Control Systems MSc Programme Specification

This specification provides a concise summary of the main features of the programme and the learning outcomes that a typical student might reasonably be expected to achieve and demonstrate if he/she takes full advantage of the learning opportunities that are provided. The latest version of this Programme Specification is available on [http://www3.imperial.ac.uk/electricalengineering/teaching/msc/control](http://www3.imperial.ac.uk/electricalengineering/teaching/msc/control). The Control Systems MSc Welcome Booklet will be distributed to the MSc students when they arrive and is available on-line to staff and relevant students by following the above web link. The accuracy of the information contained in this document is reviewed by Imperial College London and may be checked by the Quality Assurance Agency.

<table>
<thead>
<tr>
<th>1. Awarding Institution / Body</th>
<th>Imperial College London</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Teaching Institution</td>
<td>Imperial College London</td>
</tr>
<tr>
<td>3. External Accreditation by</td>
<td>Not applicable</td>
</tr>
<tr>
<td>4. Final Award</td>
<td>MSc and DIC</td>
</tr>
<tr>
<td>5. Programme Title</td>
<td>Control Systems</td>
</tr>
<tr>
<td>6. UCAS Code (or other coding</td>
<td>J9U4</td>
</tr>
<tr>
<td>system if relevant)</td>
<td></td>
</tr>
<tr>
<td>7. Relevant QAA Subject</td>
<td>Engineering</td>
</tr>
<tr>
<td>8. Date of production/revision</td>
<td>September 2015 for 2015-16</td>
</tr>
</tbody>
</table>

9. Educational Aims of the Programme

The programme is intended to:

- Provide the theoretical basis for classical and modern control theory with associated design methods and algorithms
- Produce graduates equipped to pursue careers that might involve modelling and/or classical and modern control concepts, theories, methods and controller design packages in industry and economic modelling for finance and the public sector;
- Enable graduates to recognise and tackle problems to which control can be applied;
- Offer students from a variety of mathematics-based disciplines, or who have been at work for some time, the opportunity to learn and/or refresh and/or deepen their knowledge and understanding of control;
- Provide a good background that will:
  - enable graduates to update their knowledge after they leave by reading the professional literature;
  - assist graduates wishing to undertake research in or involving control.

10. Programme Outcomes

The programme provides opportunities for postgraduate students to develop and demonstrate knowledge and understanding, qualities, skills and other attributes in the following areas. The programme outcomes are referenced (B) to the Benchmark Statement for Engineering.

### Knowledge and understanding

<table>
<thead>
<tr>
<th>A Knowledge and understanding of:</th>
<th>Teaching / learning methods and strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. fundamental concepts and principles underpinning control system theory and design, including those associated with linear and non-linear deterministic systems, stochastic systems, modelling, optimisation, control system design, on-line control.</td>
<td>Acquisition of A1 and A2 is through a combination of lectures, seminars, computer-based work, coursework and guided reading.</td>
</tr>
<tr>
<td>2. the essential facts, concepts, principles and theories relevant to the student’s chosen area of research for the individual project (B);</td>
<td>A4 is supported by various aspects of the individual research project and by attendance at a number of (GSEPS) skills workshops.</td>
</tr>
<tr>
<td>3. information retrieval as a research technique;</td>
<td>The students are encouraged throughout to undertake independent reading both to supplement and consolidate material relevant to the lectures and project and to broaden their individual knowledge and understanding of the control area.</td>
</tr>
<tr>
<td>4. management and communication skills, including problem definition, project design, decision processes, written reports, scientific publications (B)</td>
<td>Assessment of the knowledge base is through a combination of unseen written examinations and assessed coursework (A1) as well as the individual research project (A2 - A4).</td>
</tr>
</tbody>
</table>
## Skills and Other Attributes

### B. Intellectual (thinking) skills - able to:

1. **(Analysis)** model systems mathematically and apply relevant theory to study their properties and performance;
2. **(Synthesis)** apply control concepts and theory to the solution of control problems;
3. **(Computing)** apply computational principles and techniques to control problems;
4. **(Evaluative)** plan, conduct and report on a programme of original research

#### Teaching/learning methods and strategies

Intellectual skills are developed through the teaching and learning methods outlined above and in section 11, with some experience of team work. Assessment is through coursework, unseen written examinations and project work.

