UNSW Course Outline

ELEC4631 Continuous - Time Control System Design - 2024

Published on the 21 May 2024

General Course Information

Course Code : ELEC4631
Year : 2024
Term : Term 2
Teaching Period : T2
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, Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

Control systems are ubiquitous in modern technologies, ensuring that they can perform the tasks that they are designed to do in the presence of noise and uncertainties, as well as in a variety of environmental conditions. Most modern technologies cannot function without their control systems.

This course gives an introduction to modern control theory that is based on the state-space approach for continuous-time control systems. Although originally developed in the context of control engineering, state-space models and the state-space approach have found important applications in many other areas of science and engineering. The course will cover the foundations of state-space models and fundamental controller design methodologies based on these models. This includes the design of linear and nonlinear controllers and the use of methods based on modern convex optimisation. The connection of the theoretical component of the course to control engineering practice will be supported by a laboratory component, which involves completing a sequence of laboratory-based modules. Through these modules, students will learn to use MATLAB and MATLAB/Simulink as important software tools for the analysis, simulation and design of state-space control systems.

Course Aims

In recent years, modern systems and control have found numerous interesting applications in broad areas of automatic control, signal processing, communication, economics, finance, circuit analysis, mechanical and civil engineering, aeronautics, navigation and guidance, etc. The purpose of this course is to provide students with basic concepts and problem solutions of modern systems and control that are useful for the mentioned applications.

The course will:

a. Further enhance students' understanding of simple as well as more complex continuous-time control systems;

b. Introduce students to state-space representation of control systems;

c. Help students understand the importance of system state and measurement;

d. Familiarise students with the controllability and stability concepts of linear systems;

e. Give students an understanding of basic analysis and synthesis of control systems;

f. Provide opportunities for students to gain practical experience in the use of computer design and analysis tools such as MATLAB and Simulink.

Relationship to Other Courses

In recent years, modern systems and control have found numerous interesting applications in broad areas of automatic control, signal processing, communication, economics, finance, circuit analysis, mechanical and civil engineering, aeronautics, navigation and guidance etc. The purpose of this course is to provide students very basic concepts and problem solutions of modern systems and control that are useful for the mentioned applications.

The course will:

a. Further enhance students understanding of simple as well as more complex continuous-time control systems;

b. Introduce students to state-space representation of control systems;

c. Help students understand the importance of system state and measurement;

d. Familiarise students with the controllability and stability concept of linear systems;

e. Give students an understanding of basic analysis and synthesis of control systems;

f. Provide opportunities for students to gain practical experience in the use of computer design and analysis tools such as Matlab and Simulink.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Explain the notion of stability and how to assess stability using the direct and indirect methods of Lyapunov
CLO2 : Analyse simple to moderately complex control systems (linear and nonlinear) using Lyapunov theory.
CLO3 : Demonstrate a satisfactory understanding of linear systems and the fundamental notions of controllability and observability.
CLO4 : Apply concepts and methods from modern control theory to design state feedback controllers, observers, and output feedback and tracking controllers for linear systems.
CLO5 : Synthesise control systems by convex optimization methodologies
CLO6 : Use MATLAB and Simulink as software tools for synthesising modern state space controllers.

Course Learning Outcomes	Assessment Item
CLO1 : Explain the notion of stability and how to assess stability using the direct and indirect methods of Lyapunov	• Quizzes • Lab Work • Midterm Exam • Final Examination
CLO2 : Analyse simple to moderately complex control systems (linear and nonlinear) using Lyapunov theory.	• Quizzes • Midterm Exam • Final Examination
CLO3 : Demonstrate a satisfactory understanding of linear systems and the fundamental notions of controllability and observability.	• Lab Work • Quizzes • Midterm Exam • Final Examination
CLO4 : Apply concepts and methods from modern control theory to design state feedback controllers, observers, and output feedback and tracking controllers for linear systems.	• Lab Work • Quizzes • Final Examination
CLO5 : Synthesise control systems by convex optimization methodologies	• Lab Work • Final Examination
CLO6 : Use MATLAB and Simulink as software tools for synthesising modern state space controllers.	• Lab Work

Learning and Teaching Technologies

Moodle - Learning Management System

Learning and Teaching in this course

Learning in this course

Students are expected to attend all online lectures, tutorials, labs, and attempt quizzes and the mid- session exams in order to maximise learning. They must prepare well for their laboratory classes and their lab work will be assessed. Reading additional texts beyond the lecture notes will further enhance a student's learning experience. Group learning is also encouraged. UNSW assumes that self-directed study of this kind is undertaken in addition to attending formal classes throughout the course.

