ELEC324

Feedback Control and Dynamic Systems

S1 Day 2018

Dept of Engineering

Contents

General Information

Unit convenor and teaching staff

Unit Convenor
Professor Graham Town
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Contact via via iLearn
E6B 133
9 - 11am Tuesdays

Unit Convenor
Dr Mihai Ciobotaru
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Contact via via iLearn
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Mihai Ciobotaru
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Credit points
3

Prerequisites
(ELEC240 or ELEC260) and (ELEC270 or ENGG270) and (MATH232 or MATH235)

Corequisites

Co-badged status

Unit description
This unit extends the foundations of time and frequency domain descriptions of linear systems and their dynamics to include feedback control. The unit introduces the concept of state-space and its application in modelling and design of feedback control systems, and the foundations of computer-based and optimal control systems are also introduced. Applications of feedback are explored, including regulation of physical and chemical processes, control of process dynamics, and stability and robustness in the presence of external disturbances. The latter concepts and applications are illustrated using examples from diverse areas, including biomedical, electronic, electrical, mechatronic, and wireless engineering. Experimental work is used to illustrate the impact of feedback on the dynamics, stability, and compensation of servo-motor systems and electronic circuits. MatLab is used extensively for system modelling and design. The unit provides a strong foundation for advanced topics in most engineering majors.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

- 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.
- The ability to communicate technical concepts and results in written reports.

General Assessment Information

Students are reminded of the University policies regarding assessment, academic honesty and disruption to studies.

Requests for extension on assessable work are to be made to the Unit Coordinator, but will only be considered in the event of illness or misadventure

Assessment Tasks

Name	Weighting	Hurdle	Due
Regular tutorial assignments	20%	No	see iLearn for unit schedule
Major assignment	10%	No	see iLearn for unit schedule
Quizzes	10%	No	see iLearn for unit schedule
Laboratory tasks and reporting	5%	No	see iLearn for unit schedule

Name	Weighting	Hurdle	Due
Laboratory report	5%	No	see iLearn for unit schedule
Final examination	50%	No	as per exam timetable

Regular tutorial assignments

Due: **see iLearn for unit schedule**
Weighting: **20%**

Assigned weekly problems as per the unit schedule, to be submitted via iLearn for marking.

On successful completion you will be able to:

- 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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- 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.
- The ability to communicate technical concepts and results in written reports.

Major assignment

Due: **see iLearn for unit schedule**
Weighting: **10%**

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

On successful completion you will be able to:

- 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 communicate technical concepts and results in written reports.

Quizzes

Due: **see iLearn for unit schedule**
Weighting: **10%**

3 multiple choice quizzes (~ 15 minutes each) conducted in class during semester on the days listed in the unit schedule.

On successful completion you will be able to:

- 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: **see iLearn for unit schedule**
Weighting: **5%**

Four laboratory tasks (starting Week 1, and then as per the unit schedule) to be completed and recorded in a dedicated laboratory workbook for assessment in the laboratory.

On successful completion you will be able to:

- 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.
- The ability to communicate technical concepts and results in written reports.

Laboratory report

Due: **see iLearn for unit schedule**
Weighting: **5%**

A detailed report of the work conducted and results obtained for one of the laboratory tasks is to be submitted for assessment via iLearn, as specified in the unit schedule.

On successful completion you will be able to:

- 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.
- The ability to communicate technical concepts and results in written reports.

Final examination

Due: **as per exam timetable**
Weighting: **50%**

Moderated 3 hour closed-book examination at the end of semester. A formula sheet identical to that available on iLearn will be provided.

On successful completion you will be able to:

- 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).
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Delivery and Resources

TEXTBOOK

N.S. Nise, “Control Systems Engineering”, John Wiley & Sons, 7th edn 2014. ISBN: 9781118170519

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 iLearn 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.

