Course Overview

The aim of this course is to introduce students to the concepts and techniques involved in structural dynamics and their practical applications in structural engineering. This course begins with an introduction of the dynamics of simple structures and then develops the fundamental knowledge of vibration analysis of multi-degree-of-freedom structures and continuous structures. Students will develop an understanding of the nature of dynamic loads produced by wind, earthquake, waves and other sources and acquire the ability to assess the response of civil engineering structures to such loads. The material covered in this course is essential to the analysis and design of large-scale structures such as multi-story buildings, towers and long-span bridges that are susceptible to vibration. Much of the knowledge acquired in this subject is also applicable to dynamic problems in other areas such as geotechnical engineering, mechanical engineering and material science.

The flow chart in Figure 1 shows diagrammatically how this course relates to other courses in the Civil Engineering program.

This course will also provide you with opportunities to develop the following generic graduate attributes:

- the capacity for analytical and independent critical thinking;
- skills related to lifelong learning, such as self-reflection (ability to apply theory to practice in familiar and unfamiliar situations)
Figure 1. How this course relates to other courses in Civil Engineering.

HANDBOOK DESCRIPTION

Fundamentals of structural dynamic analysis for discrete and continuous structures; free and forced vibration of single and multiple degrees of freedom systems; normal modal analysis; transient dynamic analysis by numerical integration; response spectrum; introduction to nonlinear dynamic analysis of structures; wind, earthquake, human-induced vibration and wave loads: definitions and effects on structures; design of structures to resist dynamic loads.


OBJECTIVES

The objective of this course is to enable students to gain a thorough understanding of the nature of dynamic loads and the key factors influencing the dynamic behaviour of structures. The course will provide you with an appreciation of the fundamental concepts of structural dynamics, as well as with analytical and numerical tools to be used in the design of structures against dynamic action.

These objectives contribute to the achievement of civil and environmental program outcomes in the following way:

- By studying the theoretical background concepts of structural dynamics and their application to realistic structural problems you will engage in depth with disciplinary knowledge in structural engineering.
- By applying the theoretical concepts learned to defined and open-ended class problems you will develop a capacity for analytical and critical thinking and for creative problem solving.
- By working on an assignment that requires you to find information beyond what was conveyed in the classroom you will engage in independent and reflective learning.
- By documenting your assignment work in a standard that would be expected in a real consultancy environment you will acquire skills for effective communication.

The assessment strategies used in this course will assist in achieving these objectives. Assessment consists of a mix of short weekly homework problems, which encourage you to revise the theoretical background material learned in a timely and effective manner, in-class quizzes, that test your understanding of the fundamental concepts and your ability to apply learned strategies to relevant problems, a major assignment, that challenges your engineering abilities and a final exam. Further details are provided in the Assessment section.

TEACHING STRATEGIES

This subject consists of a mixture of lectures, workshops and hands-on computer sessions.

Lectures will cover the basic theories of structural dynamics and its applications to structural engineering. A commercial software package, which you will use to accomplish your assignment, will be introduced. Application of the theories to formulate guidelines in the analysis of practical engineering problems will be emphasized.
The workshops provide you with the opportunity to discuss the lecture material with your demonstrators and to solve the set exercise problems. In order to understand the subject matter well, it is essential to attend the workshops and solve the set problems by yourself.

For each hour of contact it is expected that you will put in at least 1.5 hours of private study. You are recommended to review the lecture and workshop material weekly.

The teaching/learning activities are summarized in the following table:

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Workshops</th>
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<tbody>
<tr>
<td>• Cover material to be learned for assessment tasks</td>
<td>• Practice solving set problems</td>
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<tr>
<td>• Follow worked examples</td>
<td>• Be guided by demonstrators</td>
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<tr>
<td>• Hear announcements on course changes</td>
<td>• Ask questions</td>
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<tr>
<th>Computer Sessions</th>
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<tbody>
<tr>
<td>• Hands-on exercises using commercial software</td>
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<tr>
<td>• Familiarise with pre- and post-processors</td>
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<tr>
<td>• Reflect and discuss on practical issues in numerical</td>
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<tr>
<td>simulation</td>
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<table>
<thead>
<tr>
<th>Private Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Review lecture material and textbook</td>
</tr>
<tr>
<td>• Prepare for the workshop and do set problems</td>
</tr>
<tr>
<td>• Reflect on class problems</td>
</tr>
<tr>
<td>• Study relevant references</td>
</tr>
<tr>
<td>• Work on assignment</td>
</tr>
<tr>
<td>• Download materials from Moodle</td>
</tr>
<tr>
<td>• Keep up with notices and find out marks via Moodle</td>
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<table>
<thead>
<tr>
<th>Assessments (hand-ins, assignment, quizzes, exam)</th>
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<tbody>
<tr>
<td>• Demonstrate your knowledge and skills</td>
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<tr>
<td>• Demonstrate higher understanding and problem solving</td>
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</table>

**Suggested approaches to learning** in this course include:

- Regular participation in lectures and workshops. *Review lecture and workshop material. Follow worked examples. Reflect on class problems and quizzes.*

- Weekly reading and recording of your learning.

