The Hong Kong University of Science and Technology

UG Course Syllabus

Course Title: Vibration, Control and Programming

Course Code: MECH 3750

Number of Credits: 3

Pre-requisites: MECH 2020

Name: Zhengbao YANG

Email: zbyang@ust.hk

Office Hours: Monday 1-3 pm, or by email appointments

Course Description

Master the essential principles of vibration that drive innovation in the mechanical, civil, and aerospace industries. This course takes you from the fundamentals of simple vibrations to the complex analysis of multi-degree-of-freedom structures and beams. You will learn to command powerful engineering software like MATLAB and Finite Element Analysis (FEA) to model and solve real-world challenges. Our approach is hands-on and practical. You will transform theory into practice through engaging lectures, interactive labs, and collaborative projects. This method builds teamwork and innovation, giving you a distinct advantage for your final year design project, internships, and job interviews. Assessments are straightforward, balancing exams with creative project work to ensure you learn deeply without unnecessary stress. Graduates from this course are highly sought after for rewarding careers in aerospace, automotive, and civil engineering, etc., where expertise in time-varying systems drives innovation and efficiency.

Intended Learning Outcomes (ILOs)

By the end of this course, students should be able to:

ILO1: Ability to derive 1DoF system equations.

ILO2: Ability to modify, in a design scenario, the system parameters such as stiffness, mass and damping ratio to alter vibration response

ILO3: Ability to determine natural frequencies and vibration shape(s)

ILO4: Ability to apply modern computational techniques (i.e., Matlab and ANSYS for basic vibration analysis)

ILO5: Ability to select and use sensors and actuators

Assessment and Grading

This course will be assessed using criterion-referencing, and grades will not be assigned using a curve. Detailed rubrics for each assignment are provided below, outlining the criteria used for evaluation.

Assessment and Grading:

This course will be assessed using criterion-referencing. Grades will not be assigned using a curve. Student performance will be evaluated according to their demonstrated achievement of the intended learning outcomes (ILOs) via homework assignments, an integrative project, and a mid-term examination. Rubrics and grade descriptors are provided below to clarify the criteria used for evaluation.

Assessment Task	Contribution to Overall Course grade (%)	Due date
Quiz/Assignment	20%	Week 1-12
Mid-term exam	40%	Week 7
Course project	40%	Week 12

Mapping of Course ILOs to Assessment Tasks

Assessed Task	Mapped ILOs	Explanation
Quiz/Assignment	ILO1, ILO2, ILO3, ILO4, ILO5	This task assesses students' ability to catch up on the lecture materials and encourages them to apply learnt knowledge to analyze engineering problems.
Mid-term exam	ILO1, ILO2, ILO3.	This task is to assess students' overall learning outcomes.
Course project	ILO1, ILO2, ILO3, ILO4, ILO5.	This task is designed to motivate students to apply their knowledge and skills to solve real-world engineering problems while also practicing their teamwork and communication skills.

Grading Rubrics:

The following rubrics describe the general criteria used to assess the major assessment components in this course. More detailed task-specific marking schemes may be provided for individual homework assignments, project elements, and examination questions.

Rubric for Assignments

Criteria	Excellent	Good	Satisfactory	Marginal	Fail	Mapto ILOs
Conceptual understanding	Demonstrates clear and accurate understanding of the relevant concepts and physical mechanisms. Correctly explains the assumptions and limitations of the models used.	Shows good understanding of the main concepts, with only minor omissions or imprecision.	Shows adequate understanding of basic concepts but may lack depth or contain some conceptual gaps.	Shows limited understanding; explanations are incomplete or partially incorrect.	Shows little or no understanding of the relevant concepts.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5
Mathematical accuracy and problem solving	Solutions are mathematically sound, logically organized, and lead to correct results with appropriate units and notation.	Solutions are generally correct, with minor algebraic, numerical, or unit errors.	Solutions show reasonable effort and partial correctness but include some significant errors.	Solutions are incomplete or contain major mathematical errors.	Solutions are largely absent, incorrect, or not submitted.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5
Physical interpretation of results	Provides clear interpretation of results, including trends, limiting cases, model assumptions, and engineering significance.	Provides reasonable interpretation, though some details may be missing.	Provides basic interpretation but may not fully connect results to physical behavior.	Provides limited or superficial interpretation.	Provides no meaningful interpretation of results.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5
Clarity of presentation	Work is clear, well structured, legible, and easy to follow, with appropriate equations, diagrams, and explanations.	Work is mostly clear and organized.	Work is understandable but may be disorganized or difficult to follow in places.	Work is poorly organized or hard to follow.	Work is illegible, incoherent, or missing.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5

