CEE 4491A – Structural Dynamics II – Course Outline Fall 2023

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.

Land Acknowledgment:

Western University recognizes that its campus is situated on First Nations territory. The Great Lakes woodland region of Turtle Island has been home to many Nations over centuries and at different times, including the Anishinaabek, Haudenosaunee, Lunaapéewak and Huron-Wendat peoples. The three local First Nations communities in closest proximity to Western are:

- Chippewas of the Thames First Nation;
- Oneida Nation of the Thames; and
- Munsee-Delaware Nation.

For some time, the Dish with One Spoon Covenant Wampum served as an agreement between the Haudenosaunee and Anishinaabek for sharing hunting territory, thus ensuring the viability of this land into the future. After contact, Treaty making between the Anishinaabek and Britain took place. In the London area, there are several Treaties including the Treaty 6 London Township, Treaty 7 Sombra Township and Treaty 21 Longwoods. Today, London and the region are home to a diverse Indigenous population including First Nations, Métis and Inuit people. By recognizing Indigenous peoples' historic and present relationships to the land and London, Ontario, Western makes explicit Indigenous peoples' ongoing presence and their rights to self-determination. Please visit: <https://indigenous.uwo.ca/>

Calendar Copy:

Students are introduced to the analysis of multi-degree-of-freedom system under dynamic loading, including those due to wind and earthquakes. Topics include: the effects of the mass and damping; random dynamic loads; the design of dynamically sensitive structures, and fatigue. (0.5 course)

Antirequisites:

The former CEE 4490

Prerequisites:

CEE 3344A/B

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.

Contact Hours:

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

Attendance at the tutorial session is **mandatory**.

Key Sessional Dates:

Classes begin: September 7, 2023

Fall Reading Week: October 30 – November 5, 2023

Classes end: December 8, 2023

Exam period: December 10 – 22, 2023

Contingency plan for an in-person class pivoting to 100% online learning

In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, affected 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 as determined by the course instructor.

Instructor:

Dr Craig Miller, P.Eng.; SEB 2084; e-mail: cmiller@eng.uwo.ca.

Office hours: By appointment

CEE office: civil@uwo.ca

Reference Textbook:

Dynamics of Structures, Fifth Edition, by Anil K. Chopra, Prentice Hall, 2017.

Other References:

Students are responsible for checking the course OWL site (<http://owl.uwo.ca>) on a regular basis for news and updates. This is the primary method by which information will be disseminated to all students in the class.

All course material will be posted to OWL: <http://owl.uwo.ca>.

If students need assistance with the course OWL site, they can seek support on the OWL Help page. Alternatively, they can contact the Western Technology Services Helpdesk. They can be contacted by phone at 519-661-3800 or ext. 83800.

Units:

SI unit systems will be used in lectures, tutorials and examinations.

Specific Learning Objectives:

1. Introduction [KB3]
 - 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 [KB4, PA3]
 - a) Derive the mass and stiffness matrices for multi-degree of freedom (MDOF) structures
 - b) 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 [KB4, PA3]
 - 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 [KB4, PA3, ET3]
 - 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 [ET3]
 - 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 [KB4, PA3]
 - 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 or revise material presented in the course as appropriate.

General Learning Objectives:

E=Evaluate, T=Teach, I=Introduce; (I) = Introduction, (D) = Developing, (A) = Advanced level

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

Evaluation:

The final mark will be determined as follows:

Assignments:	25%
Quiz:	15%
Final assessment:	60%
Total:	<u>100%</u>

Note: 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. 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.

1. Quizzes and Examinations:

A one-hour midterm quiz will be scheduled during the first hour of the tutorial on Thursday, October 26, 2023.

A three-hour written final examination will be held during the regular December examination period.

Except for the use of a calculator, all quizzes and the final examination are closed book. Only approved programmable calculators are permitted in the final examination and quizzes. Students should consult the list of approved calculators posted outside the Civil and Environmental Engineering Department Office. Formula sheets and other required reference material will be provided as part of the mid-term quiz and final examination papers.

2. Weekly Assignments:

Individual or group assignments will be given on a weekly basis. Assignments are to be submitted prior to the due date to Gradescope accessed by OWL. Late assignments will be assessed a penalty of 10% per day, to a maximum of 4 days, after which they will receive a mark 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 penalized up to 10% of the marks on all assignments, tests, and examinations for 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.

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.

Accommodation and Accessibility:**Religious Accommodation**

When a course requirement conflicts with a religious holiday that requires an absence from the University or prohibits certain activities, students should request accommodation for their absence in writing at least two weeks prior to the holiday to the course instructor and/or the Academic Counselling office of their Faculty of Registration. Please consult University's list of recognized religious holidays (updated annually) at

<https://multiculturalcalendar.com/ecal/index.php?s=c-univwo>.

Accommodation Policies

Students with disabilities are encouraged to contact Accessible Education, which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The policy on Academic Accommodation for Students with Disabilities can be found at:

[https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic Accommodation_disabilities.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Accommodation_disabilities.pdf).

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. 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:

If you are unable to meet a course requirement due to illness or other serious circumstances, please follow the procedures below.

Assessments worth less than 10% of the overall course grade:

Extensions will be given for missed assignments on receipt of valid medical or supporting documentation to the Academic Counselling Office of your Faculty of Registration as soon as possible.

Assessments worth 10% or more of the overall course grade:

For work totalling 10% or more of the final course grade, you must provide valid medical or supporting documentation to the Academic Counselling Office of your Faculty of Registration as soon as possible. For further information, please consult the University's medical illness policy at

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_medical.pdf.

