UNSW Course Outline

ELEC9732 Analysis and Design of Non-linear Control - 2024

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General Course Information

Course Code : ELEC9732
Year : 2024
Term : Term 3
Teaching Period : T3
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

Practical systems in the real world mostly behave in a complicated nonlinear manner. It is important that control engineers are able to understand and characterise the behaviour of such systems and develop control solutions, beyond the linear methodology, to achieve better system

performance.

The course covers basic nonlinear control, design, and analysis. The analysis includes phase plane methods and Lyapunov stability and input/output stability. Nonlinear control design includes: describing functions, feedback linearisation, gain scheduling, sliding mode control, and an introduction to optimal control and reinforcement learning.

Course Aims

Control Engineering is an enabling theory and methodology underlying all branches of electrical engineering. Nonlinear control offers superior performance compared to classical linear design approaches. This graduate-level course aims to provide an introduction to nonlinear systems analysis and an introduction to nonlinear control design.

Relationship to Other Courses

Builds on undergraduate courses.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Explain basic aspects of nonlinear systems and control, from both an analysis and a design point of view.
CLO2 : Use this knowledge to solve basic problems in nonlinear systems analysis and nonlinear control design.

Course Learning Outcomes	Assessment Item
CLO1 : Explain basic aspects of nonlinear systems and control, from both an analysis and a design point of view.	• Homework 1 • Homework 2 • Final Exam
CLO2 : Use this knowledge to solve basic problems in nonlinear systems analysis and nonlinear control design.	• Homework 1 • Homework 2 • Final Exam

Learning and Teaching Technologies

Moodle - Learning Management System | Zoom

Other Professional Outcomes

Relationship to Engineers Australia Stage 1 competencies:

The Course Learning Outcomes (LOs) contribute to the Engineers Australia (National Accreditation Body) Stage I competencies as outlined below

Engineers Australia (EA), Professional Engineer Stage 1 Competencies

PE1: Knowledge and Skill Base: LO 1,2
PE1.1 Comprehensive, theory-based **understanding of underpinning fundamentals**: LO 1, 2
PE1.2 Conceptual understanding of underpinning maths, **analysis**, statistics, **computing**: LO 1, 2
PE1.3 In-depth understanding of specialist bodies of **knowledge**: LO 1,2
PE1.4 Discernment of knowledge development and research directions: NA
PE1.5 Knowledge of **engineering design** practice: LO 1,2
PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice: NA

PE2: Engineering Application Ability:
PE2.1 Application of established engineering methods to **complex problem solving**: LO 1,2
PE2.2 Fluent **application of engineering techniques**, tools and resources: LO 1, 2
PE2.3 Application of systematic engineering synthesis and design processes: LO 1,2
PE2.4 Application of systematic approaches to the conduct and management of engineering projects: NA

PE3: *Professional and Personal Attributes:*
PE3.1 Ethical conduct and professional accountability: NA
PE3.2 Effective **oral and written communication** (professional and lay domains): LO 1,2
PE3.3 **Creative, innovative** and pro-active demeanour: NA
PE3.4 Professional use and management of information: NA
PE3.5 Orderly management of **self, and professional conduct**: NA
PE3.6 Effective team membership and team leadership: NA

This course is also designed to provide the course learning outcomes which arise from targeted graduate capabilities. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (also listed below).

Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning

UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the laboratory experiments and interactive checkpoint assessments and lab exams during the labs.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.
- Developing citizens who can apply their discipline in other contexts, are culturally aware and environmentally responsible, through interdisciplinary tasks, seminars and group activities

Additional Course Information

Prerequisite is an undergraduate course in control engineering. This should include experience with matlab and particularly simulink.Further, very strong mathematics grades are a great advantage.

Homeworks are to be completed on your own.You cannot discuss with others.You cannot copy from any source.The work that you hand in (and any related working) must be yours alone.Late homeworks will be penalized: 10% of the maximum mark per day late.The same conditions apply to the take-home Exam. You cannot use large language models or related sfotware

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Homework 1 Assessment Format: Individual	17%	
Homework 2 Assessment Format: Individual	16%	
Homework 3 Assessment Format: Individual	17%	
Final Exam Assessment Format: Individual	50%	

Assessment Details

Homework 1

Assessment Overview

Covers material so far delivered. Graded according to closeness to correct solution. Comments written on each individual assignment.