Especially important are learning strategies that students have to adopt.

- Learning is effortful - you have to make the effort.
- You have to develop your own mental models for how things work. The lecturer can give you insights, but you have to develop your own “schema”.
- You learn from errors and from discovering misconceptions. You cannot do this just by listening or reading. You have to try things out.
- Firstly, close your books and explain and write down concepts for yourself or for friends.

Check. If your concept is not complete and accurate, do it again. You learn through the tip of your pen.
- Do all the tutorial problems to test your new-found understanding.
- You learn by doing. Make sure you become competent in the laboratory. Always come prepared before attending the labs, and pace yourself to complete in-lab tasks and experiments within the assigned lab time.
- The ultimate test of whether you have learned something is whether you can use it next year, or when you begin working. Only your schema are enduring. You will forget details, and setting out to simply memorise things is worthless - of minor assistance for exams only

Other Professional Outcomes

Engineers Australia (EA), Professional Engineer Stage 1 Competencies

The Course Learning Outcomes (CLOs) contribute to your development of the following EA competencies:

PE1: Knowledge and Skill Base:

PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals: CLO 1, 2, 3, 4, 5

PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing: CLO 1, 2, 3, 4, 5

PE1.3 In-depth understanding of specialist bodies of knowledge: CLO 1, 2, 3, 4, 5

PE1.4 Discernment of knowledge development and research directions: n/a

PE1.5 Knowledge of engineering design practice: CLO 1, 2, 3, 4, 5, 6

PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice: n/a

PE2: Engineering Application Ability:

PE2.1 Application of established engineering methods to complex problem solving: CLO 1, 2, 3, 4, 5, 6

PE2.2 Fluent application of engineering techniques, tools and resources: CLO 1, 2, 3, 4, 5, 6

PE2.3 Application of systematic engineering synthesis and design processes: CLO 4, 5 , 6

PE2.4 Application of systematic approaches to the conduct and management of engineering projects: n/a

PE3: Professional and Personal Attributes:

PE3.1 Ethical conduct and professional accountability: n/a

PE3.2 Effective oral and written communication (professional and lay domains): CLO 6

PE3.3 Creative, innovative and pro-active demeanour: CLO 1, 2, 3, 4, 5, 6

PE3.4 Professional use and management of information: CLO 1, 2, 3,4,5, 6

PE3.5 Orderly management of self, and professional conduct: n/a

PE3.6 Effective team membership and team leadership: CLO 6

Additional Course Information

This is a 6 UoC course and the expected workload is 15 hours per week throughout the 10-week term.

Relationship to Other Courses This is a 4th year elective undergraduate course and a 1st year/ postgraduate course in the School of Electrical Engineering and Telecommunications.

Pre-requisites and Assumed Knowledge The pre-requisite for this course is ELEC3114 Control Systems. It is also essential that you are familiar with MATH2069, Mathematics 2A, and MATH2099, Mathematics 2B, before this course is attempted. Students are expected to be familiar and comfortable with:

- Vector calculus: functions of several variables, multivariable calculus, scalar fields, vector fields, gradients (MATH2069)
- Linear algebra: matrices, matrix inversion, matrix determinant, vectors, vector spaces, basis vectors, linearly independence, linear span of vectors, null/kernel spaces, characteristic equations, eigenvalues, eigenvectors, diagonalisation of a matrix, exponentiation of a matrix, Jordan canonical form (MATH2099)
- Control systems: Laplace transform, inverse Laplace transform, transfer functions, poles and zeros, feedback loop, steady-state error (ELEC3114)

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Quizzes Assessment Format: Individual	12%	Start Date: To be announced Due Date: To be announced
Lab Work Assessment Format: Individual	12%	Start Date: Week 2
Midterm Exam Assessment Format: Individual	20%	
Final Examination Assessment Format: Individual	56%	

Assessment Details

Quizzes

Assessment Overview

The two short take-home quizzes are given to provide you with some feedback on some sections of the course. These should be done independently and honestly. Marks will be assigned according to the correctness of the responses. Plagiarism is a serious academic misconduct that will entail a heavy penalty.