### C. Practical skills – able to:

1. Formulate mathematical models of systems and identify the parameters of such models from observations using appropriate statistical techniques;
2. Solve control analysis and synthesis problems using appropriate statistical, frequency-response and state-space methods;
3. Analyse and interpret computed results;
4. Write programs using at least one common language (Matlab);
5. Understand the literature so personal knowledge and skills can be kept up-to-date;
6. Define problems and design/manage associated projects;
7. Write effective technical reports

#### Teaching/learning methods and strategies

Practical skills are developed through the teaching and learning programme outlined above (and in section 11).

Practical computational skills regarding C1-4 are developed through coursework and project work and through interaction with research supervisor(s) and (sometimes) research students. Skills C6-7 are taught and developed through guided reading and (GSEPS) workshops and practice, with feedback, associated with the individual project. Practical skills are assessed where appropriate through the coursework and project work.

### D. Transferable skills – able to:

1. Communicate effectively, as a result of clear and precise thinking, using presentations, web-pages and written reports (B);
2. Apply knowledge skills to new control problems;
3. (Management skills) formulate problem definitions; design and evaluate projects using objective criteria (B);
4. Transfer techniques and solutions from one discipline to another;
5. Use Information and Communications Technology (B);
6. Manage resources and time (B);
7. Learn independently with open-mindedness and critical enquiry (B);
8. Learn effectively for the purpose of continuing professional development (B)

#### Teaching/learning methods and strategies

Transferable skills are developed through the teaching and learning programme outlined above and in section 11.

Skill D1 is taught through (GSEPS) workshops and feedback on individual project work.

Skills D2-6 are taught mainly through the individual research project.

Skill D7 is developed throughout the course within a framework of staged coursework deadlines and the examination system. Although not explicitly taught, skills D8 and D9 are encouraged and developed throughout the course, which is structured and delivered in such a way as to promote this.

Skill D1 is assessed through written examinations, course work and the individual project.

Skills D2-D7 are assessed through coursework, written examinations and project work.

Skills D8-9 are assessed through project work.
### Programme structures and features, curriculum units (modules), credit and award requirements

**Examinations**

The modules available are listed below. Each student is free to choose the 8 or 9 modules on which to be examined, constrained only by at least 4 being ‘core’ modules (please see the tables below). Unless otherwise stated below, each subject is assessed by coursework and by an unseen written examination at the start of Term 3. For subjects with written examination and coursework, the module mark is determined as $0.75 \times \text{exam mark} + 0.25 \times \text{coursework mark}$. The overall mark for the examinations is the average of the best 8 module marks that include at least 4 core modules.

**Laboratory**

This consists of experiments carried out during the autumn and spring terms.

**Individual Research Project**

This is executed part-time from January to March and full-time from after the last exam (usually late May) to Friday 9th September 2016.

**Poster Presentation**

Presentations take place on Monday 12th September 2016.

**Award of the MSc**

A student will be awarded the highest grade of MSc for which the following conditions are satisfied:

- **MSc**
  1. at least 40% for each of the 8 modules counted for the computation of the examinations average
  2. at least 50% for the laboratory average
  3. at least 50% for both the project and examinations average

- **MSc with Merit**
  1. at least 40% for each of the 8 modules counted for the computation of the examinations average
  2. at least 50% for the laboratory average
  3. at least 60% for both the project and examinations average

- **MSc with Distinction**
  1. at least 40% for each of the 8 modules counted for the computation of the examinations average
  2. at least 50% for the laboratory average
  3. at least 70% for both the project and examinations average.

