Engineering Tripos Part IIA, 3F1: Signals & Systems, 2018-19

Module Leader

Dr T O'Leary [1]

Lecturers

Dr T. O'Leary and Dr F. Forni [2]

Lab Leader

Prof M Smith [3]

Timing and Structure

Michaelmas term. 16 lectures.

Aims

The aims of the course are to:

- Cover three basic topics in signals and systems which provide the basis for further topics in signal processing, communications, control and related subjects.
- Introduce the z-transform, which is the generalisation of the Laplace transform to discrete time systems.
- Introduce digital filtering.
- Introduce stochastic processes.

Objectives

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

- Be familiar with the theory and application of the z-transform.
- Analyse the stability of discrete-time systems
- Understand the use of correlation and spectral density functions.
- Analyse the behaviour of linear systems with random inputs.

Content

Enabling theory, application and design, Dr T. O'Leary and Dr F. Forni

Introduction to signals and systems, discrete time signals and systems, Z-transform (5L – O'Leary)

- Discrete signals and systems, LTI systems, convolution.
- z-transform and solution of linear difference equations
- System analysis in the z-domain.
- Impulse and frequency responses.

Applications & digital filtering (8L – Forni)

- Design and properties of digital feedback systems. Nyquist stability criterion.
- Design and properties of Digital Filters, FIR and IIR
- Analysis of systems with discrete/continuous interfaces.
- DTFT/DFT and links to z-transforms
- The Fast Fourier Transform (FFT)
- Windowed spectral analysis of data
- Introduction to 2D filtering, image analysis

Introduction to random processes and linear systems (3L – O'Leary)

- Continuous time random processes, correlation functions, spectral density.
- Response of continuous time linear systems to random excitation.

Coursework

Flight control

Learning objectives:

- Simulation of various aircraft models on the computer.
- Study real-time (manual) control and the limitations imposed by time delays.
- Design of a simple autopilot.
- Illustrate frequency response concepts in analogue and digital control systems, conditions for oscillation in feedback systems and stability.
- Gain familiarity with MATLAB.

Practical information:

- Sessions will take place in the EIETL laboratory on Wednesdays and Fridays of full term from 11am-1pm.
- Students will find it helpful to read through the lab sheet in advance of carrying out the experiment.
- Students will have the option to submit a Full Technical Report.

Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please see the Booklist for Part IIA Courses [4] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [5].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [6] 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.

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.

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Links
[1] mailto:tso24@cam.ac.uk
[2] mailto:tso24@cam.ac.uk, f.forni@eng.cam.ac.uk
[3] mailto:mcs@eng.cam.ac.uk
[4] https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=48921
[5] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[6] https://teaching.eng.cam.ac.uk/content/uk-spec