MMAN3200

Linear Systems and Control

Term Two // 2021

School of Mechanical and Manufacturing Engineering // UNSW Engineering

Course Overview

Staff Contact Details

Convenors

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

Lecturers

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

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. The School will only be able to refer students on to the relevant team if contacted

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 and modification. Simulation of linear and non-linear systems. The matrix exponential and state space notation. The transfer matrix. Pole and state feedback, controllability and observability. Use of MATLAB 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 of a variety of systems	PE2.1, PE2.2, PE1.2
2. Analyse linear time invariant continuous systems in both time- and complex- domains	PE1.2, PE2.1, PE2.2
3. Interpret and model systems through state space representation	PE1.2, PE2.1, PE2.2

Teaching Strategies

Lectures in the course are designed to provide the basic theory behind the concepts taught. For most classes, lecture notes 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 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 hour of each three-hour lecture block.

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

Additional Course Information

Additional matters: Several necessary mathematical concepts learnt in MATH2018/2019 are regarded as prerequisite knowledge for MMAN3200, in particular the Laplace Transform, and Vector and Matrix Algebra. To assist the students in revising those necessary concepts, an 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
Test	35%	Not Applicable	1, 2
Final Exam	45%	Not Applicable	1, 2, 3
Lab Report	20%	03/08/2021 11:50 PM	1, 2, 3

Assessment Details

Assessment 1: Test

Start date: Not Applicable

Length: 70 minutes and 110 minutes for Test 1 and Test 2 respectively

Details:

There will be two components, Test 1 in Week 3 worth 10% and Test 2 in week 5 worth 25%.

These are **individual** assessment tasks.

To obtain the full mark both the final answers AND the procedure have to be correct for all parts of all questions. Partial marks will be awarded for correct procedures.

Additional details:

The tests will run via Moodle.

Revision time will be provided in the lead-up to the tests.

Marks will be returned within two weeks from the date of the test.

Submission notes: Online tests

Turnitin setting: This is not a Turnitin assignment

Assessment 2: Final Exam

Start date: Not Applicable

Length: 150 minutes

Details:

The final examination will focus on the material covered between Lecture 9 and the end of the course; however, those elements of the material presented earlier in the course that are integral to the examinable material cannot be excluded.

This is an **individual** assessment.

To obtain the full mark both the final answers AND the procedure have to be correct for all parts of all questions. Partial marks will be awarded for correct procedures.

Additional details:

The date and time of the final exam will be set centrally by the examination unit. The marks will be released at the same time when all marks for Term 2 are released.

The exam will run online via Moodle.

Submission notes: Online test in form of a Moodle quiz

Turnitin setting: This is not a Turnitin assignment

Assessment 3: Lab Report

Start date: 20/07/2021 09:00 AM

Length: 20 pages maximum

Details:

The experiment will be performed on the water tank rig. The activities will consist of three basic steps:

1. System identification
2. Application of control loops
3. Analytical work

Additional details:

For students enrolled on-line, the experiment will be filmed and data provided

The deadline for absolute fail is 07/08/2021 at 11:50 PM, four days after the standard deadline.

Marks will be returned within two weeks from the submission deadline.

Submission notes: Submission notes will be posted on Moodle and MS Teams.

Turnitin setting: This is not a Turnitin assignment

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: 31 May - 4 June	Topic	Laplace transform and inverse Laplace Transform. Use of tables. Concept of transfer function. Linearisation of non-linear equations and operating curves.
Week 2: 7 June - 11 June	Topic	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: 14 June - 18 June	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. TEST 1
Week 4: 21 June - 25 June	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: 28 June - 2 July	Lecture	Lecture 1 Root Locus approach. Rules for creating root locus. Routh-Hurwitz stability criterion. Lecture 2 Fourier Transform. Frequency Domain. Frequency Response of LTI systems. Bode plots. Gain Margin and Phase Margin. Bandwidth. TEST 2
Week 6: 5 July - 9 July	Lecture	Flexibility week: Consultations and/or revision during lecture time

		Lectures on non-assessable but useful material possible
Week 7: 12 July - 16 July	Lecture	Lecture 1: PD, PI and PID controllers, definition and analysis via Root Locus and Bode. Robustness. Closed loop Performance against model uncertainties and perturbations. Lecture 2: State space representation. Process model of LTI systems. SISO and MIMO systems. Non linear cases. Linearization of non linear process models.
Week 8: 19 July - 23 July	Lecture	Transfer function (For LTI SISO and MIMO cases). Controllable canonical form. Similarity transformation. Solution of state space equation. Matrix exponential.
Week 9: 26 July - 30 July	Lecture	Stability analysis, eigenvalues. State feedback. Pole placement. Controllability.
Week 10: 2 August - 6 August	Lecture	State estimation. Observers. Observability. Implementing state feedback via estimated states. Revision

Resources

Prescribed Resources

Lecture notes are provided, as well as sets of tutorial problems.

Example code of simulations in Matlab and Simulink will be provided too.

UNSW Library website: https://www.library.unsw.edu.au/

Moodle: https://moodle.telt.unsw.edu.au/login/index.php

Recommended Resources

Ogata, K. “Modern Control Engineering” (5th edition), Pearson

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

Feedback on the course is gathered periodically using various means, including the UNSW myExperience process, informal discussion in the final class for the course, and the School’s

Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

A combination of the previous students' feedback and an improved budget for casual staff resulted in the following changes being introduced this term:

1) The amount of material required for Test 2 is reduced by testing the knowledge on Root Locus in the final exam only. Consequently, the weighting of both tests is reduced and that of the final exam increased. The value of the lab report is also increased by 2 marks.

2) The time management of the tests is made easier for students by clearly separating the answering time from the file submission time.

3) A new and relevant topic is covered: State estimation /observers, for implementation of state feedback in a realistic way. We will also verify it, working, through realistic simulations in Matlab/Simulink.

4) The old fashioned hand made Bode plots are replaced by using proper analysis via computer

software.

Laboratory Workshop Information

Due to the uncertainties with the pandemic, two different options are prepared. One will require no presence on campus whatsoever enabling students to access a remote server to complete their work; the other one will have two modes, on-line and in-person (in the Undergraduate Teaching lab in Willis annex).

Either way, this will be an individual piece of assessment.

Full information will be provided closer to the lab time.

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. No over-enrolment is allowed in face-to-face classes. 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
- Computing Facilities
- Student Resources
- Course Outlines
- Faculty Transitional Arrangements for COVID-19
- Makerspace
- UNSW Timetable
- UNSW Handbook
- 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	