MONASH University

Unit Guide

ECE4032
Advanced control

Semester 2, 2017

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Unit handbook information

Synopsis

This unit aims to firstly develop an understanding of key features of methods for mathematically modelling various categories of dynamical systems in terms of sets of dynamic and algebraic equations, ranging from engineering to biomedical systems. Secondly, students are shown how to write algorithms for efficient numerical solution of these equations. Computer-aided control systems design using optimal and robust control methods is then covered. Thirdly, students are introduced to Lyapunov and function analytic techniques for nonlinear systems stability analysis, and to nonlinear control design methods including feedback linearisation, sliding mode and passivity-based control techniques.

Mode of delivery

Malaysia (Day)

Workload requirements

2 hours lectures, 3 hours laboratory and practice classes and 7 hours private study per week

Unit relationships

Prerequisites

ECE2031 and (ECE3062 or ECE3031)

Prohibitions

ECE4302, ECE5032, ECE5302

Co-requisites

None

Chief Examiner(s)

Professor Manos Varvarigos

Unit Coordinator(s)

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Academic Overview

Program Education Objectives
The Electrical and Computer Systems / Mechatronics engineering discipline expects to produce graduates, who are:
1. competent in Electrical and Computer Systems / Mechatronics engineering
2. responsible and effective global citizens
3. leaders in their chosen profession or society at large.

Program Outcomes
The Electrical and Computer Systems / Mechatronics engineering discipline has developed a set of Program Outcomes (POs) for all of its graduates based on the competencies required by the Malaysian Engineering Accreditation Council.

Program Outcomes (POs)	Activities used in this unit to develop POs, achievement of Bloom's domains and complex problem solving
PO1 **Electrical and Computer Systems / Mechatronics Engineering Knowledge:** Apply knowledge of mathematics, natural science, engineering fundamentals and specialisation in Electrical and Computer Systems / Mechatronics engineering to the solution of complex engineering problems	Cognitive: Lectures, tutorials, assignments /labs, exam
PO2 **Problem Analysis:** Identify, formulate, survey research literature and analyse complex Electrical and Computer Systems / Mechatronics engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences	Cognitive:
PO3 **Design/Development of Solutions:** Design solutions for complex Electrical and Computer Systems / Mechatronics engineering problems and design systems, components or processes that meet specified needs.	Cognitive: Lectures, tutorials, assignments /labs, mid-semester test, exam Psychomotor:
PO4 **Research-based Investigation:** Conduct investigations of complex Electrical and Computer Systems / Mechatronics engineering problems using research-based knowledge and research methods including design of experiments, (analysis and interpretation of data, and synthesis of information to provide valid conclusions.	Cognitive: Lectures, tutorials, assignments /labs, mid-semester test, exam

Program Outcomes (POs)	Activities used in this unit to develop POs, achievement of Bloom's domains and complex problem solving
PO5 **Modern Tool Usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex Electrical and Computer Systems / Mechatronics engineering problems, with an understanding of the limitations	Cognitive: Psychomotor: Assignments/labs
PO6 **Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex Electrical and Computer Systems / Mechatronics engineering problems	Affective:
PO7 **Environment and Sustainability:** Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex Electrical and Computer Systems / Mechatronics engineering problems in environmental contexts.	Cognitive: Affective:
PO8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.	Affective:
PO9 **Communication:** Communicate effectively on complex Electrical and Computer Systems / Mechatronics engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	Affective:
PO10 **Individual and Team work:** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings	Affective:
PO11 **Lifelong Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change	Affective: Assignments
PO12 **Project Management and Finance:** Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to manage projects	Cognitive: Affective:

Teaching and learning method

The unit consists of lectures which cover both theory and problem solving. Problem solving is further reinforced through a series of 12 tutorial classes,using assigned problems that will be selected from the prescribed text and advised in advance of each session. Topic tests and informal discussion provide feedback on students' performance. In order to illustrate the practical applications of the subject matter, and provide feedback on students' analysis and written communication skills, 4 laboratory/computational experiments are included with clear reporting and marking expectations.

Learning outcomes

At the successful completion of this unit you will be able to:

1. Generate dynamic models using various system identification techniques/tools such as (but not limited to) step response identification, least squares and the System Identification Toolbox.
2. Design optimal controllers and observers for both continuous-time and discrete-time dynamic systems.
3. Analyse robustness of uncertain systems and to suggest suitable controller structures.
4. Use various methods to design controllers and observers for nonlinear systems, such as (but not limited to) feedback linearisation, diffeomorphism, and Linear Matrix Inequalities.
5. Discern the need for life-long learning about advanced control technique.
6. Design and simulate controllers and observers using computer-aided tools.

