MMAN3200

Linear Systems and Control

Term One // 2021

School of Mechanical and Manufacturing Engineering // UNSW Engineering

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Jose Guivant	j.guivant@unsw.edu.au	Microsoft Teams Video Chat Hours: TBA	Building J17, Room 510D	9385 5693

Lecturers

Name	Email	Availability	Location	Phone
Zoran Vulovic	z.vulovic@unsw.edu.au	Microsoft Teams Video Chat Hours: TBA	Building J17, Room 311D	9385 6261

School Contact Information

Location

UNSW Mechanical and Manufacturing Engineering

Ainsworth building J17, Level 1

Above Coffee on Campus

Hours

9:00–5:00pm, Monday–Friday*

*Closed on public holidays, School scheduled events and University Shutdown

Web

School of Mechanical and Manufacturing Engineering

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)

(+61 2) 9385 4097 – School Office**

**Please note that the School Office will not know when/if your course convenor is on campus or available

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

School Office – School general office administration enquiries

- NB: the relevant teams listed above must be contacted for all student enquiries

Course Details

Credit Points 6

Summary of the Course

Models of physical systems: differential equations for physical systems including mechanical, electrical, hydraulic, thermal and pneumatic systems; linearisation. System analysis techniques: solution by Laplace transform method. Transfer functions and block diagrams. System response: response of first and second order systems to impulse, step, ramp and periodic inputs; higher order system response; concept of system stability, applications. Concept of control. Stability criteria; use of Root Locus and Bode for system analysis. Simulation of linear and non-linear systems. Basic passive and and active analog filters. Frequency Domain / Fourier. PID controller. State space representation of linear and certain non-linear systems. The matrix exponential. The transfer matrix. State feedback, pole Placement and controllability. State estimation/observers and observability. Use of MATLAB/Simulink as a simulation environment.

The course is offered in terms 1 (T1) and 2 (T2). The majority of places in T1 will be reserved for Mechatronics students. The majority of places in T2 will be reserved for Aerospace, Mechanical and Mechanical and Manufacturing students.

Course Aims

The primary function of Linear Systems and Control is to serve as the first step towards mastering control engineering. The ultimate purpose of control engineering is to approach various systems from the stability point of view, with special attention given to transient processes. With that in mind, MMAN3200 endeavors to provide students with analytical tools that are easily applied to a wide spectrum of engineering problems.

Some components of this module have other roles. Systems modeling for example, which occupies a major part, helps you acquire knowledge necessary for simulation, analysis or design of numerous systems. It helps you consolidate the knowledge gained so far in courses dealing with Mechanics, Design, Fluids, Thermodynamics, Solids and Electrical Engineering. Linearisation provides a useful tool for simplification of complex systems while at the same time points out possible problems that could arise from oversimplification. In the latter part of the course, you will learn state space analysis, a powerful and general technique for studying dynamic systems.

The aim of MMAN3200, as an important part of control engineering, is to offer the knowledge of methodologies specifically designed for Laplace domain, which in turn enables easier and more efficient analysis of complex engineering systems. Numerous types of systems from real engineering applications will be used throughout the course to give you the practical aspects of the methods covered.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Create linear mathematical models diverse systems	PE1.2, PE2.1, PE2.2
2. Analyse linear time invariant continuous systems in both, time	PE1.2, PE2.1, PE2.2

Learning Outcome	EA Stage 1 Competencies
and complex, domains	

Teaching Strategies

Lectures in the course are designed to provide the basic theory behind the concepts taught. For most classes, lecture notes slides will be available online and beforehand. Students are encouraged to ask questions during the classes.

It is very important for third year students to be able to use multiple sources. For that reason, apart from the textbook and provided lecture notes, several recommended texts are listed. You are welcome to consult your lecturers on this.

Demonstrations are designed for practical applications of the theoretical concepts introduced in lectures. A comprehensive set of tutorial problems will be provided beforehand. Two types of demonstrations will be organised, standard and interactive.

In “standard” demonstrations, it is the demonstrator who sets the pace and works on select examples. The times of those classes are found in your timetables.

In ‘interactive” demonstrations, it is students who work individually or in small groups, and therefore it is up to them to select the examples and dictate the pace. The demonstrators and the lecturer will be on hand to provide guidance. These demonstrations will run in the middle 45 minutes of each lecture block, on Wednesdays.

Finally, the lab work is important in giving you the practical aspects of some of the concepts learnt in classes.