- Appropriate preparation for workshop activities.

- Planning your time to achieve all assessment requirements (see assessment).

- Keep up with the notices via Moodle and UNSW email. It is your responsibility to check your UNSW email regularly. **NOTE:** *Announcements made in emails are equally official as announcements made during lectures.*

- We encourage you to work with your peers. A good way to learn the material is in small study groups. Such groups work best if members have attempted the problems individually before meeting as a group. A valued and honest collaboration occurs when, for example, you “get stuck” early on in attacking an exercise and go to your classmate with a relevant question. Your classmate then has the opportunity to learn from your question as well as help you.

- Students who perform poorly in the quizzes are strongly encouraged to discuss their progress with the lecturer during the semester. Please do not suffer in silence – seek help at an early stage! We would like you to make most of this learning process and receive a high grade in the course.

**CONSULTATION**

We would like for you to learn the material, gain the required skills and make a high grade in this course. Questions are welcome in class and during the consultation times, which will be announced on Moodle. Ask your classmates, ask your demonstrator, ask me. Also, your comments/suggestions/criticisms, expressed either to your lecturer or demonstrators, are most welcome!
EXPECTED LEARNING OUTCOMES

At the conclusion of this course, students should be able to:

1. identify and specify various types of dynamic loads for structural analysis
2. demonstrate an understanding of fundamental concepts of structural dynamics
3. apply the laws of dynamics to establish simple and realistic mathematical models of engineering structures
4. determine the natural frequency, the dynamic response to a dynamic load and other important parameters for structural design
5. evaluate the dynamic susceptibility of structures and the limitations of modelling techniques
6. apply dynamic analysis methods to practical problems in structural engineering and other disciplines
7. develop computer models of structures under dynamic loading and to critically reflect on the limitations of these models
8. demonstrate collaborative skills by working with other students in TEAMS

While the fundamental concepts and theoretical background of structural dynamics will be presented and discussed by the teacher during the lectures, it is what **YOU** do with it, that makes you achieve these outcomes. Your active participation and engagement in workshops, homework exercises and open-ended problems determines to a great extent what you learn.

ASSESSMENT

Assessment will be based on **two- online tutorials, eight homework hand-ins, two quizzes, one assignment** and a final exam.

- **Online tutorials (weeks 1 and 2)**: The purpose is to encourage you to revise and apply what you are learning at the early stages of the course immediately. These tutorials consist of a mix of animations that help you understand dynamic effects, revision and marked tasks. The tasks require critical thinking and application of what you have learned. The tutorials are *adaptive*, i.e. you will be provided with staggered feedback when you need it to assist your learning and problem solving. The online tutorials will be marked automatically and you will be able to check your score directly after the completion of the task. A zero score will be given if you do not complete the tutorial by the due date and time.

- **Homework hand-ins**: The purpose is to provide you with a clear study framework and to encourage a weekly revision of the material. It will also provide you with the opportunity to develop self-learning and problem solving skills. 8 homework hand-ins will be circulated by your demonstrator at the end of 10 selected classes (weeks 3-8, 10 and 12). You need to submit the hand-in to the lecturer’s assignment box marked “BIRK” on level 7 of the CE building by Tuesday, 6pm, of the following week. It will be returned to you a week after submission during the workshops. A general marking of Satisfactory = 1, Unsatisfactory = 0.5, Null = 0 will be given. A zero score will be given if you do not submit your homework in due date and time. The solutions of the homework problems will be uploaded a week after submission.

- **Two quizzes**: Two quizzes are scheduled for Weeks 4 and 8 and will take place during the last hour of the 2-hour tutorial block. The duration of the quizzes is 50 minutes. The quizzes will be held under exam conditions. The purpose of the quizzes is to test your understanding of the fundamental concepts and your ability to apply learned strategies to relevant problems.

- **Assignment**: The purpose of the assignment is to expose you to a realistic structural dynamics problem, which requires you to apply what you have learned, including the use of commercial software. Similar to engineering practice, this will require you to find additional information by asking, reading or discussing with your classmates, to critically evaluate your model and to formulate conclusions. Here, documentation is equally important as results. It is expected that you submit a report that is similar in scope, form and style to what you would submit to a private or public client who has commissioned you with the dynamic analysis.

- **Final Examination**: A mark of at least 40% in the final examination is required before the class work is included in the final mark. The formal exam scripts will not be returned.
The relative value of each of the assessable tasks is as follows:

- **Online Tutorials:** 5%
- **8 Homework Hand-ins:** 5%
- **Quiz 1:** 15%
- **Quiz 2:** 15%
- **Assignment:** 15%
- **Final Exam:** 45%

**Total:** 100%

There are no exemptions from any part of this assessment. **Note:** The course coordinator reserves the right to adjust the final scores by scaling if agreed to by the Head of School.

### ASSIGNMENTS

1. **Online Tutorial 1:**
   - **Available on:** 30/07/14
   - **Due on:** 06/08/14

2. **Online Tutorial 2:**
   - **Available on:** 06/08/14
   - **Due on:** 13/08/14

3. **(8) Homework Hand-ins**
   - **Issued on:** weekly
   - **Due on:** see course program

4. **Assignment:**
   - **Issued in:** week 7
   - **Due on:** 31/10/14 5pm

**Late submissions** of the major assignment will be **penalised** at the rate of 20% after the due time and date have expired.

