Engineering Tripos Part IIB, 4A15: Acoustics, 2022-23

Module Leader

Dr A Agarwal [1]

Lecturers

Dr A. Agarwal and Dr W. Graham

Timing and Structure

Lent term: 16 lectures + 2 examples classes; Assessment: 100% exam

Prerequisites

No prerequisites. The module would be of interest to students with Aero, Mechnical, Bio or Civil Engineering background.

Aims

The aims of the course are to:

- analyse and solve a range of practical engineering problems associated with acoustics.

Objectives

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

- understand what sound is and how we perceive it
- understand how sound is generated and propagated
- understand the acoustics of a wide range of music and noise production

Content

We will analyse and solve a range of practical engineering problems associated with acoustics. Examples include modelling of noise sources from jets, fans, musical instruments, human voice, kettles, dripping taps, whistling mice, singing flames, etc. We will also study ways to reduce noise either at the source or through acoustic damping. Upon completion of this module, the students would be well placed to pursue academic research in the area of acoustics and related fields or to work in industry (the topics covered in the course is of interest to GE, Rolls-Royce, Airbus, Dyson, Mitsubishi Heavy Industries, automotive companies, music and biomedical industries, and acoustic consultancies).

What is sound and how does it propagate? (5L) (Dr A Agarwal)

- Introduction
- The wave equation
- Some simple 3D wave fields (plane waves, surface waves and spherical waves)

- Sound transmission through different media

Simples sounds sources (2L) (Dr A Agarwal)

- Pulsating sphere
- Oscillating sphere
- Example: loudspeaker with and without a cabinet

General solution to wave eqn (2L) (Dr. A Agarwal)

- Green's function
- Sound from general mass and force sources (examples, Bliz siren and singing telephone wires)

Jet noise (Dr A Agarwal) (1 L)

- Scaling of jet noise. How much does jet noise increase by if we double the jet's velocity?
- What do jets and tuning forks have in common?
- Lighthill's acoustic analogy
- Sound of aircraft jets and handdriers

Duct acoustics (2 L) (Dr A Agarwal)

- Rectangular ducts (example, sound box)
- Low-frequency sound in ducts
- Circular ducts
- Acoustic liners (Helmholtz resonator, blowing over a beer bottle)

Musical acoustics & everyday things (3L) (Drs A Agarwal)

- String instruments
- Wind instruments
- Brass instruments
- Whistling of steam kettles and Rayleigh's Bird Call
- Acoustics of dripping taps

Vocalisation (0.5 L) (Dr A Agarwal)

- Human speech, singing and overtone singing
- Mice mating calls

Fan noise (1L) (Dr A Agarwal)

- Rotor alone noise
- Rotor-stator interaction noise

Thermoacoustics instability (0.5 L) (Dr A Agarwal)

- Rijke tube experiment (singing flames)

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 [2].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [3] 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.

P1

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

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

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.

US4

An awareness of developing technologies related to own specialisation.

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