

Engineering Tripos Part IIA, 3F2: Systems & Control, 2018-19

Module Leader

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Timing and Structure

16 Lectures, Lent Term

Aims

The aims of the course are to:

- make students familiar with “state-space” methods of modelling and analysing dynamic systems. These methods are extremely important for control engineering, signal processing, and related subjects.

Objectives

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

- understand what a state-space model is, and how to obtain such a model;
- relate state-space models to transfer-function models;
- analyse the behaviour and structure of a state-space model;
- have some understanding of feedback design using state-space, transfer function and root-locus techniques, and be able to relate them to each other;
- appreciate the need for and usefulness of state observers, and their role in feedback and other systems.

Content

State-space models (6L)

- Review of second-year material (linear algebra, transfer functions, poles)
- Formulation from physical models
- Linearising nonlinear models
- Relationship to transfer function matrix (multiple inputs/outputs)
- Free and forced responses (state-transition matrix convolution, stability)
- Interconnections of systems

Feedback system design (4L)

- Review of second-year material (frequency responses, controller structures, objectives of feedback)

design).

- The root-locus diagram
- Routh-Hurwitz criterion (examples of use).

State estimation (3L)

- Observability.
- State observer; Observer design.
- Connections to Kalman filters, sensor fusion etc.

Control in state-space framework (3L)

- Controllability.
- State feedback and pole-placement.
- Optimal control.
- State observer combined with state feedback

Examples papers

Paper 1: State-space models - issued in week 3

Paper 2: Root locus - issued in week 5

Paper 3: Observers and state feedback - issued in week 7

Coursework

Inverted pendulum experiment (state feedback). Laboratory report and/or full technical report.

Ball and beam experiment (state trajectories, nonlinear control). Laboratory report only.

Learning objectives:

- State feedback
- Pole placement
- Control design

Practical information:

- Sessions will take place in **EIETL laboratory**, on Wednesdays and Fridays of full term
- Students will find it helpful to read through the lab sheet in advance of carrying out the experiment.).

Full Technical Report:

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

Booklists

Please see the [Booklist for Part IIA Courses](#) [2] for references for this module.

Examination Guidelines

Please refer to [Form & conduct of the examinations](#) [3].

UK-SPEC

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [4] 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 [5] which sets out the standard for degree accreditation.

The [Output Standards Matrices](#) [6] 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

[1] <mailto:gv103@cam.ac.uk>

[2] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=48931>

[3] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[4] <http://www.engc.org.uk/ukspec.aspx>

[5] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/>

[6] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>