ELEC324

Feedback Control and Dynamic Systems

S1 Day 2016

Dept of Engineering

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General Information

Unit convenor and teaching staff
Unit Convenor
Graham Town
graham.town@mq.edu.au
Contact via graham.town@mq.edu.au
E6B 133
9 - 11am Tuesdays

Credit points
3

Prerequisites
ELEC240(P) and (ELEC270(P) or ENGG270(P) or ELEC290(P)) and (MATH232(P) or MATH235(P))

Corequisites

Co-badged status
ELEC624

Unit description
Topics covered in this unit include: - Overview of mathematical models of linear systems (differential equations, transfer function, state space and canonical forms). - Analysis and performance of single-input single-output feedback systems – zero-input response, zero-state response, transfer function, transient response (rise time, overshoot, settling time), proportional-integral-derivative (PID) compensation, lead-lag compensation). - Modern control-system analysis and design methods – controllability, observability, cost functions, optimal control, optimal observer and state estimation, multiple-input multiple-output systems). - Introduction to analysis and design of digital control systems – discrete approximations of continuous systems, transform techniques, state-space methods). - Applications of control in electronic systems (eg, feedback amplifiers, phase-locked loops) and servo-control systems (eg, for antenna pointing and satellite tracking). - Use of MATLAB for control-system analysis and design.

Important Academic Dates
Information about important academic dates including deadlines for withdrawing from units are available at https://students.mq.edu.au/important-dates
Learning Outcomes

1. The ability to develop and use mathematical models of systems: time domain (differential equations, state space), frequency domain (transfer functions), Laplace transforms. System reduction methods: signal flow graphs, block diagrams System response characteristics: steady-state response, transient response, stability, sensitivity.

2. The ability to design feedback control systems using tools such as MatLab and Simulink to achieve specified closed-loop response characteristics. Root locus design methods (transient response), Bode design methods (frequency response), state-space design methods. Common control and compensation methods (PID control, lead and lag compensation).

3. The ability to solve complex problems and use appropriate computer based tools and laboratory instrumentation to analyse and design feedback control systems.

4. The ability to extend continuous time control theory to discrete-time systems (i.e. fundamentals of computer-based or digital control systems). Mathematical models (z-transform), system response, simple controller design.

5. Written communication skills will be utilised and developed in completing assessment tasks.

Assessment Tasks

<table>
<thead>
<tr>
<th>Name</th>
<th>Weighting</th>
<th>Due</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular tutorial assignments</td>
<td>20%</td>
<td>as per the unit schedule</td>
</tr>
<tr>
<td>Major assignment</td>
<td>10%</td>
<td>as per unit schedule</td>
</tr>
<tr>
<td>Quizzes</td>
<td>10%</td>
<td>as per unit schedule</td>
</tr>
<tr>
<td>Laboratory tasks and reporting</td>
<td>0%</td>
<td>as per unit schedule</td>
</tr>
<tr>
<td>Laboratory report</td>
<td>10%</td>
<td>as per unit schedule</td>
</tr>
<tr>
<td>Final examination</td>
<td>50%</td>
<td>as per exam timetable</td>
</tr>
</tbody>
</table>

Regular tutorial assignments

Due: as per the unit schedule
Weighting: 20%

Assigned problems as per the unit timetable. Each week's assigned problems to be completed and returned for marking by the following week.
This Assessment Task relates to the following Learning Outcomes:

- The ability to develop and use mathematical models of systems: time domain (differential equations, state space), frequency domain (transfer functions), Laplace transforms. System reduction methods: signal flow graphs, block diagrams System response characteristics: steady-state response, transient response, stability, sensitivity.
- The ability to design feedback control systems using tools such as MatLab and Simulink to achieve specified closed-loop response characteristics. Root locus design methods (transient response), Bode design methods (frequency response), state-space design methods. Common control and compensation methods (PID control, lead and lag compensation).
- The ability to solve complex problems and use appropriate computer based tools and laboratory instrumentation to analyse and design feedback control systems.
- The ability to extend continuous time control theory to discrete-time systems (i.e. fundamentals of computer-based or digital control systems). Mathematical models (z-transform), system response, simple controller design.
- Written communication skills will be utilised and developed in completing assessment tasks.