### Term 1

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE9-CS1-1</td>
<td>Control engineering (not examinable, for revision only)</td>
</tr>
<tr>
<td>EE9-CS2-1</td>
<td>Core Stability and control of nonlinear systems</td>
</tr>
<tr>
<td>EE9-CS2-2</td>
<td>Discrete-event systems</td>
</tr>
<tr>
<td>EE9-CS3-1</td>
<td>Mathematics for signals and systems</td>
</tr>
<tr>
<td>EE9-CS3-2</td>
<td>Core Optimization</td>
</tr>
<tr>
<td>EE9-CS5-1</td>
<td>Probability and stochastic processes</td>
</tr>
<tr>
<td>EE9-CS5-2</td>
<td>Core Systems identification</td>
</tr>
<tr>
<td>EE9-CS6-1</td>
<td>Modelling and control of multi-body mechanical systems</td>
</tr>
<tr>
<td>EE9-CS7-23</td>
<td>Coding theory</td>
</tr>
</tbody>
</table>

### Term 2

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE9-CS1-2</td>
<td>Core Design of linear multivariable control systems</td>
</tr>
<tr>
<td>EE9-CS1-3</td>
<td>Core Discrete-time systems and computer control</td>
</tr>
<tr>
<td>EE9-CS4-1</td>
<td>Core Predictive control</td>
</tr>
<tr>
<td>EE9-CS5-3</td>
<td>Core Estimation and fault detection</td>
</tr>
<tr>
<td>EE9-CS6-2</td>
<td>Power system control, measurement and protection</td>
</tr>
<tr>
<td>EE9-CS7-1</td>
<td>Topics in control systems (examined by coursework alone)</td>
</tr>
<tr>
<td>EE9-CS7-2</td>
<td>Games Theory</td>
</tr>
</tbody>
</table>

A control-related course

One course selected from courses on wavelets and applications, traffic theory and queuing systems, intelligent data and probabilistic inference, distributed computation and networks: a performance perspective, information theory, real-time digital signal processing and machine learning for computer vision. The choice is somewhat restricted owing to timetabling issues.

### Project

Choose and begin work on the Individual Research Project; normally the project is chosen from those offered by staff however a student may undertake a suitable self-proposed project or a suitable project at another university or a company (not necessarily in the UK). Suitability is determined by the Programme Director.

### Term 3

Unseen written examinations in April-May followed by work on the Individual Research Project until Friday 9th September 2016.
### 12. Support for students and their learning

- An induction programme during the first week for orientation, introduction to library and information technology, and the Department;
- MSc Course Handbook 2015-16, which includes descriptions of each lecture course;
- Staff student ratio for teaching: 12 teaching staff for a class size that has varied recently between 15 and 40;
- Immediate access by email to staff for academic help or pastoral care;
- Personal Tutors who act as an interface between the student and the Administration;
  - The Postgraduate Tutor, Senior Tutor, Director of Postgraduate Studies, Postgraduate Administrator and Advisor to Women Students are available if Personal Tutors do not suffice;
- A large community of postgraduate research students and postdoctoral researchers who work in the Control area. The research programmes in the Department provide general as well as specific support for appropriate individual projects;
- Library and other learning resources and facilities;
- Dedicated computing facilities;
- Many visiting speakers;
- Access to student counsellors and College Tutors on the South Kensington site;
- Access to Teaching and Learning Support Services for assistance and guidance and to the Imperial College Careers Advisory Service

### 13. Criteria for admission

Our academic entry requirement is a 1st Class Honours degree in Electrical Engineering, Physics or Mathematics from a UK academic institution. If studying at a Chinese university we would be looking for an overall degree total of 85%+. If you are studying on a 2+2 programme we would be looking for a 1st Class degree with a final year mark of 75%. Offers made to students are initiated by the Postgraduate Admissions Tutor. When an applicant has a lesser degree qualification but has at least 3 years of work experience, exceptionally the Postgraduate Admissions Tutor will make a special case for admission; few such applications are made.