LABORATORIES

- All laboratory and tutorial work must be recorded in dedicated laboratory and/or exercise books.
- 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.
- An excellent reference on engineering communication and writing reports may be found at: http://ecp.engineering.utoronto.ca/online-handbook/

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 https://ilearn.mq.edu.au/login/MQ/
- All announcements and other communications regarding this unit will be via the latter website.

REFERENCE BOOKS

1. = recommended reference - old editions of all except Stefani held in Macquarie University library

- = supplementary reference - an edition held in Macquarie University Library
- = supplementary reference - not held in Macquarie University Library

- K.J. Astrom and B. Wittenmark, “Computer-Controlled Systems: Theory and Design”, Prentice-Hall, 3rd edition, 1997.
- R.H. Bishop, “Modern Control Systems Analysis and Design Using MATLAB”, Addison-Wesley, 1997. (Supplement to Dorf & Bishop).

1. R.C. Dorf and R.H. Bishop, “Modern Control Systems”, Addison-Wesley.

- J. Dorsey, Continuous and Discrete Control Systems”, McGraw-Hill, 2002.

1. G.F. Franklin, J.D. Powell and A. Emami-Naeini, “Feedback Control of Dynamic Systems”, 4th edition, Addison-Wesley, 2002.

- G.F. Franklin, J.D. Powell, and M.L. Workman, “Digital Control of Dynamic Systems”, Addison-Wesley, 3rd edition, 1998.
- G.C. Goodwin, S.F. Graebe and M.E. Salgado, “Control System Design”, Prentice Hall 2001.
- B.C. Kuo and F. Golnaraghi, “Automatic Control Systems”, Wiley, 8th edition, 2002.
- N.E. Leonard and. W.S. Levine, “Using MATLAB to analyze and design control systems”, 2nd edition, Addison-Wesley, 1995.
- **W.C. Messner and D.M.. Tilbury, “Control Tutorials for MATLAB and Simulink – A Web-based Approach”, Addison-Wesley. *(see also CTM websites listed below)*.**
- K. Ogata, “Modern Control Engineering”, 4th edition, Prentice-Hall, 2001.
- R.T. Stefani, B. Shahian, C.J. Savant, G.H. Hostetter, “Design of Feedback Control Systems”, Oxford University Press, 4th edition, 2002.
- **A. Stubberud, I.J. Williams, and J.J. DiStefano, “Schaum's Outline of Feedback and Control Systems”, McGraw-Hill, 2nd edition, 1994.**
- A. Tewari, “Modern Control Design With MATLAB and Simulink”, John Wiley & Sons,

2002.

1. MATLAB and Simulink Student Version

SOME WEB RESOURCES

Unit homepage: https://ilearn.mq.edu.au/login/MQ/

This document, the schedule, assignments and other documents required for this unit will be available for download from the above website.

Text website (student resources, etc):

http://bcs.wiley.com/he-bcs/Books?action=index&itemId=1118170512&bcsId=9295

Control system tutorials using MATLAB & Simulink:

http://ctms.engin.umich.edu/CTMS/index.php?aux=Home

Control Engineering Virtual Library

http://www-control.eng.cam.ac.uk/extras/Virtual_Library/Control_VL.html

MathWorks Website (MATLAB, Simulink, user-guides, tutorials, etc):

- MatLab Courseware

  https://au.mathworks.com/academia/courseware.html

- MatLab and SimuLink Training for Macquarie University Students

  https://trainingenrollment.mathworks.com/selfEnrollment?code=TSH4E9QU6C9G

  http://www.mathworks.com/

  http://www.mathworks.com/academia/

  http://www.mathworks.com/help/techdoc/

  http://www.mathworks.com/help/toolbox/simulink/

  http://www.mathworks.com/help/toolbox/control/

UNIT OVERVIEW

This unit is concerned with two main topics; system modeling, and controller design, **with emphasis on system *transient response*, *steady-state response*, and *stability*. We** will mostly be concerned with systems that are continuous, linear, and time-invariant (LTI), so the latter topics can be dealt with in both the time-domain (TD.: differential equation, and state-space desriptions) and frequency-domain (FD.: transfer function description, characterised by its poles and zeroes). It is also intended to briefly cover some advanced control topics such as nonlinear control, robust control, optimal control, and optimal state estimation in the presence of noise (i.e.

