Engineering Tripos Part IIB, 4C6: Advanced Linear Vibrations, 2019-20

Module Leader
Dr JP Talbot [1]

Lecturers
Prof RS Langley and Dr JP Talbot [2]

Lab Leader
Dr JP Talbot [1]

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 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.

Analysis of damped systems (4L, Prof RS Langley)

- 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 Prof RS Langley)

- 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.

<table>
<thead>
<tr>
<th>Coursework</th>
<th>Format</th>
<th>Due date &amp; marks</th>
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<tbody>
<tr>
<td><strong>Lab experiment: modal analysis</strong></td>
<td>Individual/pair</td>
<td>Before final lab is a feedback lab</td>
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<tr>
<td>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.</td>
<td>Report</td>
<td>Wed week 8</td>
</tr>
<tr>
<td>Learning objective:</td>
<td>Anonymously marked</td>
<td>[15/15]</td>
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- 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

Booklists

Please see the [Booklist for Group C Courses](3) for references for this module.

Examination Guidelines

Please refer to [Form & conduct of the examinations](4).

UK-SPEC

The [UK Standard for Professional Engineering Competence (UK-SPEC)](5) describes the requirements that have
to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the 'Accreditation of Higher Education Programmes’ (AHEP) document [6] which sets out the standard for degree accreditation.

The Output Standards Matrices [7] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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Links
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