

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

CEE 3344b - STRUCTURAL DYNAMICS I – Course Outline 2023/24

Students are introduced to concepts of structural dynamics and the response of civil engineering structures to time-varying loads, including those due to wind and earthquakes. This requires the extension of the structural theory to include the effects of the mass and damping and to evaluate the action of various deterministic and random dynamic loads. The importance of dynamic loads in the design of dynamically sensitive civil engineering structures, such as tall buildings, towers and chimneys, and long-span bridges is examined and their treatment in the National Building Code of Canada is reviewed. Topics include:

- Equation of motion of single-degree-of-freedom systems;
- Free and forced vibrations;
- Response spectra;
- Numerical evaluation of dynamic response;
- Generalised single-degree-of-freedom systems;
- Rayleigh's method;

Prerequisites:

CEE 2221A/B

Corequisites:

CEE 3340A/B

Antirequisites:

CEE 4490

Note: It is the **student's responsibility** to ensure that all Prerequisite and/or Corequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also **students' responsibility** to ensure that they have not taken any 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:

2 lecture hours per week; 2 tutorial hours per week. Attendance at the tutorial session is **mandatory**.

Note: Review of lecture material and self-study should take approximately 5 hours per week.

Instructor:

Dr. Jin Wang, ACEB 4400B; e-mail: jwan2225@uwo.ca;

Administrative Support: SEB 3005

Contact policy:

- Contact the course instructor via email (above)
- Weekly Office hours are held either via Zoom or in-person.
- A general FAQ section on the ‘forums’ section of OWL will be used for students to post course-related questions so that all have the same information.

Textbook:

Prepared class notes should be brought to each class, and may be purchased at the UWO bookstore (purchase required).

Chopra, A.K., Dynamics of Structures, Theory and Applications to Earthquake Engineering, Prentice Hall, (3rd edition) 2006. (purchase required).

Other References:

Tedesco, J.W., McDougal, W. G., and Ross, C.A. “Structural Dynamics”, Addison-Wesley

Humar, J. L. “Dynamics of structures”, Balkema, 2005.

Clough, Penzien, "*Dynamics of Structures*", McGraw-Hill, 1993

M. Paz, "*Structural Dynamics*", Van Nostrand Reinhold Co., 1985.

Hurty, Rubinstein, "*Dynamics of Structures*", Prentice-Hall, 1964

Biggs, "*Introduction to Structural Dynamics*", McGraw-Hill, 1964

Units:

SI units will be used in lectures and examinations

Specific Learning Objectives [GA Indicator – **bold** denotes evaluated indicator]:

KB1. Demonstrate competence in mathematics

KB3. Demonstrate competence in engineering fundamentals appropriate to the engineering discipline

KB4. Demonstrate competence in specialized engineering knowledge

PA2. Demonstrate ability to formulate a strategy to solve an engineering problem

ET3. Demonstrates ability to create/develop/adapt appropriate engineering tools

1. Equation of motion of single-degree-of-freedom systems. At the end of this section, the student should be able to:
 - a) Understand the concept of damping, mass stiffness, and motion, and their relation [**KB1, KB3**]
 - b) Idealise the motion and derive a mathematical description of motion [**KB1, KB3**]
2. Free and forced vibrations of single-degree-of-freedom. At the end of this section, the student should be able to apply knowledge of mathematics, science, and engineering to:
 - a) Solve the differential equation of motion, and describe free vibration [**KB1, KB3**]
 - b) Find natural frequency, and resonant response [**KB4**]
 - c) Differentiate between the responses of undamped and damped vibration
 - d) Calculate response to harmonic and periodic excitations, transmissibility [**KB4**]
 - e) Understand human response to vibrations
 - f) Calculate response to arbitrary, step and pulse excitations using Duhamel's integral
3. Numerical evaluation of dynamic response. At the end of this section, the student should recognize the need of using numerical methods in the dynamics of structures. The student should be able to compute the dynamic response by implementing the following in the spreadsheet
 - a) Method based on interpolation of excitation
 - b) Central difference method [**ET3**]
 - c) Newmark's method, Wilson's method [**KB4, ET3**]
4. Response spectra.
 - a) Understand the response spectrum concept [**KB4**]
 - b) Identify the relations between deformation, pseudo-velocity and pseudo-acceleration spectra

