Engineering Tripos Part IIB, 4C6: Advanced Linear Vibrations, 2024-25

Module Leader

Dr JP Talbot [1]

Lecturers

Dr JP Talbot, Dr Tore Butlin [2]

Lab Leader

Dr JP Talbot [1]

Timing and Structure

Michaelmas term. 13 lectures + 2 examples classes + coursework. Assessment: 75% exam/25% coursework. This course will be delivered in-person in 2021-22.

Prerequisites

3C6 assumed.

Aims

The aims of the course are to:

- teach some essential tools for the understanding, analysis and measurement of vibration in engineering structures.

Objectives

As specific objectives, by the end of the course students should be able to:

- be familiar with the theory and practice of modal analysis and its application to engineering structures.
- apply experimental modal techniques.
- understand the vibration behaviour of idealised system components, and be able to draw implications from this for complex coupled systems.
- appreciate the physical principles of vibration damping.
- analyse simple damped vibrating systems.

Content

Introduction (1L, Dr JP Tabot)

Outline of course and introduction to the laboratory experiment.

Measurement methods and modal analysis (4L, Dr JP Talbot)

- Instrumentation for vibration measurement;
- Review of modal analysis; General properties of vibration response;
- Introduction to experimental modal analysis; Modelling the bounce of a hammer;
- Applications.

Analysis of damped systems (4L, Dr Tore Butlin)

- Mechanisms of damping: complex modulus, boundary dissipation, lumped dissipative elements;
- Adding damping to structures, constrained and unconstrained layers;
- Viscous damping, complex modes.

System components and coupling (4L Dr Tore Butlin)

- The Helmholtz resonator and its uses;
- Review of beam, membrane and plate governing equations;
- The circular membrane, Bessel functions, mode shapes and frequencies;
- Coupling of subsystems, constraints and the interlacing theorem.

Further notes

Coursework

One laboratory experiment on experimental modal analysis, to be performed in pairs, essentially unsupervised. A booking sheet will offer a wide range of possible times at which the experiment may be performed. A normal laboratory write-up is to be prepared, which will be assessed for the coursework credit. Total time commitment will be comparable to a Part IIA experiment plus FTR.

Coursework	Format	Due date & marks
Lab experiment: modal analysis Measure vibration transfer functions over a grid of points covering a simple structure, then use modal analysis techniques explained in the lectures to infer the first few mode shapes. <u>Learning objective:</u> • Revise measurement procedures for transfer functions • Consolidate and apply material from lectures on modal fitting • Develop critical skills in interpreting modal data • Undertake a small-scale industrial-style application of the method, to modify a structure to meet vibration targets	Individual/pair Report Anonymously marked	Complete should be via Moodl file by 4p Dec [15/15]

Booklists

Please refer to the Booklist for Part IIB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

E4

Understanding of and ability to apply a systems approach to engineering problems.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

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