湖北工業大學
HUBEI UNIVERSITY OF TECHNOLOGY

Course Title	Structural Dynamics II: Multi-Degree Systems and Dynamic Design
Course Code	CIVL 5514
Semester	Spring 2027
Course Length	8 Weeks, 60 Contact Hours
Credits	4
Instructor	TBA
Office	TBA
Email	TBA
Prerequisite(s)	Successful completion of Structural Dynamics I: Single-Degree Systems and Dynamic Response
Antirequisite	CIVL 5512 Structural Dynamics II: Multi-Degree Systems and Dynamic Design (4 Weeks)

Course Description:

This course is the second part of a two-part sequence in structural dynamics. Building on the single degree of freedom foundations established in the first course, it extends the analysis to multiple degree of freedom (MDOF) and continuous systems, and then applies dynamic analysis to earthquake, blast, wave, and man-made loads within a design context.

The course moves from MDOF idealisation through modal analysis and numerical integration to design. Students examine two-degree and general MDOF systems, natural frequencies and mode shapes, the mass and stiffness matrices, modal orthogonality, modal decomposition and superposition, approximate methods, continuous systems, and dynamic finite element concepts. Each method is presented with its assumptions and range of validity so that it can be applied with engineering judgement.

The course then turns to design applications. Students examine seismic loading and the Australian earthquake code, seismic design and detailing, base isolation and energy dissipation, blast-resistant design and pressure – impulse curves, man-made ground vibrations, wave-induced dynamic loads, structural control and health monitoring, and performance-based design. The course culminates in a dynamic design project, assessed through a written report and an oral presentation.

Course Goals:

Students who successfully complete this course will demonstrate competency in the following general education core goals:

- **Critical Thinking Skills** - Students will engage in analytical thinking, demonstrating the ability to critically evaluate, synthesize, and apply knowledge to complex problems, and construct well-reasoned solutions and arguments.
- **Independent Research and Inquiry** - Students will conduct independent research, utilizing academic resources to explore relevant topics, formulating research questions, analyzing data, and presenting findings in a coherent, scholarly manner.
- **Problem-Solving and Application** - Students will apply theoretical concepts and methodologies learned in the course to real-world problems, demonstrating the ability to develop practical solutions informed by academic inquiry.
- **Global and Cultural Awareness** - Students will gain awareness of the global and cultural contexts relevant to the course, appreciating diverse perspectives and considering the implications of their studies in a broader, international context.

Student Learning Outcomes:

Upon completion of this course, students will be able to:

- Formulate and solve the equations of motion for MDOF systems.
- Determine natural frequencies and mode shapes and apply modal orthogonality.
- Perform modal decomposition and superposition for forced response.
- Apply numerical integration and approximate methods to MDOF systems.
- Analyse continuous systems and dynamic finite element formulations.
- Apply seismic loading and the Australian earthquake code to design.
- Design base isolation, energy dissipation, and blast-resistant systems.
- Incorporate performance-based design and reliability in dynamic design.
- Work effectively in teams and communicate design results through reports and presentations.

Textbooks:

1) Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson.
2) Clough, R. W., & Penzien, J. (1993). *Dynamics of structures* (2nd ed.). McGraw-Hill.
3) Craig, R. R., & Kurdila, A. J. (2006). *Fundamentals of structural dynamics* (2nd ed.). Wiley.
4) Humar, J. L. (2012). *Dynamics of structures* (3rd ed.). CRC Press.
5) Kramer, S. L. (1996). *Geotechnical Earthquake Engineering*. Prentice Hall.
6) Sarpkaya, T., & Isaacson, M. (1981). *Mechanics of wave forces on offshore structures*. Van Nostrand Reinhold.
7) Standards Australia. *AS 1170.4 Structural design actions - Earthquake actions in Australia*.
8) US Department of the Army. *TM5-1300 Structures to resist the effects of accidental explosions*.

Course Requirements:

Assignment 1: MDOF Modal Analysis (15%)
Students will complete a set of quantitative problems covering MDOF formulation, natural frequencies and mode shapes, modal orthogonality, modal decomposition, and numerical integration. Solutions must show the governing equations, full working, and correct units, and should demonstrate understanding of the assumptions behind each method.

Assignment 2: Seismic and Code-Based Calculations (15%)
Students will solve problems on seismic loading, code-based calculations under AS 1170.4, and blast and isolation problems. The exercise tests the ability to apply standards and dynamic methods with correct working and stated assumptions.

Assignment 3: Dynamic Design Project (20%)
Working in teams, students complete the dynamic design of a structure for a realistic setting. The project should include:

- Definition of the dynamic model and the design loads.
- Modal analysis, including frequencies, mode shapes, and forced response.
- Code-based seismic load calculation and detailing.
- Isolation or protective measures where relevant, with reliability and failure modes.
- Reference to the applicable standards and clear statements of assumptions and units.

Final Examination (50%)
A closed-book examination covering MDOF analysis, modal methods, numerical integration, seismic and code design, isolation, and blast-resistant design. The examination includes both conceptual questions and quantitative problems.

Assessments: Activity	**Percent Contribution**
Assignment 1: MDOF Modal Analysis	15%
Assignment 2: Seismic and Code-Based Calculations	15%
Assignment 3: Dynamic Design Project	20%
Final Examination	50%

Grading:

Final grades will be based on the sum of all possible course points as noted above.