**Major assignment**

**Due:** as per unit schedule  
**Weighting:** 10%

An assignment task defined early in semester, to be completed during the semester, and submitted for assessment as per the unit timetable.

This Assessment Task relates to the following Learning Outcomes:

- The ability to develop and use mathematical models of systems: time domain (differential equations, state space), frequency domain (transfer functions), Laplace transforms. System reduction methods: signal flow graphs, block diagrams System response characteristics: steady-state response, transient response, stability, sensitivity.
- The ability to design feedback control systems using tools such as MatLab and Simulink to achieve specified closed-loop response characteristics. Root locus design methods (transient response), Bode design methods (frequency response), state-space design methods. Common control and compensation methods (PID control, lead and lag compensation).
- The ability to solve complex problems and use appropriate computer based tools and laboratory instrumentation to analyse and design feedback control systems.
• Written communication skills will be utilised and developed in completing assessment tasks.

Quizzes
Due: as per unit schedule
Weighting: 10%

3 multiple choice quizzes (~ 15 minutes each) conducted in class during semester.

This Assessment Task relates to the following Learning Outcomes:
• The ability to develop and use mathematical models of systems: time domain (differential equations, state space), frequency domain (transfer functions), Laplace transforms. System reduction methods: signal flow graphs, block diagrams System response characteristics: steady-state response, transient response, stability, sensitivity.
• The ability to design feedback control systems using tools such as MatLab and Simulink to achieve specified closed-loop response characteristics. Root locus design methods (transient response), Bode design methods (frequency response), state-space design methods. Common control and compensation methods (PID control, lead and lag compensation).
• The ability to solve complex problems and use appropriate computer based tools and laboratory instrumentation to analyse and design feedback control systems.
• The ability to extend continuous time control theory to discrete-time systems (i.e. fundamentals of computer-based or digital control systems). Mathematical models (z-transform), system response, simple controller design.

Laboratory tasks and reporting
Due: as per unit schedule
Weighting: 0%

Four laboratory tasks (starting Week 1) to be completed and recorded in a dedicated laboratory workbook, which is to be signed off by tutors before leaving the class. A formal laboratory report is to be completed for specified laboratory task(s), to be assessed.

This Assessment Task relates to the following Learning Outcomes:
• The ability to develop and use mathematical models of systems: time domain (differential equations, state space), frequency domain (transfer functions), Laplace transforms. System reduction methods: signal flow graphs, block diagrams System response characteristics: steady-state response, transient response, stability, sensitivity.
• The ability to design feedback control systems using tools such as MatLab and Simulink
to achieve specified closed-loop response characteristics. Root locus design methods (transient response), Bode design methods (frequency response), state-space design methods. Common control and compensation methods (PID control, lead and lag compensation).

- The ability to solve complex problems and use appropriate computer based tools and laboratory instrumentation to analyse and design feedback control systems.
- The ability to extend continuous time control theory to discrete-time systems (i.e. fundamentals of computer-based or digital control systems). Mathematical models (z-transform), system response, simple controller design.
- Written communication skills will be utilised and developed in completing assessment tasks.

Laboratory report
Due: as per unit schedule
Weighting: 10%

A detailed report of the work conducted, and results obtained, for the laboratory exercise specified in the unit timetable.

This Assessment Task relates to the following Learning Outcomes:
- The ability to develop and use mathematical models of systems: time domain (differential equations, state space), frequency domain (transfer functions), Laplace transforms. System reduction methods: signal flow graphs, block diagrams System response characteristics: steady-state response, transient response, stability, sensitivity.
- The ability to design feedback control systems using tools such as MatLab and Simulink to achieve specified closed-loop response characteristics. Root locus design methods (transient response), Bode design methods (frequency response), state-space design methods. Common control and compensation methods (PID control, lead and lag compensation).
- The ability to extend continuous time control theory to discrete-time systems (i.e. fundamentals of computer-based or digital control systems). Mathematical models (z-transform), system response, simple controller design.
- Written communication skills will be utilised and developed in completing assessment tasks.

