

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

**CEE3344a - DYNAMICS OF STRUCTURES COURSE OUTLINE – Sept. 2018**

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 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 includes:

- 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:**

CEE340a, CEE341b, CEE342a

**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 **student's 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:**

None

**Antirequisites:**

ES226a, ES427a/b, ES490, CEE4490

**Contact Hours:**

2 lecture hours per week; 2 tutorial hours per week; (recommended additional personal study 3 hours). Attendance at the tutorial session is **mandatory**.

**Instructor:**

Dr. H. P. Hong, P.Eng., ESB3028; e-mail: [hhong@uwo.ca](mailto:hhong@uwo.ca); *Secretary*: Room 3005

**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, (3<sup>rd</sup> 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:**

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
  - b) Idealise the motion and derive mathematical description of motion
  
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
  - b) Find natural frequency, and resonant response
  - c) Differentiate between the responses of undamped and damped vibration
  - d) Calculate response to harmonic and periodic excitation, transmissibility
  - 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 dynamics of structures. The student should be able to compute the dynamic response by implementing the following in spreadsheet
  - a) Method based on interpolation of excitation
  - b) Central difference method
  - c) Newmark's method, Wilson's method

4. Response spectra.
  - a) Understand the response spectrum concept
  - b) Identify the relations between deformation, pseudo-velocity and pseudo-acceleration spectra
  - c) Recognise the difference between design and response spectra
  - d) Design simple structures using response spectra
  
5. Generalised single-degree-of-freedom systems and Rayleigh's method
  - a) Understand the representation of motion in generalised coordinate
  - b) Idealise and draw the shape function
  - c) Derive and solve equation of motion for continuous beam subject to lateral force, and support motion
  - d) Derive and solve equation of motion lumped mass system
  - e) Calculate frequencies using Rayleigh's method

Instructors may expand on material presented in the course as appropriate

**Evaluation:**

The final course mark will be determined as follows:

|                               |            |
|-------------------------------|------------|
| Weekly problems, assignments, | 30%        |
| Quiz,                         | 20%        |
| Final Examination,            | <u>50%</u> |
| 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:**

One 1-hour quiz (closed book) will be held during the year in the tutorial period. A three-hour final examination final examination will be held during the examination periods. The schedules of quiz is to be determined. Students should consult the list of approved calculators outside the Office of the Department of Civil and Environmental Engineering. Only approved calculators may be used.

The quiz and the final examination will be **CLOSED BOOK**: approved handheld programmable calculators are allowed, but **NO** other external sources of information, including books, notes or crib sheets, are permitted.

**Assignments:**

Weekly problems are assigned during lectures and the solutions are discussed and reviewed in detail during the tutorial session. Also, there are four assignments besides the weekly problems for the full year. They will be marked and returned. Late assignment 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](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.

**Conduct:**

Students are expected to arrive at lecture on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others.

**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, Engineering Science = 19.1 AU's; Engineering Design = 12.6 AU's; Science = 6.5.0 AU's.

**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](http://www.westerncalendar.uwo.ca).

Absences Due to Illness:

[http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page\\_12](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](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](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](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](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](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](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](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: <a href="mailto:engugrad@uwo.ca">engugrad@uwo.ca</a>                 |
| Dept. of Chemical and Biochemical Engineering & Green Process Engineering:                     | TEB 477  | Telephone: (519) 661-2131 | E-mail: <a href="mailto:cbeugrad@uwo.ca">cbeugrad@uwo.ca</a>                 |
| Dept. of Civil and Environmental Engineering:  | SEB 3005 | Telephone: (519) 661-2139 | E-mail: <a href="mailto:civil@uwo.ca">civil@uwo.ca</a>                       |
| Dept. of Electrical and Computer Engineering, Software Engineering & Mechatronics Engineering: | TEB 279  | Telephone: (519) 661-3758 | Email: <a href="mailto:eeugrad@uwo.ca">eeugrad@uwo.ca</a>                    |
| Dept. of Mechanical and Materials Engineering:   | SEB 3002 | Telephone: (519) 661-4122 | E-mail: <a href="mailto:mmeundergraduate@uwo.ca">mmeundergraduate@uwo.ca</a> |