- c) Recognise the difference between design and response spectra [KB4]
 - d) Design simple structures using response spectra [KB4, PA2, ET3]
5. Generalised single-degree-of-freedom systems and Rayleigh's method
- a) Understand the representation of motion in generalised coordinate [KB4, PA2]
 - b) Idealise and draw the shape function
 - c) Derive and solve the equation of motion for continuous beam subject to lateral force, and support motion [KB4, PA2]
 - d) Derive and solve the equation of motion lumped mass system [KB4, PA2]
 - e) Calculate frequencies using Rayleigh's method [KB4]

Instructors may expand on material presented in the course as appropriate

General Learning Objectives

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

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

Evaluation:

The final course mark will be determined as follows:

Weekly problems	35%
Quiz	15%
Final Examination	50%
Total	100%

Note:

Students must pass the final examination to pass this course. Students who do not satisfy this requirement will be assigned the aggregated mark as determined above, or 48%, whichever is less.

Quiz and Examination:

A one-hour quiz is to be held during a tutorial session. A three-hour final **in-person exam** will be held during the examination period on all work covered during the course. The final examination will be a **CLOSED-BOOK EXAM**.

However, under special circumstances, if the university policy requires that the final exam be conducted online, the examination will be an **OPEN BOOK EXAM**.

Assignments:

Weekly problems are assigned during the tutorial session and the due day will be specified. They will be marked and returned. **Late assignments will receive a grade of zero.** Extensions are to be negotiated with the course instructors, not the teaching assistants.

Course delivery with respect to the COVID-19 pandemic:

Although the intent is for this course to be delivered in-person, the changing COVID-19 landscape may necessitate some or all of the course to be delivered 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 assessments affected will be conducted online as determined by the course instructor.

When deemed necessary, tests and examinations in this course will be conducted using a remote proctoring service. By taking this course, you are consenting to the use of this software and acknowledge that you will be required to provide personal information (including some biometric data) and the session will be recorded. Completion of this course will require you to have a reliable internet connection and a device that meets the technical requirements for this service. More information about this remote proctoring service, including technical requirements, is available on Western's Remote Proctoring website at:

<https://remoteproctoring.uwo.ca>.

Course content

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

Plagiarism:

University policy states that plagiarism, defined as the “act or an instance of copying or stealing another’s words or ideas and attributing them as one’s own.” (excerpted from Black’s Law Dictionary, West Group, 1999, 7th ed., p. 1170) is a scholastic offence. In submitting any written work as part of the coursework requirements for this course students must ensure that this work is written in their own words.

A student who is found guilty of plagiarism in respect of any written work submitted as part of the coursework requirements for this course will be given a grade of zero for the submitted work. Repeated acts of plagiarism, either in this course or any other course subsequent to a first offence, will result in the student being given a failing grade for the course in which the subsequent offence occurs, and may also incur further penalties such as requiring the student to withdraw from the program in which they are enrolled in.

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, has not engaged sufficiently in 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:

Students with disabilities work with Accessible Education (formerly SSD) which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The accommodation policy can be found here: [Academic Accommodation for Students with Disabilities](#).

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

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:

<https://www.uwo.ca/univsec/pdf/board/code.pdf>

Sickness and Other Problems:

Students should immediately consult with the instructor of Department have any problem 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.

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

Assignments:

For a student with an approved academic consideration from the Dean's Office Academic Counselling unit (undergraduate services office), if Part A of any of the in-tutorial assignments is missed, the missed assignment grade will be weighted according to the average grade of all submitted assignments. If Part B of any of the in-tutorial assignments is missed, the student will be provided with an extension to work on this assignment as a take-home. The duration of this extension will be decided according to the conditions specified in the approved academic consideration.

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

For work totaling 10% or more of the final course grade (quizzes and final exam), you must provide valid medical or supporting documentation to the Academic Counselling Office of your Faculty of Registration as soon as possible.

Students should also note that individual instructors are not permitted to receive documentation directly from a student, whether in support of an application for consideration on medical grounds, or for other reasons. All documentation required for absences that are not covered by the Self-Reported Absence Policy must be submitted to the Academic Counselling office of a student's Home Faculty.

Religious Accommodation

Students should consult the University's list of recognized religious holidays, and should give reasonable notice in writing, prior to the holiday, to the Instructor and an Academic Counsellor office of their Faculty of Registration, if their course requirements will be affected by a religious observance. Additional information is given in the [Western Multicultural Calendar](#).

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

Notice:

Students are responsible for regularly checking their e-mail 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: Total = 38.2 Au's, (50% ES; 33% ED; 17% NS)

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