THE UNIVERSITY OF WESTERN ONTARIO - FACULTY OF ENGINEERING
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

CEE3344a - DYNAMICS OF STRUCTURES COURSE OUTLINE – Sept. 2022

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

Prerequisites:

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.

Corequisites:
CEE 3340A/B

Antirequisites:
the former CEE 4490

Contact Hours:
2 lecture hours/week;
Lectures will be delivered synchronously (but may be changed to asynchronously through pre-recorded videos posted to the course OWL site). Lectures will be organized into learning modules which students should review on a weekly basis. Review of lecture material and self-study should take approximately 5 hours per week.

2 tutorial hours/week.
A 2-hour tutorial session will be delivered synchronously through Zoom each week during the scheduled tutorial hours. Tutorials are not mandatory but students seeking assistance with weekly assignments or
clarification on lecture material are strongly encouraged to attend. The link to the Zoom meeting will be posted to OWL.

**Instructor:**
Dr. H. P. Hong, P.Eng., ESB3028; e-mail: hhong@uwo.ca; *Secretary:* Room 3005, Email smckay@uwo.ca

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

**Other References:**
Clough, Penzien, *"Dynamics of Structures"*, McGraw-Hill, 1993
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 recognise
the need of using numerical methods in the dynamics of structures. The student should able to
compute the dynamic response by implementing the following in the spreadsheet
a) Method based on interpolation of excitation
b) Central difference method \([\text{ET3]}\)
c) Newmark’s method, Wilson’s method \([\text{KB4, ET3]}\)

4. Response spectra.
   a) Understand the response spectrum concept \([\text{KB4]}\)
   b) Identify the relations between deformation, pseudo-velocity and pseudo-acceleration spectra
   c) Recognise the difference between design and response spectra \([\text{KB4]}\)
   d) Design simple structures using response spectra \([\text{KB4, PA2, ET3]}\)

5. Generalised single-degree-of-freedom systems and Rayleigh’s method
   a) Understand the representation of motion in generalised coordinate \([\text{KB4, PA2]}\)
   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 \([\text{KB4, PA2]}\)
   d) Derive and solve the equation of motion lumped mass system \([\text{KB4, PA2]}\)
   e) Calculate frequencies using Rayleigh’s method \([\text{KB4]}\)

Instructors may expand on material presented in the course as appropriate

**General Learning Objectives**

\(\text{E}=\text{Evaluate, } \text{T}=\text{Teach, } \text{I}=\text{Introduce (Introductory Level)}\)

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**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.

**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.

**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.

Academic Consideration for Student Absence
Students will have up to two (2) opportunities during the regular academic year to use an on-line portal to self-report an absence during the term, provided the following conditions are met: the absence is no more than 48 hours in duration, and the assessment for which consideration is being sought is worth 30% or less of the student’s final grade. Students are expected to contact their instructors within 24 hours of the end of the period of the self-reported absence, unless noted on the syllabus. Students are not able to use the self-reporting option in the following circumstances:

- for exams scheduled by the Office of the Registrar (e.g., December and April exams)
- absence of a duration greater than 48 hours,
- assessments worth more than 30% of the student’s final grade,
- if a student has already used the self-reporting portal twice during the academic year

If the conditions for a Self-Reported Absence are not met, students will need to provide a Student Medical Certificate if the absence is medical, or provide appropriate documentation if there are
compassionate grounds for the absence in question. Students are encouraged to contact their Faculty academic counselling office to obtain more information about the relevant documentation. 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.

For Western University policy on Consideration for Student Absence, see Policy on Academic Consideration for Student Absences - Undergraduate Students in First Entry Programs and for the Student Medical Certificate (SMC), see: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf.

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 if their course requirements will be affected by a religious observance. Additional information is given in the Western Multicultural Calendar.

Use of Recordings:
All of the remote learning sessions for this course will be recorded. The data captured during these recordings may include your image, voice recordings, chat logs and personal identifiers (name displayed on the screen). The recordings will be used for educational purposes related to this course, including evaluations. The recordings may be disclosed to other individuals under special circumstances. Please contact the instructor if you have any concerns related to session recordings. Participants in this course are not permitted to record the sessions, except where recording is an approved accommodation, or the participant has the prior written permission of the instructor.

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.

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.