Engineering Tripos Part IB, 2P6: Fourier Transforms & Signal and Data Analysis, 2021-22

Course Leader

Prof S J Godsill [1]

Lecturer

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Timing and Structure

Lent Term: 7 lectures Weeks 1-3, 2 lectures, week 4, 1 lecture

Aims

The aims of the course are to:

- Introduce the Fourier Transform as an extension of Fourier techniques on periodic functions and to see how the Fourier Transform is applied to real problems
- Introduce discrete Fourier methods and to develop skills in analysing discrete data.

Objectives

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

- develop the ability to discuss and manipulate signals in terms of their frequency content.
- relate properties of signals in the time domain to those in the frequency domain.
- be familiar with the difference in behaviour/properties of continuous signals compared to sampled signals, and the basic rules that apply to the latter.

Content

Introduction and preliminaries

- Motivation for signal analysis. Examples of typical datasets.
- Power and energy
- Revision and extension of delta functions
- Revision of Fourier series

The Fourier Transform (FT)

- Mathematical formulation of the FT
- Interpretation of the FT
- The inverse Fourier transform (IFT)
- Some important Fourier transforms

Properties of the Fourier Transform

- Linearity and scaling
- Time and frequency shifts (modulation)
- Duality, Parseval's Theorem, convolution
- Relationship to Laplace transforms

Sampling Theory

- The sampling theorem and aliasing
- The discrete time Fourier transform
- Signal reconstruction and the Nyquist frequency

The Discrete Fourier Transform

- Derivation of DFT and inverse DFT
- Examples of using the DFT
- The spectrogram

Booklists

Please refer to the Booklist for Part IB 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.

IA3

Comprehend the broad picture and thus work with an appropriate level of detail.

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.

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.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

US4

An awareness of developing technologies related to own specialisation.

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Links
[1] mailto:sjg30@cam.ac.uk
[2] https://teaching21-22.eng.cam.ac.uk/content/form-conduct-examinations
[3] https://teaching21-22.eng.cam.ac.uk/content/uk-spec