Grade	**Percentage of available points**
A	94-100
A-	90-93
B+	87-89
B	84-86
B-	80-83
C+	77-79
C	74-76
C-	70-73

D	64-69
D-	60-63
F	0-59

Course Schedule:
The schedule of activities is subject to change at the reasonable discretion of the instructor. Minor changes will be announced in class, major ones provided in writing.

CIVL 5514 Schedule

Lecture	Topic	Readings
L1	Review of Part I and MDOF Idealisation	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 9.
L2	Two-Degree Systems: Free Vibration	Clough, R. W., & Penzien, J. (1993). *Dynamics of structures* (2nd ed.). McGraw-Hill.
L3	Natural Frequencies and Mode Shapes	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 10.
L4	MDOF Equations of Motion	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 9.
L5	Mass, Stiffness and Damping Matrices	Craig, R. R., & Kurdila, A. J. (2006). *Fundamentals of structural dynamics* (2nd ed.). Wiley.
L6	Modal Orthogonality	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 10.
L7	Modal Decomposition and Superposition	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 12.
L8	MDOF Response to Dynamic Loads	Clough, R. W., & Penzien, J. (1993). *Dynamics of structures* (2nd ed.). McGraw-Hill.
L9	Numerical Integration for MDOF Systems	Newmark, N. M. (1959). A method of computation for structural dynamics. *Journal of the Engineering Mechanics Division, ASCE, 85*(3), 67–94.
L10	Rayleigh-Ritz and Approximate Methods	Craig, R. R., & Kurdila, A. J. (2006). *Fundamentals of structural dynamics* (2nd ed.). Wiley.
L11	Continuous and Distributed-Mass Systems	Clough, R. W., & Penzien, J. (1993). *Dynamics of structures* (2nd ed.). McGraw-Hill.
L12	Finite Element Concepts in Dynamics	Humar, J. L. (2012). *Dynamics of structures* (3rd ed.). CRC Press.
L13	Earthquake Engineering and Seismic Loading	Kramer, S. L. (1996). *Geotechnical earthquake engineering*. Prentice Hall.
L14	Australian Seismic Code AS 1170.4	Standards Australia. *AS 1170.4 Structural design actions – Earthquake actions in Australia*.
L15	Seismic Design of Structures	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson.

L16	Base Isolation and Energy Dissipation	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson.
L17	Blast Loads and Blast-Resistant Design	US Department of the Army. *TM5-1300 Structures to resist the effects of accidental explosions*.
L18	Pressure–Impulse (P-I) Curves	US Department of the Army. *TM5-1300 Structures to resist the effects of accidental explosions*.
L19	Man-Made Ground Vibrations	Humar, J. L. (2012). *Dynamics of structures* (3rd ed.). CRC Press.
L20	Wave-Induced Dynamic Loads	Sarpkaya, T., & Isaacson, M. (1981). *Mechanics of wave forces on offshore structures*. Van Nostrand Reinhold.
L21	Structural Control and Health Monitoring	Craig, R. R., & Kurdila, A. J. (2006). *Fundamentals of structural dynamics* (2nd ed.). Wiley.
L22	Dynamic Design Case Studies	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson.
L23	Performance-Based Design and Reliability	Humar, J. L. (2012). *Dynamics of structures* (3rd ed.). CRC Press.
L24	Design Project Presentations	Review all materials.
L25	Final Examination	Review all materials.

Accommodation Statement:

Academic accommodations may be made for any student who notifies the instructor of the need for an accommodation. It is imperative that you take the initiative to bring such needs to the instructor's attention. Students who may require assistance in emergency evacuations should contact the instructor as to the most appropriate procedures to follow.

Academic Integrity Statement

Each student is expected to maintain the highest standards of honesty and integrity in academic and professional matters. The University reserves the right to take disciplinary action, up to and including dismissal, against any student who is found guilty of academic dishonesty or otherwise fails to meet the standards. Any student judged to have engaged in academic dishonesty in coursework may receive a reduced or failing grade for the work in question and/or for the course.

Academic dishonesty includes, but is not limited to, dishonesty in quizzes, tests, or assignments; claiming credit for work not done or done by others; hindering the academic work of other students; misrepresenting academic or professional qualifications within or without the University; and nondisclosure or misrepresentation in filling out applications or other University records.

Other Items:

Attendance and Expectations

All students are required to attend every class, except in cases of illness, serious family concerns, or other major problems. We expect that students will arrive on time, be prepared to listen and participate as appropriate, and stay for the duration of a meeting rather than drift in or out casually. In short, we anticipate that students will show professors and fellow students maximum consideration by minimizing the disturbances that cause interruptions in the learning process. This means that punctuality is a must, that cellular phones be turned off, and that courtesy is the guiding principle in all exchanges among students and faculty. You will be responsible for the materials and ideas presented in the lecture.

Assignment Due Dates
All written assignments must be turned in at the time specified. Late assignments will not be accepted unless prior information has been obtained from the instructor. If you believe you have extenuating circumstances, please contact the instructor as soon as possible.

Make-Up Work
The instructor will not provide students with class information or make-up assignments/quizzes/exams missed due to an unexcused absence. Absences will be excused and assignments/quizzes/exams may be made up only with written documentation of an authorized absence. Every effort should be made to avoid scheduling appointments during class. An excused student is responsible for requesting any missed information from the instructor and setting up any necessary appointments outside of class.

Access, Special Needs, and Disabilities
Please notify the instructor at the start of the semester if you have any documented disabilities, a medical issue, or any special circumstances that require attention, and the school will be happy to assist.