UNSW Course Outline

ELEC9731 Robust and Linear Control Systems - 2024

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General Course Information

Course Code : ELEC9731
Year : 2024
Term : Term 1
Teaching Period : T1
Is a multi-term course? : No
Faculty : Faculty of Engineering
Academic Unit : School of Electrical Engineering & Telecommunications
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

Linear and robust control systems are important areas of modern control engineering. It is important that control engineers are able to model, analyze, and design linear and robust control systems and develop effective control solutions to achieve better system performance.

The course covers basic topics of linear and robust control such as continuous and discrete linear time-invariant (LTI) systems, discrete-time approximations, controllability, canonical forms, pole placement, observability, Lyapunov stability applied to linear systems, basic robustness, sensitivity and complementary sensitivity, classical loop shaping, single-input and single-output (SISO) controller design using polynomial methods, singular value decomposition, optimal control, the optimal linear regulator (discrete, continuous), model predictive control, Kalman filter and predictor (discrete, continuous), advanced robustness, disturbance rejection, H-infinity control and state estimation.

Course Aims

Control Engineering is an enabling theory and methodology underlying all branches of electrical engineering. This graduate-level course provides an introduction to multivariable linear system theory and control from both an input/output and a state space point of view. It also provides an introduction to Robust Control and some aspects of System Identification.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Describe aspects of linear system theory.
CLO2 : Describe aspects of robust control theory.
CLO3 : Explain aspects of optimal and robust filtering.
CLO4 : Demonstrate case studies from biomedical engineering and power systems.
CLO5 : Solve problems in linear system theory.
CLO6 : Solve problems in robust control, optimal and robust filtering.

Course Learning Outcomes	Assessment Item
CLO1 : Describe aspects of linear system theory.	• Assigment 1 • Final exam
CLO2 : Describe aspects of robust control theory.	• Assignment 2 • Assigment 1 • Final exam
CLO3 : Explain aspects of optimal and robust filtering.	• Assignment 2 • Assigment 1 • Final exam
CLO4 : Demonstrate case studies from biomedical engineering and power systems.	• Final exam
CLO5 : Solve problems in linear system theory.	• Assignment 2 • Assigment 1 • Final exam
CLO6 : Solve problems in robust control, optimal and robust filtering.	• Assignment 2 • Assigment 1 • Final exam

Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360

Other Professional Outcomes

Engineers Australia, Professional Engineer Stage 1 Competencies

The learning outcomes of this course contribute to your development of the following EA competencies:

	EA Stage 1 Competencies	Course Learning Outcomes (CLOs)
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	1, 2, 3, 4
PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing		1, 2, 3, 4
PE1.3 In-depth understanding of specialist bodies of knowledge		1, 2, 3, 4, 5
PE1.4 Discernment of knowledge development and research directions		5, 6
PE1.5 Knowledge of engineering design practice		3, 4, 6
PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice		
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	1, 2, 3, 4, 5, 6
PE2.2 Fluent application of engineering techniques, tools and resources		1, 2, 3, 4, 5, 6
PE2.3 Application of systematic engineering synthesis and design processes		1, 2, 3, 4, 5, 6
PE2.4 Application of systematic approaches to the conduct and management of engineering projects		
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability	1, 2, 3, 4, 5, 6
PE3.2 Effective oral and written communication (professional and lay domains)		1, 2, 3, 4, 5, 6
PE3.3 Creative, innovative and pro-active demeanour		
PE3.4 Professional use and management of information		1, 2, 3, 4, 5, 6
PE3.5 Orderly management of self, and professional conduct		1, 2, 3, 4, 5, 6
PE3.6 Effective team membership and team leadership		2, 3, 4, 5

Additional Course Information

Prerequisites and Assumed Knowledge

The main prerequisite for this course is ELEC3114. It is essential that you are familiar with a

standard introductory undergraduate course on control engineering such as ELEC3114 before this course is attempted. The prerequisites also include some undergraduate courses on Linear Algebra and Probability.

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Assignment 2 Assessment Format: Individual	25%	
Assigment 1 Assessment Format: Individual	25%	
Final exam Assessment Format: Individual	50%	

Assessment Details

Assignment 2

Assessment Overview

This is the second homework assignment. It only covers the material delivered after the first assignment. Marks will be given according to the correctness of the responses. Verbal class-wide feedback will be given during lectures.

Course Learning Outcomes

- CLO2 : Describe aspects of robust control theory.
- CLO3 : Explain aspects of optimal and robust filtering.
- CLO5 : Solve problems in linear system theory.
- CLO6 : Solve problems in robust control, optimal and robust filtering.

Assigment 1

Assessment Overview

This is the first homework assignment. It covers the material so far delivered over the first few weeks of the term. Marks will be given according to the correctness of the responses. Verbal class-wide feedback will be given during lectures.

Course Learning Outcomes

- CLO1 : Describe aspects of linear system theory.
- CLO2 : Describe aspects of robust control theory.
- CLO3 : Explain aspects of optimal and robust filtering.
- CLO5 : Solve problems in linear system theory.

- CLO6 : Solve problems in robust control, optimal and robust filtering.

