

## **Engineering Tripos Part IIB, 4C6: Advanced Linear Vibrations, 2025-26**

### **Module Leader**

[Dr T Butlin](#) [1]

### **Lecturers**

[Dr Tore Butlin](#) [2]

### **Timing and Structure**

Michaelmas term. 13 lectures + 2 examples classes + coursework. Assessment: 75% exam/25% coursework.

### **Prerequisites**

3C6 assumed.

### **Aims**

The aims of the course are to:

- teach advanced tools for the understanding, measurement, attenuation, and analysis 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.
- analyse simple damped vibrating systems.
- understand the physical principles of vibration damping and methods for deliberately introducing damping.
- understand the vibration behaviour of idealised system components, and be able to draw implications from this for complex coupled systems.
- be able to analyse simple systems from a wave propagation perspective.
- understand the properties of periodic structures (metamaterials) and be able to predict their behaviour.

### **Content**

#### **Measurement methods and modal analysis (4L, Dr Tore Butlin)**

- Instrumentation for vibration measurement;
- Review of modal analysis; General properties of vibration response;
- Introduction to experimental modal analysis; Modelling the bounce of a hammer;
- Signal processing techniques for identifying useful information from vibration tests;
- Applications.

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

- Mechanisms of damping: complex modulus, boundary dissipation, lumped dissipative elements;
- Methods for adding damping to structures;
- Feedforward active noise control;
- Viscous damping, complex modes;
- The Helmholtz resonator and its uses.

**System components and modelling techniques (4L Dr Tore Butlin)**

- The circular membrane, Bessel functions, mode shapes and frequencies;
- Understanding vibration from a wave propagation perspective;
- Periodic structures and metamaterials;
- Numerical techniques for complex structures;
- 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
<p><b>Lab experiment: modal analysis</b></p> <p>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.</p> <p><u>Learning objective:</u></p> <ul style="list-style-type: none"> <li>• Revise measurement procedures for transfer functions</li> <li>• Consolidate and apply material from lectures on modal fitting</li> <li>• Develop critical skills in interpreting modal data</li> <li>• Undertake a small-scale industrial-style application of the method, to modify a structure to meet vibration targets</li> </ul>	<p>Individual/pair</p> <p>Report</p> <p>Anonymously marked</p>	<p>Complete should be via Moodle file by 4pm Dec</p> <p>[15/15]</p>

**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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**Links**

[1] <mailto:tb267@cam.ac.uk>

[2] <mailto:tb267>

[3] <https://teaching26-27.eng.cam.ac.uk/content/form-conduct-examinations>

[4] <https://teaching26-27.eng.cam.ac.uk/content/uk-spec>