The Student Medical Certificate is available at

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf.

If you miss the mid-term quiz the amount that the quiz is worth will be reweighted to the final exam, a make-up quiz will not be offered.

Absences from Final Examinations

If you miss the Final Exam, please contact Western Engineering Undergraduate Services as soon as possible. They will assess your eligibility to write the Special Examination.

You may also be eligible to write the Special Exam if you are in a “Multiple Exam Situation” (e.g., more than 2 exams in 23-hour period, more than 3 exams in a 47-hour period).

If a student fails to write a scheduled Special Examination, the date of the next Special Examination (if granted) normally will be the scheduled date for the final exam the next time this course is offered. The maximum course load for that term will be reduced by the credit of the course(s) for which the final examination has been deferred. See the Academic Calendar for details (under [Special Examinations](#)).

Note: missed work can *only* be excused through one of the mechanisms above. Being asked not to attend an in-person course requirement due to potential COVID-19 symptoms is **not** sufficient on its own.

Academic Policies:

The website for Registrarial Services is <http://www.registrar.uwo.ca>.

In accordance with policy,

https://www.uwo.ca/univsec/pdf/policies_procedures/section1/mapp113.pdf,

the centrally administered e-mail account provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at their official university address is attended to in a timely manner.

Scholastic offences are taken seriously, and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf.

Assignments that require the submission of MATLAB scripts will be checked using MOSS or similar software as supported by Gradescope.

Support Services:

Please visit the Western Engineering Undergraduate Services webpage for information on adding/dropping courses, academic considerations for absences, appeals, exam conflicts, and many other academic related matters: <https://www.eng.uwo.ca/undergraduate/index.html>

Students who are in emotional/mental distress should refer to Mental Health@Western (<https://uwo.ca/health/>) for a complete list of options about how to obtain help.

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced sexual or gender-based violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts at

https://www.uwo.ca/health/student_support/survivor_support/get-help.html.

To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Please contact the course instructor if you require lecture or printed 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

http://academicsupport.uwo.ca/accessible_education/index.html

if you have any questions regarding accommodations.

Learning-skills counsellors at the Student Development Centre (<https://learning.uwo.ca>) are ready to help you improve your learning skills. They offer presentations on strategies for improving time management, multiple-choice exam preparation/writing, textbook reading, and more. Individual support is offered throughout the Fall/Winter terms in the drop-in Learning Help Centre, and year-round through individual counselling.

Western University is committed to a thriving campus as we deliver our courses in the mixed model of both virtual and face-to-face formats. We encourage you to check out the Digital Student Experience website to manage your academics and well-being: <https://www.uwo.ca/se/digital/>.

Additional student-run support services are offered by the USC, <https://westernusc.ca/services/>.

Course Breakdown: (Values given in accreditation units)

25% Math; 75% Engineering Science.

STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE

Western [is committed to reducing incidents of gender-based and sexual violence](#) and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, [here](#). To connect with a case manager or set up an appointment, please contact support@uwo.ca.

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 by submitting the [Academic Consideration Request Form](#), for all instances.
2. If you are an upper year student and you are missing a test/assignment/lab or examination you will report the absence by submitting [Academic Consideration Request Form](#). Absences worth LESS THAN 10% of your mark, will be processed by your department office. If your course work is worth 10% OR MORE of your final grade, your request will be processed by the Undergraduate Services Office.
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/MIDTERM TESTS

1. If you are in first year and you are unable to write a midterm/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 midterm/term test, inform your instructor PRIOR to the scheduled date of the test and request relief through the [Academic Consideration Request Form](#). 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, your request for relief will be processed by your department office. If the test is worth MORE THAN 10% of your final grade your request for relief will be processed by the Undergraduate Services Office.
3. Be prepared to attach supporting documentation to the Department Chair and/or the Undergraduate Services Office through the online form (see next page for information on documentation).
4. Discuss with the instructor if and when the test can be rescheduled. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/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 report your absence using the [Academic Consideration Request Form](#) and 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, headache, 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 submit an "[Application for a Special Exam](#)" form. 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 submit the [Academic Consideration Request Form](#) and 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 are strongly encouraged 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 2023 Western Academic Calendar available at www.westerncalendar.uwo.ca.

Absences Due to Illness:

https://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_13_5

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=#>

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/student-medical-certificate.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 15, 2023
Full courses and full-year half course (i.e. "E", "Y" or no suffix)	September 15, 2023
Second term half course (i.e. "B" or "G")	January 16, 2024

Drop Deadlines:

First term half course without penalty (i.e. "A" or "F")	November 13, 2023
Full courses and full-year half courses without penalty (i.e. "E", "Y" or no suffix)	November 30, 2023
Second term half or second term full course without penalty (i.e. "B" or "G")	March 7, 2024

Contact Information:

Undergraduate Services Office:	SEB 2097 Phone: 519-661-2130	E-mail: engugrad@uwo.ca
Chemical & Green Process Engineering:	TEB 477 Phone: 519-661-2131	E-mail: cbeugrad@uwo.ca
Civil Engineering:	SEB 3005 Phone: 519-661-2139	E-mail: civil@uwo.ca
Computer, Electrical, Mechatronic Systems & Software Engineering	TEB 279 Phone: 519-661-3758	E-mail: ecceugrad@uwo.ca
Integrated Engineering	ACEB 2410 Phone: 519-661-6725	E-mail: engceli@uwo.ca
Mechanical Engineering:	SEB 3002 Phone: 519-661-4122	E-mail: mmeundergraduate@uwo.ca