MTRN3020

Modelling and Control of Mechatronic Systems

Term One // 2021

School of Mechanical and Manufacturing Engineering // UNSW Engineering

Course Overview

Staff Contact Details

Convenors

Name	Email	Availability	Location	Phone
Jay Katupitiya	J.Katupitiya@unsw.edu.au	Through appointments	510E Ainsworth Building	93854096

Lecturers

Name	Email	Availability	Location	Phone
Jay Katupitiya	J.Katupitiya@unsw.edu.au		Ainsworth 510E	93854096

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

This subject teaches the student how to design and develop control systems in discrete-time domain that can be used in motion control systems. Material covered includes; Revision of continuous-time control systems and design tools such as root locus, Bode methods and Laplace transform. Starred Laplace transforms, z-transforms. Discretising continuous-time systems. Stability, speed of response and accuracy. Controller design using; root-locus method, direct and indirect analytical methods and bode methods. Observability, controllability. State estimators and design of observers.

Course Aims

This course will give you a thorough understanding of computer-controlled systems. Its core content can be broadly categorized into mathematical means of modelling Mechatronic Systems, model validation, design of digital controllers using a variety of different methods and the implementation of controllers on real-life systems. The systems being modelled and controlled are largely motion control systems.

The course has laboratory experiments (i) to model an inverted pendulum system and to design a classical controller (ii) to design digital control systems for speed and position control rigs.

The courses in the Mechatronics discipline are built up on four different areas: mechanical design, computing, electronics and microprocessors, and control systems. The latter three areas are interrelated, and this course forms a cornerstone of the fundamental courses on which the Mechatronic Engineering course at UNSW is built upon. A thorough understanding of the control of dynamical mechanical systems to achieve desired motions is essential for the design and development of any sophisticated Mechatronic System. Using the fundamental classical control system knowledge gained in the third year, this course builds your knowledge on designing and implementing computer-controlled systems. Control systems provide a methodical way of carrying out the motion control that also needs programming and computing. As such the contributions from this course to the Mechatronic Engineering degree program are essential and vital.

Course Learning Outcomes

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

Learning Outcome	EA Stage 1 Competencies
1. Develop an understanding of the purpose of control systems and their use	PE1.1
2. Be able to understand that a plant is given and a control system is to be designed to satisfy performance specifications	PE1.1
3. Be thoroughly conversant with the available design methodologies and have the ability to choose the appropriate design methods to enable the control system design	PE2.2
4. Have a thorough understanding of the control system	PE2.3

Learning Outcome	EA Stage 1 Competencies
application environment and be able to implement the designed control systems.	

The experimental content and the associated video content will help the students appreciate how control systems work. In a group setting, students will be able to observe, how controllers of their peers operate with different controller parameters demonstrating different behaviours.

Teaching Strategies

Teaching of this course is through Microsoft Team Classrooms. The majority of the lecture content is available as pre-recorded videos. The students are expected to watch these pre-recorded videos and complete minor quizzes before the lecture time. The minor quizzes will award marks. After watching the video content, the students are also expected to attempt the sample problems given to them before the lecture, which will be discussed and worked out during the lectures. During the lecture time a brief explanation of the weekly content is also given and then students get an opportunity work out sample problems. Tutorial classes will also take place in Microsoft Teams classrooms. Laboratory exercises will be explained and data sets for individual students will be provided.

The tutorial sessions are designed to help you use tools such as Matlab to solve complex control system problems. It is essential that you have access to Matlab during all online sessions so that you can maintain a seamless continuation of your learning. The provision of the learning environment in the online tutorial sessions is to facilitate developing confidence in managing design tasks as projects. The content delivered in the lectures will be used to design controllers and then to apply them to control models of real-life systems.

Additional Course Information

The students who come to follow this course are required to have prior knowledge from MMAN3200 Linear Systems and Control or a similar course.

This is a 6 unit-of-credit (UoC) course and involves 3 hours per week (h/w) of scheduled online contact. The normal workload expectations of a student are approximately 25 hours per term for each UOC, including class contact hours, other learning activities, preparation and time spent on all assessable work.

You should aim to spend about 15 h/w on this course. The additional time should be spent in making sure that you understand the lecture material, completing the set assignments, further reading, and revising for any examinations.

Assessment

Assessment Tasks

Assessment task	Weight	Due Date	Student Learning Outcomes Assessed
Quiz : Lecture Video Quizzes	10%	Not Applicable	
Quiz : Major Quiz Part 1	10%	TBA	1, 2
Lab 1 : Inverted Pendulum Experiment	10%	29/03/2021 11:59 PM	1, 2
Lab 2: Speed Control Experiment	15%	16/04/2021 11:59 PM	1, 2, 3
Quiz : Major Quiz Part 2	15%	TBA	1, 2, 3
Lab 3: Position Control Experiment	20%	30/04/2021 11:59 PM	1, 2, 3, 4
Quiz : Major Quiz Part 3	20%	TBA	1, 2, 3, 4

Assessment Details

Assessment 1: Quiz : Lecture Video Quizzes

Start date: Not Applicable

Details: There will be 9 lecture video quizzes that needs to be completed one hour before the lecture each week, after watching the online videos. There will be no lecture video quiz in week 6. Weeks 1 - 5, 7, 8 and week10 lecture video quizzes will get you one mark each. Week 9 lecture video quiz will get you 2 marks.

Additional details:

The students will get more than 48 hours to do the quiz. The quizzes will close 1 hour before the lecture.