### COURSE PROGRAM

**SEMESTER 2, 2014**

<table>
<thead>
<tr>
<th>W</th>
<th>Date</th>
<th>Topic</th>
<th>Workshop</th>
<th>Assessment</th>
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</thead>
</table>
| 1 | 30/07| Introduction; Types of dynamic loading  
Single-degree-of-freedom oscillator: equation of motion, free vibration analysis, natural frequency, undamped and damped systems, free vibration test | SDOF oscillator: free vibration |  |
| 2 | 06/08| Response to harmonic loading, frequency-response function, transmissibility, response to periodic loading | SDOF oscillator: particular and complete solution | OT 1 due |
| 3 | 13/08| Response to periodic loading – continued; Response to arbitrary dynamic force: impulsive response, convolution (Duhamel) integral | Fourier series expansion / Duhamel integral | OT 2 due |
| 4 | 20/08| Numerical integration: explicit and implicit methods, accuracy and stability | Numerical integration  
**QUIZ 1** | Hand-in 1 due  
**QUIZ 1** |
| 5 | 27/08| Multi-degree-of-freedom (MDOF) system: matrix equations of motion, generalized eigenvalue problem, inverse vector iteration | Equations of motion of 2-storey frame | Hand-in 2 due |
| 6 | 03/09| Modal analysis of MDOF system: mode shapes, modal superposition, free-vibration analysis, frequency- and time-domain analysis of forced vibration | Modal analysis | Hand-in 3 due |
| 7 | 10/09| Introduction to finite element analysis of structural dynamics by using commercial software: modelling issues, natural frequencies and mode shapes, response in frequency and time-domain | Computer session  
(1st group) | Hand-in 4 due |
| 8 | 17/09| Computer session (2nd group) | **QUIZ 2** | **QUIZ 2**  
Hand-in 5 due |
<p>| 9 | 24/09| <strong>Field trip week – no classes</strong> |  |  |</p>
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>01/10</td>
<td>Midsemester break – no classes</td>
</tr>
<tr>
<td>10</td>
<td>08/10 Continuous structures: partial differential equations of motion, Rayleigh’s method</td>
</tr>
<tr>
<td>11</td>
<td>15/10 Guest lecture: Human-induced vibration</td>
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<tr>
<td>12</td>
<td>22/10 Earthquake response, response spectrum concept</td>
</tr>
<tr>
<td>13</td>
<td>29/10 Earthquake analysis of MDOF systems, Introduction to wind loading</td>
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**RELEVANT RESOURCES**

**Textbook (recommended):**
The UNSW library holds 2 copies on level 8 and 1 copy in the High Use Collection.
Available at Main Library Level 8 (624.1762/78 B) and other locations

**Recommended Reading:**
   Available at Main Library Level 8 (P 624.171/112 A) and other locations
   Available at Main Library Level 8 (P 624.171/212)
   Available at Main Library Level 8 (620.3/143 N) and other locations
   Available at Main Library Level 8 (P 624.176/55)
   Available at Main Library Level 8 (624.171/194 A)

Lecture notes, workshop problems and solutions, lecture videos and selected previous exam questions will be made available on Moodle.

**DATES TO NOTE**
Refer to MyUNSW for Important Dates available at:
https://my.unsw.edu.au/student/resources/KeyDates.html

**PLAGIARISM**
Beware! An assignment that includes plagiarised material will receive a 0% Fail, and students who plagiarise may fail the course. Students who plagiarise are also liable to disciplinary action, including exclusion from enrolment.

Plagiarism is the use of another person’s work or ideas as if they were your own. When it is necessary or desirable to use other people’s material you should adequately acknowledge whose words or ideas they are and where you found them (giving the complete reference details, including page number(s)). The Learning Centre provides further information on what constitutes Plagiarism at:
https://student.unsw.edu.au/plagiarism

**ACADEMIC ADVICE**
For information about:
- Notes on assessments and plagiarism,
- School policy on Supplementary exams,
Special Considerations,
Solutions to Problems,
Year Managers and Grievance Officer of Teaching and Learning Committee, and
CEVSOC.

Refer to Academic Advice on the School website available at:
http://www.engineering.unsw.edu.au/civil-engineering/resources/academic-advice

**COURSE EVALUATION AND DEVELOPMENT**

The School of Civil and Environmental Engineering evaluates each course through (i) the UNSW Course and Teaching Evaluation and Improvement (CATEI) process, and (ii) Focus Group Meetings.

As part of the CATEI process, your student assessments on various aspects of the course are graded; the Course Coordinator prepares a summary report for the Head of School. Any problem areas are identified for remedial action, and ideas for making improvements to the course are noted for action the next time that the course is run.

Focus Group Meetings are conducted by the four Year Managers (academic staff) for any students who wish to attend, in each year of the civil and/or environmental engineering programs. Student comments on each course are collected and disseminated to the Lecturers concerned, noting any points which can help improve the course.