Additional matters: Several necessary mathematical concepts are regarded as assumed knowledge for MMAN3200, in particular the Laplace Transform, and Vector and Matrix Algebra. To assist the students in revising those necessary concepts, a entry quiz is created on Moodle. The mark for the Entry Quiz does NOT contribute to the total mark for MMAN3200, but students have to pass it in order to proceed with the course. Lecture 0 and Tutorial Set 0 serve the same purpose in helping students to revise the required mathematical knowledge. Academic staff will be glad to answer questions from students about these topics.

Assessment

Assessment Tasks

Assessment task	Weight	Due Date	Student Learning Outcomes Assessed
Tests	42%		1, 2
Final Exam	40%		1, 2
Lab Report	18%	End of term (week 10)	1, 2

Assessment Details

Assessment 1: Tests

Details:

There will be two components, Test 1 (in Week 3) worth 12% and Test 2 (in Week 7) worth 30%

Additional details:

The tests will run via Moodle.

Submission notes: online tests

Assessment 2: Final Exam

Details:

Final examination focusing on the material covered in the second half of the term.

Submission notes: The exam will be online, via Moodle.

Assessment 3: Lab Report

Details:

Applying state estimation, and control approaches, working with a given system.

The project's specifications will be released in week 6, to be solved during subsequent weeks. Submission of results will be in week 10.

Attendance Requirements

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

Course Schedule

View class timetable

Timetable

Date	Type	Content
Week 1: 15 February - 19 February	Lecture	Laplace transform and inverse Laplace Transform. Use of tables. Concept of transfer function. Linearisation of non-linear equations and operating curves.
Week 2: 22 February - 26 February	Lecture	Differential equations describing mechanical, electrical, thermal and fluid components. Input-output relations. Mathematical models of complex systems by combining simultaneous equations associated with the physical model.
Week 3: 1 March - 5 March	Lecture	Reduction of block diagrams. Simple rules for manipulations. Impulse, step, ramp and sinusoidal inputs. Transient process and the steady state. The time constant, percentage overshoot, settling time.
Week 4: 8 March - 12 March	Lecture	The pole position and its relation to stability and other performance characteristics. Open and closed loop systems. Negative feedback loops. Steady state errors of closed loop systems.
Week 5: 15 March - 19 March	Lecture	Lecture 1 (Tuesday): Root Locus approach. Rules for creating root locus. Routh-Hurwitz stability criterion. Lecture 2 (Wednesday): Fourier Transform. Frequency Domain. Frequency Response of LTI systems. Bode plots. Gain Margin and Phase Margin. Bandwidth. Electrical impedance (in Laplace domain). Basic passive and active analog filters. Active filters based on Operational Amplifiers.
Week 6: 22 March - 26 March	Lecture	Flexibility week: consultation during lecture time. Playing with Simulink, simulating analog and discrete time systems (useful for subsequent weeks in MMAN3200, and for years after MMAN3200)
Week 7: 29 March - 2	Lecture	Lecture 1 (Tue):

April		PD, PI and PID controllers, definition and analysis via Root Locus and Bode. Robustness. Closed loop Performance against model uncertainties and perturbations. Lecture 2 (Wed): State space representation. Process model of LTI systems. SISO and MIMO systems. Non linear cases. Linearization of non linear process models.
Week 8: 5 April - 9 April	Lecture	Transfer function (For LTI SISO and MIMO cases). Controllable canonical form. Similarity transformation. Solution of state space equation. Matrix exponential.
Week 9: 12 April - 16 April	Lecture	Stability analysis, eigenvalues. State feedback. Pole placement. Controllability.
Week 10: 19 April - 23 April	Lecture	State estimation. Observers. Observability. Implementing state feedback via estimated states.

Resources

Prescribed Resources

Lecture notes are provided by the lecturers.

Example code of simulations in Matlab and Simulink.

Recommended Resources

Dhanalakshmi, K. "Modeling, analysis and control of dynamic systems" (2nd edn) by William J. Palm III, John Wiley & Sons, Inc., New York, 2004, ISBN 0-471-07370-9." (2006).

Johnson, M., J. Wilkie, and R. Katebi. "Control Engineering–an Introductory Course." (2002).

Nise, Norman S. "Control systems engineering". John Wiley & Sons, 2020.

Franklin, Gene F., J. David Powell, and Abbas Emami-Naeini. "Feedback control of dynamic systems". London: Pearson, 2015.

(Most of these books are available in the library)

Course Evaluation and Development

1) In 2021, we include a relevant topic/concept: Active filters, based on Operation Amplifiers. For understanding it, we also include the definition of impedance in the Laplace Domain. We also give its interpretation in the frequency domain, in combination with Fourier transform (the usual way to interpret filters, in the signal processing area).

