Department of Civil and Environmental Engineering

The Hong Kong University of Science and Technology

Fall 2023

Course code	CIVL 4330
Course title	Introduction to Structural Dynamics
Lectures	TuTh 01:30PM - 02:50PM G001, CYT Bldg
Tutorials	Mo 12:00PM - 12:50PM G001, CYT Bldg (no tutorial in week 1)
Instructor	Dr. Thomas W. C. Hu (thomashu@ust.hk) Office: 3585 (Lift 27/28)
Teaching Assistants	KE, Yanyu (ykeag@connect.ust.hk) JIA, Guangnan (gjia@connect.ust.hk)
Prerequisite	Mechanics of materials, matrix algebra, and differential equations
Credits	[3-1-0:3]
Reference books	1. Clough, R.W. and Penzien, J., *Dynamics of Structures*, McGraw-Hill Inc. 2. Craig, R. R. and Kurdila, A. J., *Fundamentals of Structural Dynamics*, John Wiley & Sons.
Course objectives	Upon successful completion of this course, students should be able to 1. understand basic concepts of Newton's laws of motion 2. determine equations of motion (EOM) and structural response of single-degree-of-freedom (SDOF) structural systems to various types of external excitation such as transient, harmonic and periodic driving forces 3. determine design parameters of SDOF systems such as damping ratio, dynamic magnification factor, and transmissibility during ground motion 4. assemble mass and stiffness matrices for multiple-degree-of-freedom (MDOF) systems; obtain frequencies of vibration and mode shapes 5. determine structural response of MDOF systems 6. solve vibration problems involving basic continuous systems such as beams and rods 7. understand Hamilton's principle and Lagrange's equations, and assemble stiffness matrices and EOM efficiently from related energy approach 8. analyze and design tuned-mass-dampers (TMD) 9. understand and apply earthquake response spectra to analyze simple structures subjected to earthquakes
Topics	• Newton's laws of motion, inertial reference frames • Dynamics of single-degree-of-freedom systems ➢ Free and forced vibration, effects of damping ➢ Fourier series and Duhamel integration methods • Dynamics of multiple-degree-of-freedom systems ➢ Stiffness and mass matrices ➢ Rayleigh damping ➢ Normal mode analysis, eigenvalues and eigenvectors

	• Dynamics of continuous systems
	  ➢ Longitudinal vibration of rods
	  ➢ Transverse vibration of beams
	• Special topics
	  ➢ Hamilton's principle and Lagrange's equations
	  ➢ Energy approach and applications to MDOF systems
	  ➢ Tuned mass dampers
	  ➢ Earthquake response spectra

Computer usage	• CAS calculators are used for efficient ODE solving, numerical work and graphing. Free loan of handhelds will be provided.
Lab work	No lab work is required
Contribution to the professional component	100% engineering topics
Relationship to program objectives	***POE1. Provide students with professional skills in the design, construction and management of the civil infrastructure, as well as an awareness of environmental sustainability.*** This course provides students with the basic knowledge of structural dynamics, which is essential in the analysis and design of engineering structures subjected to time-varying excitation. ***POE3. Challenge students with research-type and open-ended design problems to stimulate self-learning and innovative problem solving skills.*** Various computational innovations such as CAS (computer algebra systems) are utilized in this class. These allow students to visualize and solve problems more effectively and efficiently, and explore further on their own (e.g., visualizing the effect of damping on a TMD)
Relationship to CIVL and CIEV program outcomes	***PO1. Acquire fundamental knowledge in mathematics and science on which civil engineering research and practice are based*** Fourier analysis, matrix algebra, differential equations and Newton's law of motion are applied throughout this course. ***PO2. Understand fundamental principles of engineering science relevant to civil engineering disciplines*** Students acquire various engineering principles for dynamic analysis such as resonance behavior and damping, utilizing energy principles to assemble stiffness matrices, etc. ***PO4. Acquire an ability to apply modern engineering and IT tools effectively and efficiently for engineering analysis, design and communication*** Rapid methods utilizing computer algebra systems (CAS) are taught to analyze and visualize vibrating structures more efficiently and effectively than traditional methods allow. ***PO6. Develop technical competency to design civil engineering components and systems, with an understanding of the principles behind the design methodologies*** Students will learn to choose the proper structural parameters for vibration mitigation, such as spring stiffnesses and optimal damping ratio in a TMD.

Assessment of outcomes	• 2 pre-announced in-tutorial quizzes (2×10% = 20%) • 1 midterm (30%) • 1 final (50%) ➢ Quizzes: done in tutorials (pre-announced 1 week prior) ➢ Midterm: held during lecture time
Prepared by	***Dr. Thomas W. C. Hu***
Updated	***Aug. 15, 2023***