Final examination
Due: as per exam timetable
Weighting: 50%
Moderated examination at end of semester

This Assessment Task relates to the following Learning Outcomes:

- The ability to design feedback control systems using tools such as MatLab and Simulink to achieve specified closed-loop response characteristics. Root locus design methods (transient response), Bode design methods (frequency response), state-space design methods. Common control and compensation methods (PID control, lead and lag compensation).
- The ability to extend continuous time control theory to discrete-time systems (i.e. fundamentals of computer-based or digital control systems). Mathematical models (z-transform), system response, simple controller design.

Delivery and Resources

TEXTBOOK

All students will be assumed to have access to this textbook. All tutorial problems will be taken from this text.

There is an associated student resources webpage (e.g. with m-files for textbook examples):
http://bcs.wiley.com/he-bcs/Books?action=index&itemId=1118170512&bcsId=9295

LECTURES
Lecture notes will be handed out each week - it is expected that students read these notes before the next class at which they will be discussed.

OTHER RESOURCES
All unit resources and communications relating to this unit, including a detailed week-by-week schedule of learning and assessment activities, will be provided via the iLearn unit website. (see below).

UNIT WEBSITE
The web page for this unit can be found at: https://ilearn.mq.edu.au/login/MQ/

All information and communications relevant to this unit will be via that website.
TECHNOLOGY USED IN THIS UNIT

Laboratory and tutorial classes will rely heavily on the use of MatLab and Simulink with the Control Toolbox. You are encouraged to use these tools to complete and check all tutorial and assignment work. The software is available through iLab and on Faculty computers.

CHANGES TO THIS UNIT SINCE LAST OFFERED

Assessment tasks and questions changed.

Unit Schedule

A detailed schedule of learning and assessment activities for this unit will be published on the unit's iLearn web page, and will also be available in class.

Learning and Teaching Activities

Weekly Lectures

Lecture/discussion of course materials (handout notes, text) and worked examples.

Weekly Laboratory/Tutorial classes

Classes held in the laboratory with access to computer facilities and laboratory equipment needed to complete tutorial problems and laboratory tasks to develop both course-specific learning outcomes and more general graduate attributes and capabilities.

Assessment tasks

A variety of assessment tasks tailored to develop and assess learning outcomes and graduate capabilities.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central. Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy  http://mq.edu.au/policy/docs/academic_honesty/policy.html


The
Disruption to Studies Policy is effective from March 3 2014 and replaces the Special
Consideration Policy.

In addition, a number of other policies can be found in the Learning and Teaching Category of
Policy Central.

**Student Code of Conduct**

Macquarie University students have a responsibility to be familiar with the Student Code of
Conduct: [https://students.mq.edu.au/support/student_conduct/](https://students.mq.edu.au/support/student_conduct/)

**Results**

Results shown in iLearn, or released directly by your Unit Convenor, are not confirmed as they
are subject to final approval by the University. Once approved, final results will be sent to your
student email address and will be made available in eStudent. For more information visit [ask.mq.edu.au](http://www.ask.mq.edu.au).

**LABORATORIES**

All laboratory and tutorial work must be recorded in dedicated laboratory and/or exercise books,
to be signed off by the tutor or lecturer at the end of each session. No mark will be given unless
these conditions are followed. Food and drink are not permitted in the laboratory, nor are
students with bare feet, sandals or thongs. Students not complying with these regulations will be
removed from the laboratory. A good reference on engineering communication and writing
reports may be found at: [http://www.engineering.utoronto.ca/Directory/students/ecp/handbook.htm](http://www.engineering.utoronto.ca/Directory/students/ecp/handbook.htm). A useful guide for laboratory reports is located at

**COMMUNICATIONS**

Students are reminded the University will communicate all official notices to you by email to your
university email account. Please read your @student.mq.edu.au email regularly, or forward it to
an account you do read regularly. This document and other information relevant to this unit will
be available on the unit website at HYPERLINK "https://ilearn.mq.edu.au/login/MQ/" [https://ilearn.mq.edu.au/login/MQ/](http://www.ilearn.mq.edu.au/login/MQ/) All announcements and other communications regarding this
unit will be via the above website.

