湖北工業大學
HUBEI UNIVERSITY OF TECHNOLOGY

Course Title	Structural Dynamics I: Single-Degree Systems and Dynamic Response
Course Code	CIVL 5513
Semester	Winter 2027
Course Length	8 Weeks, 60 Contact Hours
Credits	4
Instructor	TBA
Office	TBA
Email	TBA
Prerequisite(s)	Admission to the Master of Professional Engineering, Master of Offshore and Coastal Engineering, or an engineering honours program; completion of solid mechanics is recommended.
Antirequisite	CIVL 5511 Structural Dynamics I: Single-Degree Systems and Dynamic Response (4 Weeks)

Course Description:

This course is the first part of a two-part sequence in structural dynamics. It introduces the dynamic response of single degree of freedom (SDOF) structures to earthquake, blast, wave, and man-made dynamic loads, building the analytical foundation needed before multiple degree of freedom systems and design applications are addressed in the second course.

The course moves from structural idealisation through free and forced vibration. Students examine the equation of motion, natural frequency and period, damping, the response to harmonic, periodic, and arbitrary loading, the Duhamel integral, numerical time-stepping methods including the Newmark method, and the response spectrum. For each method, students examine the governing equations, the underlying assumptions, and the range of conditions over which it remains valid.

Through worked examples, workshop calculations, and structured assignments, students develop quantitative problem-solving skills and clear technical communication. The course prepares them for the second course, which covers multiple degree of freedom systems, modal analysis, seismic and blast-resistant design, base isolation, and the relevant design codes.

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:

- Idealise a real structure as an equivalent single degree of freedom system.
- Determine the natural frequency, period, and damping of an SDOF system.
- Analyse the free vibration of damped and undamped SDOF systems.
- Solve the response to harmonic and periodic loading, including resonance and transmissibility.
- Evaluate the response to arbitrary dynamic loading using the Duhamel integral.
- Apply numerical time-stepping methods, including central difference and Newmark methods.
- Construct and interpret response spectra and describe earthquake ground motion.
- Communicate quantitative engineering results clearly through calculations and reports.

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) Biggs, J. M. (1964). *Introduction to Structural Dynamics.* McGraw-Hill.
5) Paz, M., & Leigh, W. (2004). *Structural Dynamics: Theory and Computation* (5th ed.). Springer.
6) Kramer, S. L. (1996). *Geotechnical Earthquake Engineering.* Prentice Hall.

Course Requirements:

Assignment 1: Free Vibration and SDOF Fundamentals (15%)
Students will complete a set of quantitative problems covering structural idealisation, the equation of motion, natural frequency and period, equivalent stiffness, and damping. Solutions must show the governing equations, full working, and correct units, and should demonstrate understanding of the assumptions behind each model.

Assignment 2: Forced Vibration and Numerical Methods (15%)
Students will solve problems on harmonic, periodic, and arbitrary loading, including resonance and transmissibility, and will implement numerical time-stepping procedures. The exercise tests the ability to apply both analytical and numerical methods with correct working and stated assumptions.

Assignment 3: Response Spectra and Ground Motion (20%)
Students will construct and interpret response spectra and compare them with design spectra and ground-motion records. The assignment should include:

- Identification of the ground motion and the SDOF model.
- Construction of the response spectrum from response calculations.
- Interpretation of spectral displacement, velocity, and acceleration.
- Comparison with the design spectrum and code provisions.
- Clear statements of assumptions, units, and the design basis.

Final Examination (50%)
A closed-book examination covering idealisation, free vibration, damping, forced response, the Duhamel integral, numerical methods, and response spectra. The examination includes both conceptual questions and quantitative problems.

Assessments: Activity	**Percent Contribution**
Assignment 1: Free Vibration and SDOF Fundamentals	15%
Assignment 2: Forced Vibration and Numerical Methods	15%
Assignment 3: Response Spectra and Ground Motion	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 5513 Schedule		
Lecture	Topic	Readings
L1	Introduction to Structural Dynamics	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 1.
L2	Dynamic Loads and Structural Idealisation	Clough, R. W., & Penzien, J. (1993). *Dynamics of structures* (2nd ed.). McGraw-Hill, Chapter 1.
L3	The SDOF Equation of Motion	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 1.
L4	Free Vibration of Undamped SDOF Systems	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 2.
L5	Natural Frequency, Period and Equivalent Stiffness	Craig, R. R., & Kurdila, A. J. (2006). *Fundamentals of structural dynamics* (2nd ed.). Wiley.
L6	Viscous Damping and Damping Models	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 2.
L7	Free Vibration of Damped SDOF Systems	Clough, R. W., & Penzien, J. (1993). *Dynamics of structures* (2nd ed.). McGraw-Hill.
L8	Harmonic Loading: Undamped Response	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 3.
L9	Harmonic Loading: Damped Response and Resonance	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 3.
L10	Vibration Isolation and Transmissibility	Craig, R. R., & Kurdila, A. J. (2006). *Fundamentals of structural dynamics* (2nd ed.). Wiley.
L11	Periodic Loading and Fourier Series	Clough, R. W., & Penzien, J. (1993). *Dynamics of structures* (2nd ed.). McGraw-Hill.
L12	Response to General Dynamic Loading	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 4.
L13	The Duhamel Integral	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 4.
L14	Numerical Time-Stepping Methods	Newmark, N. M. (1959). A method of computation for structural dynamics. *Journal of the Engineering Mechanics Division, ASCE, 85*(3), 67–94.
L15	Central Difference and Newmark-β Methods	Paz, M., & Leigh, W. (2004). *Structural dynamics: Theory and computation* (5th ed.). Springer.
L16	Response Spectrum Concepts	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson, Chapter 6.
L17	Construction and Interpretation of Response Spectra	Biggs, J. M. (1964). *Introduction to structural dynamics*. McGraw-Hill.

L18	Earthquake Ground Motion and Design Spectra	Kramer, S. L. (1996). *Geotechnical earthquake engineering*. Prentice Hall.
L19	Generalised SDOF and Equivalent Systems	Clough, R. W., & Penzien, J. (1993). *Dynamics of structures* (2nd ed.). McGraw-Hill.
L20	Energy Principles and the Rayleigh Method	Biggs, J. M. (1964). *Introduction to structural dynamics*. McGraw-Hill.
L21	Introduction to Distributed-Mass Systems	Craig, R. R., & Kurdila, A. J. (2006). *Fundamentals of structural dynamics* (2nd ed.). Wiley.
L22	Practical SDOF Worked Examples	Chopra, A. K. (2017). *Dynamics of structures: Theory and applications to earthquake engineering* (5th ed.). Pearson.
L23	Vibration Measurement and Instrumentation	Craig, R. R., & Kurdila, A. J. (2006). *Fundamentals of structural dynamics* (2nd ed.). Wiley.
L24	Review and Integrated Problems	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.