Engineering Tripos Part IIB, 4F2: Robust and Nonlinear Control, 2020-21

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


4. Phase portrait analysis.

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


7. Describing function analysis.

Further notes

ASSESSMENT

Coursework only.

Coursework

<table>
<thead>
<tr>
<th>Coursework activity #1 Robust control of haptic interfaces</th>
<th>Format</th>
<th>Due date &amp; marks</th>
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</thead>
<tbody>
<tr>
<td>Coursework 1 brief description</td>
<td>Individual Report</td>
<td>24 February 2021</td>
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<tr>
<td>Learning objective:</td>
<td>anonymously marked</td>
<td>[30/60]</td>
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<tr>
<td></td>
<td>• Learn how to model uncertainty in an engineering application</td>
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<td></td>
<td>• Design a robust controller in Matlab</td>
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<tr>
<th>Coursework activity #2 Feedback oscillations control</th>
<th>Format</th>
<th>Due date &amp; marks</th>
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<tbody>
<tr>
<td>Coursework 2 brief description</td>
<td>Individual Report</td>
<td>24 March 2021</td>
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<tr>
<td>Learning objective:</td>
<td>anonymously marked</td>
<td>[30/60]</td>
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<td></td>
<td>• Learn how to model and analyse nonlinear oscillations in feedback systems</td>
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<td></td>
<td>• Design a nonlinear oscillator in a biologically motivated application</td>
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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](http://teaching.eng.cam.ac.uk/content/form-conduct-examinations) [3].

**UK-SPEC**

The [UK Standard for Professional Engineering Competence (UK-SPEC)](http://www.engc.org.uk/ukspec.aspx) [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](http://teaching.eng.cam.ac.uk/content/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: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](http://teaching.eng.cam.ac.uk/content/form-conduct-examinations)
[6] [http://teaching.eng.cam.ac.uk/content/output-standards-matrices](http://teaching.eng.cam.ac.uk/content/output-standards-matrices)