OBE requirements to learning outcomes (LOs)

Learning Outcomes (LOs) for Outcome Based Education (OBE) requirements	Handbook Learning Outcomes (LOs)
LO1) Generate dynamic models using various system identification techniques/tools such as (but not limited to) step response identification, least squares and the System Identification Toolbox.	LO1) Generate dynamic models using various system identification techniques/tools such as (but not limited to) step response identification, least squares and the System Identification Toolbox.
LO2) Design optimal controllers and observers for both continuous-time and discrete-time dynamic systems.	LO2) Design optimal controllers and observers for both continuous-time and discrete-time dynamic systems.
LO3) Analyse robustness of uncertain systems and to suggest suitable controller structures.	LO3) Analyse robustness of uncertain systems and to suggest suitable controller structures.
LO4) Use various methods to design controllers and observers for nonlinear systems, such as (but not limited to) feedback linearisation, diffeomorphism, and Linear Matrix Inequalities.	LO4) Use various methods to design controllers and observers for nonlinear systems, such as (but not limited to) feedback linearisation, diffeomorphism, and Linear Matrix Inequalities.

Learning Outcomes (LOs) for Outcome Based Education (OBE) requirements	Handbook Learning Outcomes (LOs)
LO5) Discern the need for life-long learning about advanced control technique.	LO5) Discern the need for life-long learning about advanced control technique.
LO6) Design and simulate controllers and observers using computer-aided tools.	LO6) Design and simulate controllers and observers using computer-aided tools.

Relationship between Unit Learning Outcomes and Program Outcomes

No.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
1				√								
2			√									
3	√											
4			√									
5										√		
6					√							

Your feedback to us

One of the formal ways students have to provide feedback on teaching and their learning experience is through the Student Evaluation of Teaching and Units (SETU) survey. The feedback is anonymous and provides the Faculty with evidence of aspects that students are satisfied with and areas for improvement.

Previous student evaluations of this unit

In response to previous SETU results of this unit, the following changes have been made:

Some changes are made (e.g. more material such as Model Predictive Control and Kalman Filters) but they are not due to SETU results.

Student feedback has highlighted the following strength(s) in this unit:

- Explanations very clear.
- Organized structure.
- Extraordinary lecturer.

If you wish to view how previous students rated this unit, please go to:
https://unitevaluations.connect.monash.edu.au/unitevaluations/index.jsp

Unit schedule

Week	Activities			Assessment
	Lecture	Tutorial	Lab	
1 24 Jul	Unit Introduction Review: Dynamic system modelling and analysis	Continue review (3 hours)		
2 31 Jul	Introduction to system identification	Tutorial (1 hour)	Lab 1 part 1 (2 hours)	Lab observation (2%)
3 7 Aug	System identification methods and examples	Tutorial (1 hour)	Lab 1 part 2 (2 hours)	
4 14 Aug	Introduction to optimal control and estimation	Tutorial (1 hour)	Lab 2 part 1 (2 hours)	Lab 1 report due (5%)
5 21 Aug	Optimal control and estimation methods	Tutorial (1 hour)	Lab 2 part 2 (2 hours)	Lab observation (2%)
6 28 Aug	Optimal control and estimation design examples	Tutorial (3 hours)		Lab 2 report due (6%)
7 4 Sept	Introduction to nonlinear control Mid-semester test	Tutorial (3 hours)		Mid-semester test (10%)
8 11 Sept	Nonlinear control methods and examples	Tutorial (1 hour)	Lab 3 (2 hours)	Lab observation (2%)
9 18 Sept	Introduction to robust control	Tutorial (1 hour)		Lab 3 report due (6%)
10 2 Oct	Robust control design methods	Tutorial (3 hours)		
11 9 Oct	Robust control design examples	Tutorial (1 hour)	Lab 4 (2 hours)	Lab observation (2%)
12 16 Oct	Revision	None		Lab 4 report due (5%)

Assessment requirements

Assessment summary

Continuous assessment: 40%
Examination (2 hours): 60%
Students are required to achieve at least 45% in the total continuous assessment component (assignments, tests, mid-semester exams, laboratory reports) and at least 45% in the final examination component and an overall mark of 50% to achieve a pass grade in the unit. Students failing to achieve this requirement will be given a maximum of 45% in the unit.

Assessment task	Value	Due date
Lab/Assignments 1-4	30% in total	One week after release date
Mid-semester test	10% of entire unit	Week 7
Final examination	60%	To be advised

Bloom's Taxonomy:
Three domains of educational activities have been identified under the general taxonomy known as Bloom's.

- **Cognitive**: mental skills (*Head*)
- **Affective**: growth in feelings or emotional areas (*Heart*)
- **Psychomotor**: manual or physical skills (*Hand*)

The *cognitive* domain involves knowledge and the development of intellectual skills. This includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills.

The *affective* domain includes the attitudes with which someone deals with things emotionally, such as feelings, values, appreciation, enthusiasms and motivations.