Final exam

Assessment Overview

The final exam aims to assess students' overall competency. Questions may be drawn from any aspect of the course. Marks will be assigned according to the correctness of the responses.

Course Learning Outcomes

- CLO1 : Describe aspects of linear system theory.
- CLO2 : Describe aspects of robust control theory.
- CLO3 : Explain aspects of optimal and robust filtering.
- CLO4 : Demonstrate case studies from biomedical engineering and power systems.
- CLO5 : Solve problems in linear system theory.
- CLO6 : Solve problems in robust control, optimal and robust filtering.

General Assessment Information

Grading Basis

Standard

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 0 : 5 February - 11 February	Reading	Notes_set_1
Week 1 : 12 February - 18 February	Lecture	Review of Matrix Methods and SISO State Space Methods.
	Reading	Notes_set_2
Week 2 : 19 February - 25 February	Lecture	Feedback Control of SISO Systems: Input/Output and State Space.
	Reading	Notes_set_3, notes_set_4, notes_set_5, notes_set_6
Week 3 : 26 February - 3 March	Lecture	Tracking and Disturbance Rejection, Introduction to MIMO systems. Polynomial Matrices and Smith-McMillan Form
	Reading	Notes_set_7, notes_set_8, notes_set_9, notes_set_10
Week 4 : 4 March - 10 March	Lecture	MIMO Decomposition and Balanced Realizations.
	Reading	Notes_set_11, notes_set_12, notes_set_13.
	Assessment	Assignment 1 out.
Week 5 : 11 March - 17 March	Lecture	Introduction to Robust control, Kharitonov theorem, edge theorem. Classical approach to robust control design, robust PID controllers, case studies.
	Reading	Notes_set_14.
	Assessment	Assignment 1.
Week 6 : 18 March - 24 March	Assessment	Assignment1.
Week 7 : 25 March - 31 March	Lecture	Optimal control: dynamic programming; linear quadratic optimal control problem; Riccati equations.
	Assessment	Assignment 1 due. Assignment 2 out.
Week 8 : 1 April - 7 April	Lecture	Model predictive control, Kalman filtering, case studies.
	Reading	Notes_set_15, notes_set_16, notes_set_17.
	Assessment	Assignment 2.
Week 9 : 8 April - 14 April	Lecture	H-infinity control, differential games; H-infinity filtering.
	Reading	Notes_set_18, notes_set_19.
	Assessment	Assignment 2 due, Take-home exam out.
Week 10 : 15 April - 21 April	Lecture	Case studies: robust control of biomedical systems, robust control of wind power systems.
	Reading	Notes_set_20, notes_set_21.
	Assessment	Take-home exam.
Week 11 : 22 April - 28 April	Assessment	Take-home exam.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

General Schedule Information

Workload

It is expected that you will spend at least ten to twelve hours per week studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and independent, self-directed study. In periods where you need to need to complete assignments, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required workload into account when planning how to balance study with

employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

Course Resources

Prescribed Resources

Software: • Matlab (including Simulink)

Textbooks Prescribed textbooks:

• R.C. Dorf and R.H.Bishop. Modern Control Systems. Addison Wesley.

• G.C. Goodwin, S.F. Graebe and M.E. Salgado. Control Systems Design. Prentice Hall.

• J.B. Burl. Linear Optimal Control. Addison Wesley.

Reference books:

• T. Kailath. Linear Systems. Prentice Hall.

• I.R. Petersen and A.V. Savkin. Robust Kalman Filtering for Signals and Systems with Large Uncertainties. Burkhauser, Boston.

• I.R. Petersen, V.A. Ugrinovskii and A.V. Savkin. Robust Control Design Using H-innity Methods. Springer-Verlag.

On-line resources

Moodle As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php. Mailing list Announcements concerning course information will be given in the lectures and/or on Moodle and/or via email (which will be sent to your student email address).

Course Evaluation and Development

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods. In particular, several practical case studies have been developed based on past students' feedback. During the last two years, two new case studies have been developed/significantly modified.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Andrey Savkin		Room 341		TBA	No	Yes

Other Useful Information

Academic Information

I. Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

II. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and polices. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

III. Equity and diversity

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: https://www.unsw.edu.au/engineering/student-life/student-resources/program-design.

Note: This course outline sets out the description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle or your primary learning management system (LMS) should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website

with a wealth of resources to support students to understand and avoid plagiarism, visit: student.unsw.edu.au/plagiarism. The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;
- Online quizzes where answers are released to students on completion;
- Professional assessment tasks, where the intention is to create an authentic assessment that

has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

School-specific Information

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Use of AI for assessments

Your work must be your own. If you use AI in the writing of your assessment, you must acknowledge this and your submission must be substantially your own work. More information can be found on this website.

Workplace Health & Safety (WHS)

WHS for students and staff is of utmost priority. Most courses involve laboratory work. You must follow the rules about conduct in the laboratory. About COVID-19, advice can be found on this website.

School Contact Information

Consultations: Lecturer consultation times will be advised during the first lecture. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email enquiries should be made from your student email address with ELEC/TELExxxx in the subject line; otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Student Support Enquiries

For enrolment and progression enquiries please contact Student Services

Web

Electrical Engineering Homepage