Assessment 2: Quiz : Major Quiz Part 1

Start date: 12/03/2021 06:00 PM

Details: This quiz will be conducted in Week 4 Friday between 6 and 7 pm. This is a compulsory quiz and will cover all content from weeks 1 - 3 (including material presented in pre-lecture videos, lecture videos, tutorial classes and lab classes if any). The conditions under which this quiz will be conducted will be announced closer to the quiz.

Assessment 3: Lab 1 : Inverted Pendulum Experiment

Start date: During week 4

Details: The students will be required to design a controller and implement it on an actual experimental rig. The experimental rig consists of an inverted pendulum and the control systems designed by each individual student is expected to hold the pendulum steady while the cart on which it is mounted moves. The data collected for each student will be made available for them and they must complete a report.

Submission notes: Students must submit a report as per the experiment specification.

Turnitin setting: This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Assessment 4: Lab 2: Speed Control Experiment

Start date: The laboratory classes will take place during week 7

Details: The students will be required to design a controller and implement it on an actual experimental rig. The experimental rig consists of a speed control system and the control systems designed by each individual student is expected to maintain the speed of the system despite load variations. The data collected for each student will be made available for them and they must complete a report.

Submission notes: The students must write a report as per the position control experiment specification

Turnitin setting: This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Assessment 5: Quiz : Major Quiz Part 2

Start date: 09/04/2021 06:00 PM

Details: This quiz will be conducted in Week 8 Friday between 6 and 7 pm. This is a compulsory quiz and will cover all content covered in weeks 4 - 7 (including material presented in pre-lecture videos, lecture videos, tutorial classes and lab classes if any). The conditions under which this quiz will be conducted will be announced closer to the quiz.

Assessment 6: Lab 3: Position Control Experiment

Start date: The experiment will take place in week 9

Details: The students will be required to design a controller and implement it on an actual experimental rig. The experimental rig consists of a position control system and the control systems designed by each individual student is expected to position a rotating arm accurately. The data collected for each student will be made available for them and they must complete a report.

Submission notes: The students must write a report as per the position control experiment specification

Turnitin setting: This assignment is submitted through Turnitin and students do not see Turnitin similarity reports.

Assessment 7: Quiz : Major Quiz Part 3

Start date: 23/04/2021 06:00 PM

Details: This quiz will be conducted on Week 10 Friday between 6 and 7 pm. This is a compulsory quiz and will cover all content covered in weeks 8 - 10 (including material presented in pre-lecture videos, lecture videos, tutorial classes and lab classes if any). The conditions under which this quiz will be conducted will be announced closer to the quiz.

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: 8 February - 12 February		
Week 1: 15 February - 19 February	Assessment	Week 1 Minor Quiz
	Lecture	Introduction and How Control Systems Work
	Tutorial	Week 1 Tutorial class from Friday 9 - 10 am.
Week 2: 22 February - 26 February	Assessment	Week 1 Minor Quiz
	Lecture	Modelling, Transfer Functions and State Space Representation
	Tutorial	Week 2 tutorial class from Friday 9 - 10 am
Week 3: 1 March - 5 March	Assessment	Week 3 Minor Quiz
	Lecture	Root Locus followed by Introduction to Discrete-Time Systems
	Tutorial	Week 3 tutorial class from Friday 9 - 10 am
Week 4: 8 March - 12 March	Assessment	Week 4 minor quiz
	Tut-Lab	Inverted Pendulum Experiment
	Lecture	z-transforms and Discrete-Time Transfer Functions
	Tutorial	Week 3 tutorial class from Friday 9 - 10 am
	Assessment	Quiz : Major Quiz Part 1 on Week 4 Friday from 6.00 pm onwards
Week 5: 15 March - 19 March	Assessment	Week 5 minor quiz
	Lecture	Stability followed by Discrete Equivalents of Continuous-time Systems
	Tutorial	Week 5 tutorial class from Friday 9 - 10 am
Week 6: 22 March - 26 March		Flexibility Week
Week 7: 29 March - 2 April	Assessment	Week 7 Minor quiz
	Tut-Lab	Speed Control Experiment
	Lecture	Direct Design: Discrete Controller Design Using Root Locus
	Tutorial	Week 7 tutorial class from Friday 9 - 10 am
Week 8: 5 April - 9 April	Assessment	Week 8 Minor quiz
	Lecture	Direct Design: Discrete Controller Design Using Direct Analytical Method
	Tutorial	Week 8 tutorial class from Friday 9 - 10 am
	Assessment	Quiz : Major Quiz Part 2

Week 9: 12 April - 16 April	Assessment	Week 9 Minor quiz
	Tut-Lab	Position Control Experiment
	Lecture	Indirect Design: Discrete Controller Design Using Bode Method
	Tutorial	Week 9 tutorial class from Friday 9 - 10 am
Week 10: 19 April - 23 April	Assessment	Week 10 Minor quiz
	Lecture	State Feedback Controllers and Observers
	Tutorial	Week 10 Tutorial
	Assessment	Quiz : Major Quiz Part 3

Resources

Prescribed Resources

Pre recorded lecture videos and lecture notes will be made available on Moodle.

Recommended Resources

The following text books may be used for reference.

1. Dorsey, J., “Continuous and Discrete Control Systems”, McGraw Hill
2. Golten, J. and A. Verwer, “Control System Design and Simulation” McGraw Hill

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.

In this course, recent improvements resulting from student feedback include complete digital uplifting of the course.

Laboratory Workshop Information

All laboratory classes will take place in Room 204 of Willis Annex.

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

This is an image of the UNSW autonomous tractors operating in the field in Menangle. The pohto was taken by now retired Mr Vincenco Carnivale

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	