The *psychomotor* domain includes physical movement, coordination, and use of the motor-skill areas. Development of these skills requires practice and is measured in terms of speed, precision, distance, procedures, or techniques in execution.

Key for the LO-assessment relationship table above:

Cognitive

C1	C2	C3	C4	C5	C6
Knowledge: Remembers previously learned material	**Comprehension:** Grasps the meaning of material (lowest level of understanding)	**Application:** Uses learning in new and concrete situations (higher level of understanding)	**Analysis:** Understands both the content and structure of material	**Synthesis:** Formulates new structures from existing knowledge and skills	**Evaluation:** Judges the value of material for a given purpose

Psychomotor

P1	P2	P3	P4	P5	P6	P7
Perception: Senses cues that guide motor activity	**Set:** Is mentally, emotionally and physically ready to act	**Guided Response:** Imitates and practices skills, often in discrete steps	**Mechanism:** Performs acts with increasing efficiency, confidence and proficiency	**Complete Overt Response:** Performs automatically	**Adaption:** Adapts skill sets to meet a problem situation	**Organisation:** Creates new patterns for specific situations

Affective

A1	A2	A3	A4	A5
Receiving: Selectively attends to stimuli	**Responding:** Responds to stimuli	**Valuing:** Attaches value or worth to something	**Organisation:** Conceptualises the value and resolves conflict between it and other values	**Internalising:** Integrates the value into a value system that controls behaviour

Relationship between Assessments and OBE Learning Outcomes (LOs)

	Assessment	LO1	LO2	LO3	LO4	LO5	LO6
1	Lab/Assignment 1 (system identification)	√					√
2	Lab/Assignment 2 (optimalcontrol)		√			√	√
3	Lab/Assignment 3 (nonlinear control)				√	√	√
4	Lab/Assignment 4 (robust control)	√		√			√
5	Mid-semester test (system identification)	√					
6	Mid-semester test (optimal control)		√				
7	Final exam (system identification)	√					
8	Final exam (optimal control)		√				
9	Final exam (nonlinear control)				√		

10	Final exam (robust control)			√			

Relationship between Assessments and Complex Problems /Activities

Assessment task	Complex problem covered
Lab/Assignment 1 (system identification)	WP1
Lab/Assignment 2 (nonlinear control)	WP1
Lab/Assignment 3 (optimal control)	WP1, WP2
Lab/Assignment 4 (robust control)	WP1
Mid-semester test (system identification)	WP1
Mid-semester test (optimal control)	WP1
Final exam (system identification)	WP1
Final exam (optimal control)	WP1
Final exam (nonlinear control)	WP1
Final exam (robust control)	WP1

Hurdle requirements

At least 45% must be achieved in the internal assessment and final exams, failing which the final mark for the unit will be capped at 44%.

Assessment tasks

Assessment title: Lab/Assignments 1-4
Mode of delivery: Practical lab experiment or simulation assignment
Details of task: You will be given 4 lab experiments or simulation assignments to conduct, and will have to write a report based on your findings and relate them to the theory that you have learnt. You will be assessed on your ability to run the experiment, and also based on the report that you submit.

Release dates (where applicable): Lab session of weeks 2, 5, 8, 11
Word limit (where applicable): Not applicable
Due date: One week after release date
Value: 30% in total
Presentation requirements: None
Hurdle requirements (where applicable): None
Individual assessment in group tasks (where applicable): A mark will be given to the entire group.
Criteria for marking: For each lab/assignment, the following are the assessment criteria:

-.Observation of you carrying out the work: 2%

- Design/analysis and presentation of results: 2%

- Discussion: 3%

- Literature search: 1% (only for lab/assignment 2 and 3)

Therefore, the total marks for each lab/assignment are as follows:

- Lab/assignment 1: 7%

- Lab/assignment 2: 8%

- Lab/assignment 3: 8%

- Lab/assignment 4: 7%

Additional remarks: None

Assessment title: Mid-semester test
Mode of delivery: Mid-semester test
Details of task: 1 hour closed-book test
Release dates (where applicable): Not applicable
Word limit (where applicable): Not applicable
Due date: Week 7
Value: 10% of entire unit
Presentation requirements: None
Hurdle requirements (where applicable): None
Individual assessment in group tasks (where applicable): Individual assessment - no group work
Criteria for marking: As per marking scheme
Additional remarks: None

Examination(s)

Exam title: Final examination
Weighting: 60%
Length: 2
Type (Open/closed book): No
Hurdle requirements (where applicable): 45% of entire exam (i.e. 27 marks out of the full mark of 60) is required.
Electronic devices allowed: Yes - those approved by Faculty of Engineering
Remarks (where applicable): None

Calculators
A list of the Faculty of Engineering approved calculators and the process for obtaining a sticker is available online at:
http://www.eng.monash.edu.au/current-students/calculators.html

IMPORTANT: Only these listed calculators with the **authorised Monash University-Science or Monash University-Engineering STICKER** will be allowed into the examination by the invigilators.