Course Learning Outcomes

- CLO1 : Explain basic aspects of nonlinear systems and control, from both an analysis and a design point of view.
- CLO2 : Use this knowledge to solve basic problems in nonlinear systems analysis and nonlinear control design.

Detailed Assessment Description

Given out week 3; due week 4.

Assessment Length

9 days

Submission notes

submitted through moodle.

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
For more information on Generative AI and permitted use please see here.

Homework 2

Assessment Overview

Covers material delivered since Homework 1. Graded according to closeness to correct solution. Comments written on each individual assignment.

Course Learning Outcomes

- CLO1 : Explain basic aspects of nonlinear systems and control, from both an analysis and a design point of view.
- CLO2 : Use this knowledge to solve basic problems in nonlinear systems analysis and nonlinear control design.

Detailed Assessment Description

Given out week 5; due week 6.

Assessment Length

9 days

Submission notes

submitted through moodle

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
For more information on Generative AI and permitted use please see here.

Homework 3

Assessment Overview

Covers material delivered since Homework 2. Graded according to closeness to correct solution.

Comments written on each individual assignment.

Detailed Assessment Description

Given out week 7; due week 8.

Assessment Length

9 days

Submission notes

submitted through moodle

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
For more information on Generative AI and permitted use please see here.

Final Exam

Assessment Overview

This exam aims to assess students' 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 : Explain basic aspects of nonlinear systems and control, from both an analysis and a design point of view.
- CLO2 : Use this knowledge to solve basic problems in nonlinear systems analysis and nonlinear control design.

Detailed Assessment Description

Given out week 10; due week 11.

Assessment Length

9 days

Submission notes

submitted through moodle

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
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General Assessment Information

There will be one extra lecture in week 1, 6pm-9pm, on Friday of that week.

Grading Basis

Standard

Requirements to pass course

Grade of 50%.

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 0 : 2 September - 8 September	Other	No week 0 items.
Week 1 : 9 September - 15 September	Lecture	Introduction and review. Nonlinear Ordinary Differential Equations. Phase plane methods. Extra lecture on Friday, week 1.
Week 2 : 16 September - 22 September	Lecture	Lyapunov Stability.
Week 3 : 23 September - 29 September	Lecture	Input/Output Stability.
Week 4 : 30 September - 6 October	Lecture	Describing Functions (= approximate Fourier analysis for nonlinear systems).
Week 5 : 7 October - 13 October	Lecture	Describing Functions continued; Introduction to Nonlinear Control.
Week 6 : 14 October - 20 October	Lecture	Nonlinearity Cancelling Feedback (aka Feedback Linearization).
Week 7 : 21 October - 27 October	Lecture	State Feedback Linearization; Sliding Mode Control.
Week 8 : 28 October - 3 November	Lecture	Gain Scheduling.
Week 9 : 4 November - 10 November	Lecture	Recursive Lyapunov Control Design (aka Backstepping). Introduction to Optimal Control.
Week 10 : 11 November - 17 November	Lecture	Optimal Control continued and and Reinforcement Learning (= Adaptve Optimal Control).

Attendance Requirements

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

General Schedule Information

There is an extra lecture in week 1; Friday 6pm-9pm.

Course Resources

Prescribed Resources

Matlab including simulink.

Recommended Resources

There is no textbook for the course.

Only the lecture notes are needed.

The following two referernce books may be useful, but it is not necessary to use them.

i. JJ Slotine, W Li (1991). Applied Nonlinear Control (Prentice Hall)ii.

H Khalil (1996,2002) Nonlinear Systems (Prentice Hall)

Course Evaluation and Development

Students are encouraged to ask questions during lectures and/or email questions at any time.

Course material is continually adjusted to keep it up to date e.g. reinforcement learning was

added in recent years. Students are encouraged to repeat the simulations shown in the lecture notes.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Prof. V. Solo		NA	NA	by email	No	Yes
Lecturer	Mr. Xinhui Rong		NA	NA	by email	No	No

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