School of Electrical Engineering & Telecommunications

UNSW Engineering

ELEC9732

Analysis and Design of Non-linear Control

Term 3, 2022

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Prof. V. Solo	v.solo@unsw.edu.au	by email	EE345	93854010

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

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

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)

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, 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

Course Details

Units of Credit 6

Summary of the Course

The course covers basic nonlinear control, design and analysis.
The analysis includes phase plane methods and Lyapunov stabilty 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

Provide an introduction to nonlinear systems analysis and an introduction to nonlinear control design.

Course Learning Outcomes

After successfully completing this course, you should be able to:

Learning Outcome	EA Stage 1 Competencies
1. Understand and explain basic aspects of nonlinear systems and control, from both an analysis and a design point of view.	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE2.1, PE2.2, PE2.3, PE3.1
2. Use this knowledge to solve basic problems in nonlinear systems analysis and nonlinear control design.	PE1.1, PE1.2, PE1.3, PE1.4, PE1.5, PE2.1, PE2.2, PE2.3, PE3.1, PE3.2

Teaching Strategies

To give the basic material in written form, and to highlight the importance of different sections and help with the formation of schema. to give practice in problem solving, and to assess your progress. the final test of competency.

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.

Assessment

Assessment task	Weight	Due Date	Course Learning Outcomes Assessed
1. Homework 1	17%	Not Applicable	1, 2
2. Homework 2	16%	Not Applicable	1, 2
3. Homework 3	17%	Not Applicable	1, 2
4. Final Exam	50%	Not Applicable	1, 2

Assessment 1: Homework 1

Assessment length: 9 days
Submission notes: submitted through moodle.

Handed out Thursday week 3; due Friday 4pm week 4.

Assessment 2: Homework 2

Assessment length: 9 days
Submission notes: submitted through moodle

Handed out Thursday of week 5; due Friday 4pm, week 6

Assessment 3: Homework 3

Assessment length: 9 days
Submission notes: submitted through moodle

Handed out Thursday of week 7; due Friday 4pm, week 8

Assessment 4: Final Exam

Assessment length: 9 days
Submission notes: submitted through moodle

Handed out Thursday of week 10; due Friday 4pm, week 11

Attendance Requirements

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

Course Schedule

View class timetable

Timetable

Date	Type	Content
O-Week: 5 September - 9 September	Topic	No activities in week 0.
Week 1: 12 September - 16 September	Lecture	Introduction and Review Nonlinear Ordinary Differential Equations, Phase Plane Methods
	Lecture	One extra lecture on Friday of week 1 only.
Week 2: 19 September - 23 September	Lecture	Lyapunov Stability
Week 3: 26 September - 30 September	Lecture	Input/Output Stability
Week 4: 3 October - 7 October	Lecture	Describing Functions
Week 5: 10 October - 14 October	Lecture	Describing Functions, Nonlinear Control - Introduction
Week 6: 17 October - 21 October	Lecture	Feedback Linearization (Nonlinearity Cancelling Feedback)
Week 7: 24 October - 28 October	Lecture	State Feedback Linearization, Sliding Mode Control
Week 8: 31 October - 4 November	Lecture	Gain Scheduling
Week 9: 7 November - 11 November	Lecture	Backstepping Design (Recursive Lyapunov Design)
Week 10: 14 November - 18 November	Lecture	Introduction to Optimal Control and Reinforcement Learning (Adaptive Control).

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)

Academic Honesty and Plagiarism

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see https://student.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

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.

Academic Information

COVID19 - Important Health Related Notice

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

Dates to note

Important Dates available at: https://student.unsw.edu.au/dates

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://student.unsw.edu.au/policy), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **15 hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both formal classes and *independent, self-directed study*. In periods where you need to complete assignments or prepare for examinations, 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.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You can apply for special consideration when illness or other circumstances beyond your control interfere with an assessment performance. If you need to submit an application for special consideration for an exam or assessment, you must submit the application **prior to the start** of the exam or before the assessment is submitted, except where illness or misadventure prevent you from doing so. Be aware of the "fit to sit/submit" rule which means that if you sit an exam or submit an assignment, you are declaring yourself well enough to do so and cannot later apply for Special Consideration. For more information and how to apply, see https://student.unsw.edu.au/special-consideration.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and UNSW policies:

https://student.unsw.edu.au/guide

https://www.engineering.unsw.edu.au/electrical-engineering/resources

Disclaimer

This Course Outline sets out 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 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 (as updated in Moodle), the description in the Course Outline/Moodle applies.

Image Credit

Synergies in Sound 2016

CRICOS

CRICOS Provider Code: 00098G

Acknowledgement of Country

We acknowledge the Bedegal people who are the traditional custodians of the lands on which UNSW Kensington campus is located.

Appendix: Engineers Australia (EA) Professional Engineer Competency Standard

Program Intended Learning Outcomes	
Knowledge and skill base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline	✓
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline	✓
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	✓
PE1.4 Discernment of knowledge development and research directions within the engineering discipline	✓
PE1.5 Knowledge of engineering design practice and contextual factors impacting the engineering discipline	✓
PE1.6 Understanding of the scope, principles, norms, accountabilities and bounds of sustainable engineering practice in the specific discipline	
Engineering application ability	
PE2.1 Application of established engineering methods to complex engineering problem solving	✓
PE2.2 Fluent application of engineering techniques, tools and resources	✓
PE2.3 Application of systematic engineering synthesis and design processes	✓
PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
Professional and personal attributes	
PE3.1 Ethical conduct and professional accountability	✓
PE3.2 Effective oral and written communication in professional and lay domains	✓
PE3.3 Creative, innovative and pro-active demeanour	
PE3.4 Professional use and management of information	
PE3.5 Orderly management of self, and professional conduct	
PE3.6 Effective team membership and team leadership	