### 14. Methods for evaluating and improving the quality and standards of teaching and learning

#### Mechanisms for review and evaluation of teaching, learning, assessment, the curriculum and outcome standards

- Module reviews, based on feedback questionnaires.
- Annual course review prepared by the Course Director for the Examiners’ Meeting
- Biennial review of the course by an Imperial College academic staff member from outside the Department with a report and grading to the Quality and Academic Review Committee.
- MSc Staff – Student Committee, which meets each term and reports to the Departmental Teaching Committee.
- Biennial staff appraisal.
- Peer teaching observations.
- External Examiner’s reports
- Employer needs and opinions feed into the programme through guest lecturers from industry, student placements in relevant industries, industry-based projects, past students, our Strategic Advisory Group as well as collaboration between academic staff and industry in research and consultancy. The aims of the Strategic Advisory Group are concerned with Departmental coupling to the long term requirements of industry, both for research and education, including the content of MSc courses, topics for projects and co-operative studentships. At present the Strategic Advisory Group contains members from at least 14 external organisations (either companies or government research establishments).
- Periodic review of Departmental teaching by an external panel with members drawn from another university, a research institute and industry.

#### Committees with responsibility for monitoring and evaluating quality and standards

- Postgraduate Staff – Student Committee
- Undergraduate Course Committee regarding courses also taken by MEng. students
- Board of Examiners – meets in November to consider awards
- MSc Course Development Committee
- Postgraduate Quality Committee
- Senate

#### Mechanisms for gaining student feedback on the quality of teaching and their learning experience:

- Staff – Student Committee;
- Course questionnaire evaluating modules and overall course;
- Meetings between MSc Programme Director and Postgraduate Tutor.

#### Staff development priorities include:

- Active research programme in the control area;
- Staff appraisal scheme and institutional staff development courses;
- College Teaching Development Grant Scheme to fund the development of new teaching and appraisal methods;
- Updating personal skills to take account of professional and IT/computing developments.
15. Regulation of assessment

Assessment rules & degree classification

In order to be awarded a result of merit, a candidate must achieve at least 60 per cent in each element; in order to be awarded a result of distinction, a candidate must achieve at least 70 per cent in each element.

Where appropriate, a Board of Examiners may award a result of merit where a candidate has achieved an aggregate mark of 60 per cent or greater across the programme as a whole AND has obtained a mark of 60 per cent or greater in each element with the exception of one element AND has obtained a mark of 50 per cent or greater in this latter element.

Where appropriate, a Board of Examiners may award a result of distinction where a candidate has achieved an aggregate mark of 70 per cent or greater across the programme as a whole AND has obtained a mark of 70 per cent or greater in each element with the exception of one element AND has obtained a mark of 60 per cent or greater in this latter element.

Candidates should only be considered for promotion to pass, merit or distinction if their aggregate mark is within 2.5 per cent of the relevant borderline. Nevertheless, candidates whom the Board deems to have exceptional circumstances may be considered for promotion even if their aggregate mark is more than 2.5 per cent from the borderline. In such cases the necessary extra marks should be credited to bring the candidate’s aggregate mark into the higher range.

Marking schemes shall be submitted to the appropriate Graduate School Master’s Quality Committee when requested.

Role of External Examiner

The external examiner for this course is from another university and is nominated by the MSc Academic Board and approved by the Graduate School of Engineering & Physical Sciences Management (or Executive) Committee. The external examiner normally serves for 3 years and

- Approves examination papers;
- Reviews coursework;
- Sees all examination scripts and individual research project dissertations;
- Attends the Board of Examiners;
- Completes a report to the College;
- Provides informal feedback regarding the nature and direction of the Course.

At present the external examiner is Professor George Halikias of City University.

16. Indicators of quality and standards

- Favourable comments by External Examiners;
- Research training, grant and publications record in Control and related areas;
- Evaluation by GSEPS;
- Independent review of the quality of the educational provision of the Electrical and Electronic Engineering Department by the Quality Assurance Agency subject review process (in 1997 the Department was awarded 24/24).

Please note.

This specification provides a concise summary of the main features of the programme and learning outcomes that a typical student might reasonably be expected to achieve and demonstrate if she/he takes full advantage of the learning opportunities that are provided. More detailed information on the learning outcomes, content and teaching, learning and assessment methods of each module can be found in the Course Handbook which is available to appropriate groups. The accuracy of the information contained in this document is reviewed by the College and may be checked by the Quality Assurance Agency for Higher Education (QAA).

Key sources of information about this course can be found in the MSc Student Handbook [http://www3.imperial.ac.uk/electricalengineering/teaching/msc](http://www3.imperial.ac.uk/electricalengineering/teaching/msc)