Kalman filtering). Some of the results from continuous LTI systems will then be extended to discrete-time systems (i.e. computer control).

References to relevant sections in the text and references are given in the table below (N=Nise 5th edn. D=Dorf 9th edn., F=Franklin 4th edn., S=Stefani 4th edn.)

Main topic	Sub-topic	References
Continuous system modeling	**Mathematical models**	
	Differential equation (TD)	N3.2, D2.2, F2.1
	State space (TD)	N3.3-6, D3, F2.2, S8.2
	Transfer function (FD)	N2, D2.5, F2.1
	Laplace transforms (TD & FD)	N2.2, D2.4, F3.1, FAppA, SAppB
	System reduction methods	
	Signal flow graphs (T.D.)	N5.4-6, D2.7, F3.2, S1.14
	Block diagrams (F.D.)	N5.2-3, D2.6, F3.2, S1.13
	System response characteristics	
	Steady-state response	N7, D4.5, D5.7-5.8, F4.3, S3.3
	Transient response	N4, D4.3, D5.3-6, F3.3, S2.2-4
	Stability	N6, D6, D9, F3.6 S1.12, S2.5
	Sensitivity to parameter changes and disturbances	N7.7, D4.2, D4.4, F4, F6.9, S3.6
Continuous controller design	**Root locus methods (à transient response)**	N8-9, D7, D10, F5, S4-5
	PID control	N9.4, D7.7, D12.6, F4.2, S3.7.2
	Bode & Nyquist methods (à frequency response)	N10-11, D8, D10, F6, S6-7
	Lag-lead compensation	N11.5, D10.4-8, F6.7, S7.7

	State-space (TD) design	N12, D11, F7, FappD-E
	Controller design	N12.2-12.3, F7.3, S9.2-3
	Observer/estimator design	N12.5-12.7, F7.5, S9.4-5
	Additional topics	
	Optimal control	D5.9, D11.4, F7.4.2, S10.2-4
	Kalman filter	S10.3
	Robust control	D12, F7.9, S10.5-7
	Nonlinear control	F5.7.3
Discrete system modeling and control	**Mathematical models**	
	Sampled-data system modeling	N13.1-8, D13.3-8, F4.4, S11.3-7
	z-transform	N13.3, D13.4, F8.2, S11.4
	System response characteristics	
	Stability	N13.6, D13.6, S11.7.4, S11.8.2
	Computer control design	
	Frequency-domain design	N13.9-11, D13.8-11, F8.3, S11.8
	State-space design	F8.5, D13.11, S11.9
	Direct design	F8.4, S11.10

Unit Schedule

A detailed week-by-week schedule of learning and assessment activities and topics for this unit is available on the unit's iLearn web page.

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 (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public
- Special Consideration Policy *(**Note:** The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Undergraduate students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/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/study/getting-started/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.

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.
- An excellent reference on engineering communication and writing reports may be found at: http://ecp.engineering.utoronto.ca/online-handbook/

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 https://ilearn.mq.edu.au/login/MQ/
- All announcements and other communications regarding this unit will be via the latter website.

Student Support

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

Learning Skills

Learning Skills (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
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

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).
- 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

- Quizzes
- Laboratory report

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.

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:

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

Discipline Specific Knowledge and Skills

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 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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- 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.

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 systemically 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.
- 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

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- 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

- 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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- 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.

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

- The ability to communicate technical concepts and results in written reports.

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.

Changes from Previous Offering

All laboratory work is now being assessed.

Changes in Response to Student Feedback

Specific assessment tasks and their weightings have been changed.