Calculators

The following scientific calculators that are **not** programmable, but are capable of **1-variable and 2-variable statistics,** (**with the authorised "Monash University-Science, or Engineering" sticker**) **are approved** for use in this unit examination:

Graphical calculators and programmable calculators are not permitted in exams.

APPROVED Scientific Calculators:

Caieion: FM-83 **Canon:** F720, F720i

Casio: fx-82, fx-83, fx-85, fx-100, fx-115, fx-350, fx-570, fx-911, fx-991, fx-992 series, and fx-3650P series

Citizen: SR-135, SR-260, SR-270, SR-275

Hewlett Packard: HP-6s, HP-8s, HP-9s, HP-10s, HP-30s, and HP smartcalc-300s **Texas instruments:** TI-30 and TI-34 series

Texet: Albert 2, Albert 3, Albert 5

Sharp: EL-506, EL546V, EL-509, EL-520, EL-520WG and EL-531WH series

Extensions and penalties

Late assignments will not generally be accepted in this unit. Further, no extensions will be allowed. The comments below only apply to rare circumstances and their application will be at the discretion of the lecturer-in-charge / unit coordinator.

Plagiarism and collusion

Intentional plagiarism or collusion amounts to cheating under Part 7 of the Monash University (Council) Regulations.

Plagiarism: Plagiarism means taking and using another person's ideas or manner of expressing them and passing them off as one's own. For example, by failing to give appropriate acknowledgement. The material used can be from any source (staff, students or the internet, published and unpublished works).

Collusion: Collusion means unauthorised collaboration with another person on assessable written, oral or practical work and includes paying another person to complete all or part of the work. Where there are reasonable grounds for believing that intentional plagiarism or collusion has occurred, this will be reported to the Associate Dean (Education) or delegate,

Referencing requirements

None

To build your skills in citing and referencing, and using different referencing styles, see the online tutorial Academic Integrity: Demystifying Citing and Referencing at http://www.lib.monash.edu.au/tutorials/citing/

Assignment submission

Hard Copy Submission:

Assignments must include a cover sheet. The coversheet is accessible via the Monash portal page located at http://my.monash.edu.au under the heading 'Learning and teaching tools'. Please keep a copy of tasks completed for your records.

Online Submission: If Electronic Submission has been approved for your unit, please submit your work via the Moodle site or other; as directed by your demonstator for this unit.
Please keep a copy of tasks completed for your records.

Feedback to you

Feedback given to students in this unit include written comments on assignments graded, verbal comments, feedback to the whole class, to groups, and to individuals during lectures and practice classes.

Learning resources

Monash Library Unit Reading List (if applicable to the unit):
http://readinglists.lib.monash.edu/index.html

Required resources

Students generally must be able to complete the requirements of their course without the imposition of fees that are additional to the student contribution amount or tuition fees. However, students may be charged certain incidental fees or be expected to make certain purchases to support their study. For more information about this, go to Administrative Information for Higher Education Providers: Student Support, Chapter 21, Incidental Fees at: http://www.innovation.gov.au/HigherEducation/TertiaryEducation/ResourcesAndPublications/Pages/default.aspx

Field trips

There will be a field trip towards the end of the semester.

Other information

Policies

Monash has educational policies, procedures and guidelines, which are designed to ensure that staff and students are aware of the University's academic standards, and to provide advice on how they might uphold them. You can find Monash's Education Policies at:
http://www.policy.monash.edu/policy-bank/academic/education/index.html

Graduate Attributes Policy

http://www.monash.edu/policy-bank/academic/education/course-governance-and-design/course-design-policy

Student Charter

http://www.monash.edu/students/policies/student-charter.html

Student Services

The University provides many different kinds of services to help you gain the most from your studies. Contact your tutor if you need advice and see the range of services available at:
http://www.monash.edu.my/Student-services/

Monash University Library

The Library and Learning Commons, Monash University Malaysia Campus, provides a range of services and resources that enable you to save time and be more effective in your learning and research.
Go to http://www.lib.monash.edu.my or the library tab in my.monash portal for more information.

Disability Support Services

Students who have a disability, ongoing medical or mental health condition are welcome to contact Disability Support Services.

Disability Support Services also support students who are carers of a person who is aged and frail or has a disability, medical condition or mental health condition.

Disability Advisers visit all Victorian campuses on a regular basis.

- Website: monash.edu/disability
- For information and referral, telephone: Student Adviser, Student Community Services at 03 55146018
- Drop In: Student Community Services Department, Level 2 Building 2, Monash University Malaysia Campus
- Email: disabilitysupportservices@monash.edu (Disability Support Services, Monash University Australia)