# Engineering Tripos Part IIB, 4F2: Robust and Nonlinear Control, 2021-22

### Module Leader

Prof R Sepulchre [1]

### Lecturers

Prof R Sepulchre and Dr F Forni [2]

### Timing and Structure

Lent term. 14 lectures + 2 computer lab sessions. Assessment: 100% coursework

### Prerequisites

3F2 assumed.

## Aims

The aims of the course are to:

- introduce fundamental concepts from nonlinear dynamic systems
- introduce techniques for the analysis and control of nonlinear and multivariable systems.

## Objectives

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

- apply standard analysis and design tools to multivariable and nonlinear feedback systems.
- appreciate the diversity of phenomena in nonlinear systems.

## Content

**Part I. ROBUST CONTROL (7L + 1 Computer Lab session, Prof R. Sepulchre)**

1. Uncertainty and Nonlinearity in control systems: simple models.

2. Signal spaces and system gains.

3. The small-gain theorem and the passivity theorem. Phase versus gain uncertainties

4. Dissipativity theory

5. Robust stability and performance. Stability margins.

6. An introduction to H-infty control.

7. Gap metrics

**PART 2: NONLINEAR SYSTEMS (7L + 1 computer lab session, Dr F Forni)**

1. Small and large signal analysis. Contractive systems. Fading memory operators.

2. State-space analysis and Nyquist. Differential stability. Differential dissipativity. Differential circle criterion.

3. Feedback systems: simple models.

4. Phase portrait analysis.

5. Analysis and design of switches and clocks. Robust differential control.

6. Monotone systems. Contraction of cones. Polyhedral cones. Applications in biology.

7. Describing function analysis.

## Further notes

ASSESSMENT

Coursework only.

## Coursework

| Coursework | Format | Due date & marks |
|---|---|---|
| **[Coursework activity #1 Robust control of haptic interfaces**<br><br>Coursework 1 brief description<br><br>Learning objective:<br><br>• Learn how to model uncertainty in an engineering application<br>• Design a robust controller in Matlab | Individual Report<br><br>anonymously marked | 25 February 2<br><br>[30/60] |
| **[Coursework activity #2 Feedback oscillations control ]**<br><br>Coursework 2 brief description<br><br>Learning objective:<br><br>• Learn how to model and analyse nonlinear oscillations in feedback systems<br>• Design a nonlinear oscillator in a biologically motivated appication | Individual Report<br><br>anonymously marked | 25 March 20<br><br>[30/60] |

## 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 [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.

Last modified: 27/09/2021 09:29



**Links**
[1] mailto:rs771@cam.ac.uk
[2] mailto:rs771@cam.ac.uk, ff286@cam.ac.uk,
[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