Rubric for Project

Criteria	Excellent	Good	Satisfactory	Marginal	Fail	Mapto ILOs
Vibration analysis	Accurately applies Vibration theories. Results are clearly interpreted and compared with numerical and/or experimental data.	Performs analysis correctly with minor errors or omissions. Comparisons with numerical and/or experimental results are mostly clear.	Performs basic analysis but with limited depth, some technical errors, or incomplete comparison across methods.	Provides incomplete or weak analysis with significant errors in theory, calculation, or interpretation.	Fails to conduct meaningful vibration analysis.	ILO 1, ILO 2, ILO 3, ILO 4
Integration of analytical, experimental, and numerical methods	Insightfully compares analytical and numerical results; explains similarities and discrepancies.	Compares different methods clearly and identifies major similarities and differences.	Provides some comparison across methods, but discussion is mainly descriptive rather than analytical.	Provides limited comparison with weak explanation of discrepancies.	Provides no meaningful comparison or integration of different analysis methods.	ILO 1, ILO 2, ILO 4
Application	Selects and applies appropriate theories and equations correctly and efficiently.	Applies appropriate methods with mostly correct reasoning and only minor errors.	Applies standard methods to familiar problems but may require clearer justification or contain some procedural errors.	Attempts to apply relevant methods but with significant errors or weak justification.	Fails to apply appropriate methods or uses irrelevant approaches.	ILO2, ILO 3, ILO 4, ILO 5
Quality of figures, tables, and data presentation	Figures, tables, equations, and plots are accurate, clearly labelled, well formatted, and used effectively to support technical arguments.	Most figures, tables, and plots are clear and accurate, with minor formatting or labeling issues.	Presentation is adequate but may include unclear plots, missing labels, or limited use of supporting data.	Presentation is difficult to follow, with poorly prepared or incomplete figures and tables.	Presentation is absent, unclear, or technically unusable.	ILO 1, ILO 2, ILO 3
Physical reasoning and engineering judgement	Demonstrates strong physical insight, recognizes limitations of methods, and makes sound engineering judgements about dynamic design implications.	Provides good physical explanations and reasonable engineering judgement	Provides basic explanations but may lack depth or miss some important implications	Provides limited or superficial physical reasoning.	Provides no meaningful physical reasoning or engineering judgement.	ILO 1, ILO 2, ILO 3, ILO 4, ILO 5

Rubric for <u>Examination</u>

Criteria	Excellent	Good	Satisfactory	Marginal	Fail	Mapto ILOs
1 DOF vibration analysis	Correctly and independently applies lumped-parameter vibration theory and related analytical tools to calculate vibration responses of structures	Applies theories and methods mostly correctly with minor errors.	Applies vibration analysis methods to familiar problems but with some errors or incomplete reasoning.	Shows limited ability to apply vibration analysis methods.	Fails to apply basic tools for vibration response estimation .	ILO 1
Analysis of stiffness, mass and damping	Clearly explains and quantifies the dynamic system parameters such as stiffness, mass and damping to vibration responses	Demonstrates good understanding of stiffness, mass and damping ratio with minor omissions.	Demonstrates adequate understanding of basic vibration effects but with limited depth.	Demonstrates limited or fragmented understanding of vibration theory.	Demonstrates insufficient understanding of lumped-parameter vibration	ILO 2
Mode analysis	Clearly explains and analyzes natural frequencies and vibration shapes of different structures.	Provides good analysis of vibration modes with minor errors or omissions.	Provides adequate discussion or calculation of vibration modes but may lack depth.	Shows limited understanding of the vibration mode analysis	Fails to explain the basic vibration modes.	ILO 3

Final Grade Descriptors

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Demonstrates a comprehensive grasp of subject matter, expertise in problem-solving, and significant creativity in thinking. Exhibits a high capacity for scholarship and collaboration, going beyond core requirements to achieve learning goals.
B	Good Performance	Shows good knowledge and understanding of the main subject matter, competence in problem-solving, and the ability to analyze and evaluate issues. Displays high motivation to learn and the ability to work effectively with others.
C	Satisfactory Performance	Possesses adequate knowledge of core subject matter, competence in dealing with familiar problems, and some capacity for analysis and critical thinking. Shows persistence and effort to achieve broadly defined learning goals.
D	Marginal Pass	Has threshold knowledge of core subject matter, potential to achieve key professional skills, and the ability to make basic judgments. Benefits from the course and has the potential to develop in the discipline.
F	Fail	Demonstrates insufficient understanding of the subject matter and lacks the necessary problem-solving skills. Shows limited ability to think critically or analytically and exhibits minimal effort towards achieving learning goals. Does not meet the threshold requirements for professional practice or development in the discipline.

Course AI Policy

The use of artificial intelligence (AI) tools is permitted in this course for learning support, brainstorming, checking understanding, improving writing clarity, and assisting with coding or software-related tasks. However, students remain fully responsible for the accuracy, originality, and integrity of all submitted work.

For homework and project submissions, students may use AI tools to support their learning, but they must ensure that the final submitted work reflects their own understanding and reasoning. Students should not submit AI-generated solutions without verification, explanation, and independent judgement. Any use of AI that contributes substantively to submitted work should be acknowledged where appropriate.

During the final examination, the use of AI tools is not permitted.

Communication and Feedback

Assessment marks for individual assessed tasks will be communicated in class within two weeks of submission. Students who have further questions about the feedback, including marks, should consult the instructor within five working days after the feedback is received.

Late submission Policy

To ensure fairness for students who submit assignments on time, a penalty for late submission is listed as follows:

- Late submission within 12 hours, 25% penalty will be applied.
- Late submission between 12 to 24 hours, 50% penalty will be applied.
- Late submission for more than 24 hours will not be accepted.

Required Texts and Materials

S.S. Rao, Mechanical Vibration, 5/e, Prentice Hall, 2011.

Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to Academic Integrity | HKUST – Academic Registry for the University's definition of plagiarism and ways to avoid cheating and plagiarism.