**Student Support**

Macquarie University provides a range of support services for students. For details, visit [http://students.mq.edu.au/support/](http://www.students.mq.edu.au/support/)

**Learning Skills**

Learning Skills ([mq.edu.au/learningskills](http://www.mq.edu.au/learningskills)) provides academic writing resources and study
strategies to improve your marks and take control of your study.

- **Workshops**
- **StudyWise**
- **Academic Integrity Module for Students**
Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

**Learning outcomes**

- The ability to design feedback control systems using tools such as MatLab and Simulink to achieve specified closed-loop response characteristics. Root locus design methods (transient response), Bode design methods (frequency response), state-space design methods. Common control and compensation methods (PID control, lead and lag compensation).
- The ability to solve complex problems and use appropriate computer based tools and laboratory instrumentation to analyse and design feedback control systems.
- The ability to extend continuous time control theory to discrete-time systems (i.e.
fundamentals of computer-based or digital control systems). Mathematical models (z-transform), system response, simple controller design.

Assessment tasks

- Regular tutorial assignments
- Major assignment
- Quizzes
- Laboratory tasks and reporting
- Laboratory report
- Final examination

Learning and teaching activities

- Lecture/discussion of course materials (handout notes, text) and worked examples.
- Classes held in the laboratory with access to computer facilities and laboratory equipment needed to complete tutorial problems and laboratory tasks to develop both course-specific learning outcomes and more general graduate attributes and capabilities.
- A variety of assessment tasks tailored to develop and assess learning outcomes and graduate capabilities.

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

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Effective Communication
We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcome
• Written communication skills will be utilised and developed in completing assessment tasks.

Assessment tasks
• Regular tutorial assignments
• Major assignment
• Laboratory tasks and reporting
• Laboratory report
Learning and teaching activities

- Classes held in the laboratory with access to computer facilities and laboratory equipment needed to complete tutorial problems and laboratory tasks to develop both course-specific learning outcomes and more general graduate attributes and capabilities.
- A variety of assessment tasks tailored to develop and assess learning outcomes and graduate capabilities.

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcomes

- The ability to develop and use mathematical models of systems: time domain (differential equations, state space), frequency domain (transfer functions), Laplace transforms. System reduction methods: signal flow graphs, block diagrams System response characteristics: steady-state response, transient response, stability, sensitivity.
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- Quizzes
- Laboratory tasks and reporting
- Laboratory report
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• A variety of assessment tasks tailored to develop and assess learning outcomes and graduate capabilities.

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systematically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

• The ability to develop and use mathematical models of systems: time domain (differential equations, state space), frequency domain (transfer functions), Laplace transforms. System reduction methods: signal flow graphs, block diagrams System response characteristics: steady-state response, transient response, stability, sensitivity.
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Assessment tasks

• Regular tutorial assignments
• Major assignment
• Quizzes
• Laboratory tasks and reporting
• Laboratory report
• Final examination
Learning and teaching activities

- Lecture/discussion of course materials (handout notes, text) and worked examples.
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- A variety of assessment tasks tailored to develop and assess learning outcomes and graduate capabilities.

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcomes

- The ability to design feedback control systems using tools such as MatLab and Simulink to achieve specified closed-loop response characteristics. Root locus design methods (transient response), Bode design methods (frequency response), state-space design methods. Common control and compensation methods (PID control, lead and lag compensation).
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- The ability to extend continuous time control theory to discrete-time systems (i.e. fundamentals of computer-based or digital control systems). Mathematical models (z-transform), system response, simple controller design.

Assessment tasks

- Quizzes
- Laboratory report

Learning and teaching activities

- Lecture/discussion of course materials (handout notes, text) and worked examples.
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- A variety of assessment tasks tailored to develop and assess learning outcomes and graduate capabilities.
Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

**Assessment tasks**

- Regular tutorial assignments
- Major assignment
- Quizzes

**Learning and teaching activities**

- Classes held in the laboratory with access to computer facilities and laboratory equipment needed to complete tutorial problems and laboratory tasks to develop both course-specific learning outcomes and more general graduate attributes and capabilities.
- A variety of assessment tasks tailored to develop and assess learning outcomes and graduate capabilities.