2) Actually covering a relevant topic: State estimation /observers, for being able to implement state feedback in a realistic way. We will also verify it, working, through realistic simulations in Matlab/Simulink.

3) Replaced old fashion hand made Bode plots by using proper analysis via computer software

4) Experimental work is designed to be individual, and which can be solved from home or at uni.

Laboratory Workshop Information

Experimental work will be performed individually (not in groups), not requiring to do it in person.

Submission of Assessment Tasks

Assessment submission and marking criteria

Should the course have any non-electronic assessment submission, these should have a standard School cover sheet.

All submissions are expected to be neat and clearly set out. Your results are the pinnacle of all your hard work and should be treated with due respect. Presenting results clearly gives the marker the best chance of understanding your method; even if the numerical results are incorrect.

Marking guidelines for assignment submissions will be provided at the same time as assignment details to assist with meeting assessable requirements. Submissions will be marked according to the marking guidelines provided.

Late policy

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of 20 percent (20%) 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.

Work submitted after the 'deadline for absolute fail' is not 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 are clearly indicated in the course outline, and such assessments receive a mark of zero if not completed by the specified date. Examples include:

1. Weekly online tests or laboratory work worth a small proportion of the subject mark, or
2. Online quizzes where answers are released to students on completion, or
3. Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date, or
4. Pass/Fail assessment tasks.

Examinations

You must be available for all quizzes, tests and examinations. For courses that have final examinations, these are held during the University examination periods: February for Summer Term, May for T1, August for T2, and November/December for T3.

Please visit myUNSW for Provisional Examination timetable publish dates. For further information on exams, please see the Exams webpage.

Special Consideration

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 submitting an assessment or sitting an exam.

UNSW now has a Fit to Sit / Submit rule, which means that if you attempt an exam or submit a piece of assessment, 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.

Please note that students will **not** be required to provide **any** documentary evidence to support absences from any classes missed **because of COVID-19 public health measures such as isolation**. UNSW will **not** be insisting on medical certificates from anyone deemed to be a positive case, or when they have recovered. Such certificates are difficult to obtain and put an unnecessary strain on students and medical staff.

Applications for special consideration **will** be required for assessment and participation absences – but no documentary evidence **for COVID 19 illness or isolation** will be required.

Academic Honesty and Plagiarism

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.

If plagiarism is found in your work when you are in first year, your lecturer will offer you assistance to improve your academic skills. They may ask you to look at some online resources, attend the Learning Centre, or sometimes resubmit your work with the problem fixed. However more serious instances in first year, such as stealing another student's work or paying someone to do your work, may be investigated under the Student Misconduct Procedures.

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) even suspension from the university. The Student Misconduct Procedures are available here:

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

Academic Information

Credit points

Course credit is calculated in Units-Of-Credit (UOC). The normal workload expectation for one UOC is approximately 25 hours per term. This includes class contact hours, private study, other learning activities, preparation and time spent on all assessable work.

Most coursework courses at UNSW are 6 UOC and involve an estimated 150 hours to complete, for both regular and intensive terms. Each course includes a prescribed number of hours per week (h/w) of scheduled face-to-face and/or online contact. Any additional time beyond the prescribed contact hours should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

On-campus class attendance

Public distancing conditions must be followed for all face-to-face classes. To ensure this, only students enrolled in those classes will be allowed in the room. Class rosters will be attached to corresponding rooms and circulated among lab demonstrators. No over-enrolment is allowed in face-to-face class. Students enrolled in online classes can swap their enrolment from online to a **limited** number of on-campus classes by Sunday, Week 1. Please refer to your course's Microsoft Teams and Moodle sites for more information about class attendance for in-person and online class sections/activities.

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. Further information is available on any course Moodle or Teams site.

In certain classroom and laboratory situations where physical distancing cannot be maintained or there is a high risk that it cannot be maintained, face masks will be considered **mandatory PPE** for students and staff.

For more information, please refer to the
FAQs: https://www.covid-19.unsw.edu.au/safe-return-campus-faqs

Guidelines

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

Important Links

- Moodle
- Lab Access
- Health and Safety
- Computing Facilities
- Student Resources
- Course Outlines
- Engineering Student Support Services Centre
- Makerspace
- UNSW Timetable
- UNSW Handbook
- UNSW Mechanical and Manufacturing Engineering
- Equitable Learning Services

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	