Course Learning Outcomes

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- CLO2 : Analyse simple to moderately complex control systems (linear and nonlinear) using Lyapunov theory.
- CLO3 : Demonstrate a satisfactory understanding of linear systems and the fundamental notions of controllability and observability.
- CLO4 : Apply concepts and methods from modern control theory to design state feedback controllers, observers, and output feedback and tracking controllers for linear systems.

Assessment Length

1 week

Submission notes

Submissions after the specified deadline (to be announced on Moodle) are automatically deemed as late. Late quiz submissions will attract a penalty for late assignments per UNSW rules.

Lab Work

Assessment Overview

Laboratories are primarily about learning, and the laboratory assessment is designed mainly to check your knowledge as you progress through each stage of the laboratory tasks. It is essential that you prepare well before coming to the lab. This means reading through the lab manual and reviewing any relevant materials from lectures as required for the lab. You will be recording your observations/readings and your solutions to the lab exercises in your lab book. After completing each experiment, your work will be marked by the laboratory demonstrator with verbal feedback given. The demonstrators will keep a record of the marks that you achieved in any particular lab.

Course Learning Outcomes

- CLO1 : Explain the notion of stability and how to assess stability using the direct and indirect

methods of Lyapunov
- CLO3 : Demonstrate a satisfactory understanding of linear systems and the fundamental notions of controllability and observability.
- CLO4 : Apply concepts and methods from modern control theory to design state feedback controllers, observers, and output feedback and tracking controllers for linear systems.
- CLO5 : Synthesise control systems by convex optimization methodologies
- CLO6 : Use MATLAB and Simulink as software tools for synthesising modern state space controllers.

Assessment Length

10 weeks (Week 2 to Week 10)

Midterm Exam

Assessment Overview

The mid-term written examination will test your general understanding of the course material covered thus far in the lectures and is designed to give you feedback on your progress through the analytical components of the course. It will definitely contain numerical and analytical questions. Assessment is a graded mark according to the correct fraction of answers to the test questions. Individual feedback will be provided on the mid-term examination result.

Course Learning Outcomes

- CLO1 : Explain the notion of stability and how to assess stability using the direct and indirect methods of Lyapunov
- CLO2 : Analyse simple to moderately complex control systems (linear and nonlinear) using Lyapunov theory.
- CLO3 : Demonstrate a satisfactory understanding of linear systems and the fundamental notions of controllability and observability.

Assessment Length

1 hour

Submission notes

The midterm exam is planned to be an in-person invigilated closed-book exam. In the event that the exam cannot be conducted in-person and has to be held online, the following late submission penalty applies: 10% of the full mark for submissions late by up to at most 5 minutes, 25% for submissions that are more than 5 minutes and up to 10 minutes late, 50% for submissions that are more than 10 minutes and up to 15 minutes late, and 75% for submissions that are more than 15 minutes and up to 20 mi

Assessment information

Midtem exam date and time will be announced by the course convenor.

Assignment submission Turnitin type

Not Applicable

Final Examination

Assessment Overview

The final exam is a 2-hour written examination to be scheduled during the final exam period. The examination tests analytical and critical thinking and general understanding of the course material. Questions may be drawn from any aspect of the course unless specifically indicated otherwise by the lecturer. Assessment is a graded mark according to the correct fraction of answers to the test questions.

Course Learning Outcomes

- CLO1 : Explain the notion of stability and how to assess stability using the direct and indirect methods of Lyapunov
- CLO2 : Analyse simple to moderately complex control systems (linear and nonlinear) using Lyapunov theory.
- CLO3 : Demonstrate a satisfactory understanding of linear systems and the fundamental notions of controllability and observability.
- CLO4 : Apply concepts and methods from modern control theory to design state feedback controllers, observers, and output feedback and tracking controllers for linear systems.
- CLO5 : Synthesise control systems by convex optimization methodologies

Assessment Length

2 hours

Submission notes

The final exam is planned to be an in-person invigilated closed-book exam. In the event that the exam cannot be conducted in-person and has to be held online, the following late submission penalty applies: 10% of the full mark for submissions late by up to at most 5 minutes, 25% for submissions that are more than 5 minutes and up to 10 minutes late, 50% for submissions that are more than 10 minutes and up to 15 minutes late, and 75% for submissions that are more than 15 minutes and up to 20 minutes late. No marks will be awarded for submissions more than 20 minutes late.

Assessment information

The final exam is a centrally timetabled invigilated exam.

General Assessment Information

Grading Basis

Standard

Requirements to pass course

Students must obtain a weighted mark of 50 across all assessment items to pass the course.

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 27 May - 2 June	Lecture	Brief review of linear algebra and vector calculus
	Lecture	Brief review of linear algebra and vector calculus (continued)
Week 2 : 3 June - 9 June	Lecture	Dynamical systems and linear state-space systems
	Lecture	Dynamical systems and linear state-space systems (continued)
	Tutorial	Tutorial 1: Brief review of linear algebra and vector calculus
	Laboratory	Laboratory 1
	Assessment	Quiz 1
Week 3 : 10 June - 16 June	Lecture	Lyapunov stability analysis
	Lecture	Lyapunov stability analysis (continued)
	Tutorial	Tutorial 2: Brief review of linear algebra and vector calculus
	Laboratory	Laboratory 1
Week 4 : 17 June - 23 June	Lecture	Stability, controllability and observability for LTI systems
	Lecture	State-space transformations and pole placement
	Tutorial	Tutorial 3: Lyapunov stability analysis
	Laboratory	Laboratory 2
Week 5 : 24 June - 30 June	Lecture	Introduction to linear quadratic regulator theory
	Tutorial	Tutorial 4: Stability, controllability and observability for LTI systems
	Tutorial	Tutorial 5: State-space transformations and pole placement
	Laboratory	Laboratory 2
	Assessment	Midterm Exam: The midterm exam will be an in-person invigilated closed-book exam.
Week 6 : 1 July - 7 July	Other	Flexibility Week No lectures, tutorials or labs. Please use this week for revision.
Week 7 : 8 July - 14 July	Lecture	Observers and output feedback
	Lecture	An introduction to linear matrix inequalities
	Tutorial	Tutorial 6: Linear quadratic regulator theory
	Laboratory	Laboratory 3
	Assessment	Quiz 2
Week 8 : 15 July - 21 July	Lecture	Controller and observer synthesis using LMIs
	Tutorial	Tutorial 7: Observers and output feedback
	Tutorial	Tutorial 8: An introduction to linear matrix inequalities
	Laboratory	Laboratory 3
Week 9 : 22 July - 28 July	Lecture	State and output feedback control for reference tracking
	Lecture	State feedback design using Lyapunov functions
	Tutorial	Tutorial 9: Controller and observer synthesis using LMIs
	Laboratory	Laboratory 4
Week 10 : 29 July - 4 August	Lecture	Review lecture
	Tutorial	Tutorial 10: State and output feedback control for reference tracking
	Tutorial	Tutorial 11: State-feedback design using Lyapunov functions
	Laboratory	Laboratory 4

Attendance Requirements

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

Course Resources

Prescribed Resources

Lecture notes

Lecture notes will be posted on Moodle.

Recommended Resources

Further texts and references

Additional resources that will be useful as references besides the lecture notes are

1. Franklin, Powell and Emami-Naeini, Feedback Control of Dynamic Systems, 6th edition, Addison- Wesley.
2. Jean-Jacques E. Slotine and W. Li, Applied Nonlinear Control, Prentice-Hall, 1991.
3. Two courses EE263 Introduction to Linear Dynamical Systems and EE363 Linear Dynamical Systems at Stanford University (USA). All info available on the websites: http://www.stanford.edu/class/ee263/ and http://www.stanford.edu/class/ee363/

Course Evaluation and Development

Student feedback will be solicited via Moodle and the myExperience survey before the final exam. The structure of the course lectures and tutorials was revised in T3 2023 to make the course delivery more balanced between the first half and the last half of the term, while keeping the same overall course materials. Based on the feedback from Term 2 2023, this term will continue to assess and tweak lecture and tutorial delivery in this new structure.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Dr Hendra Nurdin		G17 Level 3 Room 315	57556	To be announced	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