UNSW SYDNEY | Australia's Global University

Mechanical and Manufacturing Engineering

Course Outline

Term 1 2019

MTRN3020

MODELLING AND CONTROL OF MECHATRONIC SYSTEMS

Contents

1. Staff contact details

Contact details and consultation times for course convenor

Name: Associate Professor Jay Katupitiya
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Consultation: Please contact the course convenor by email or phone to make appointments when you need consultation.

Contact details and consultation times for additional lecturers/demonstrators/lab staff

Please see the course Moodle.

2. Important links

- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Engineering Student Support Services Centre

3. Course details

Credit points

This is a 6 unit-of-credit (UoC) course, and involves 3 hours per week (h/w) of face-to-face contact.

Contact hours

	Day	**Time**	**Location**
Lectures	Monday	2 – 4pm	Colombo Theatre A
(Web stream)	Any	Any	Moodle
Demonstrations	Monday	4 – 5pm	Quad G034
Lab	Monday	9 – 11am	Mechatronic Lab 212 (J18)
Weeks 2, 4, 6, 8, 11	Mond	11 – 1pm	Mechatronic Lab 212 (J18)

Please refer to your class timetable for the learning activities you are enrolled in and attend only those classes.

Summary and Aims of the course

This course focuses on the design of digital control systems and their implementation on linear time invariant systems.

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 implement digital control systems on 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.

Student learning outcomes

This course is designed to address the learning outcomes below and the corresponding Engineers Australia Stage 1 Competency Standards for Professional Engineers as shown. The full list of Stage 1 Competency Standards may be found in Appendix A.

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 design a control system.	PE2.2
4.	Have a thorough understanding of the control system application environment and be able to implement the designed control systems.	PE2.3 synthesis and design processes

4. Teaching strategies

Teaching of this course is through lectures, demonstrations and laboratory sessions. All laboratory work is individual work and attendance is essential.

The tutorial sessions are designed to help you use tools such as Matlab to solve complex control system problems. The tutorials will be partially introduced in the class and will be continued in the computer labs. Though not essential, you are encouraged to bring your own computer with Matlab installed (student version is sufficient) so that you can maintain a seamless continuation of your learning. The provision of the learning environment in the laboratory is to facilitate developing confidence in managing laboratory tasks as projects. The content delivered in the lectures will be used to design controllers and then to apply them to control real-life systems. Demonstrators in the laboratories are there to provide you all the guidance and assistance is managing the laboratory tasks.

5. Course schedule

Topic	Mondays (2pm – 4pm)	Location	Lecture Content	Demo/ Lab	Suggested Readings
Introduction	Week 1	Colombo A	Introduction, Qualitative analysis of a control system, simulation of control systems using Matlab	None	Moodle lecture notes
s-Domain to z-Domain	Week 2	Colombo A	Computer controlled systems, Introduction to Discrete-time control systems, z-transforms and inverse z-transforms.	None	Moodle lecture notes
Computer Controlled Systems	Week 3	Colombo A	Discrete time systems, characteristic equation, stability and time response	None	Moodle lecture notes
Modelling of Mechatronic Systems	Week 4	Colombo A	ADC, DAC, PWM, Encoders, their digital representation, Zero order hold (ZOH), samplers. Direct controller design.	None	Moodle lecture notes
Design Methods for Discrete Time Controllers	Week 5	Colombo A	Direct controller design methods: Ragazzini's method. Speed controller design.	None	Moodle lecture notes

Topic	Mondays (2pm – 4pm)	Location	Lecture Content	Demo/ Lab	Suggested Readings
Design Methods for Discrete Time Controllers	Week 6	Colombo A	Root locus, Direct controller design methods: Root Locus	None	Moodle lecture notes
Design Methods for Discrete Time Controllers	Week 7	Colombo A	State space representation, discretization of state space systems, direct design of state feedback controllers in state space.	None	Moodle lecture notes
Design and Implementation of Controllers	Week 8	Colombo A	Frequency domain methods. Indirect design of controllers using frequency domain methods.	None	Moodle lecture notes
Controllability and Observability	Week 9	Colombo A	State observers, design of predictive observers	None	Moodle lecture notes
Estimators	Week 10	Colombo A	Design of current observers, observer – controller pair	None	Moodle lecture notes

6. Assessment

Assessment overview

Assessment	Group Project?	If Group, number of Students per group	Length	Weight	Learning outcomes assessed	Assessment criteria	Due date and submission requirements	Deadline for absolute fail	Marks returned
Pendulum experiment†	No	N/A	A full report as per submission specifications.	10%	1 and 2	Refer to laboratory specification for exact details.	Submit electronically to Moodle submission site by 11.59 pm of 29 March 2019 (Week 6 Friday)	11.59 pm of 3 April 2019	By midnight of Friday of week 8
Speed Control Experiment†	No	N/A	A full report as per submission specifications.	15%	3 and 4	Refer to laboratory specification for exact details.	Submit electronically to Moodle submission site by 11.59 pm of 12 April 2019 (Week 8)	11.59 pm of 17 April 2019	By midnight of Friday of week 10
Position Control Experiment†	No	N/A	A full report as per submission specifications.	20%	3 and 4	Refer to laboratory specification for exact details.	Submit electronically to Moodle submission site by 11.59 pm of 26 April 2019 (week 10)	11.59 pm of 1 May 2019	By midnight of Friday of week 12
Quiz*	No	N/A	10, 15 and 30 MCQ/Short answer questions	55% (10%+15%+30%)	1,2,3 and 4	Content of weeks 1-3, 4-6 and 7-10.	During demonstration classes in weeks, 4, 7 and 11.	N/A	Immediately

† The laboratory experiment specifications will be available from week 2 onwards in Moodle.

*The quizzes must be taken under supervised conditions in the demonstration computer labs. One question is accessible at any given time and once answered they cannot be revisited. The durations allowed for a quiz is timed. The students may use, books and lecture notes, and some questions may require use of MATLAB.

Assignments

Presentation

During experimentations, each student will collect his/her own personalized data. It is essential that each student use his/her personalized data in his/her reports. Marks are awarded for neat, tidy and complete reports with complete content as specified in the laboratory instructions sheets. Your content will not be marked if the reports are not presented with the presentation quality specified in the laboratory instructions sheets.

Submission

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:

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

Marking

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.

Examinations

You must be available for all quizzes. This course has no final examination.

Calculators

You will need to provide your own calculator of a make and model approved by UNSW for the examinations. The list of approved calculators is available at student.unsw.edu.au/exam-approved-calculators-and-computers

It is your responsibility to ensure that your calculator is of an approved make and model, and to obtain an "Approved" sticker for it from the Engineering Student Supper Services Centre prior to the examination. Calculators not bearing an "Approved" sticker will not be allowed into the examination room.

Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that has interfered with your assessment performance, you are eligible to 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.

7. Expected resources for students

Recommended Textbooks

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

Additional Readings

Worked solutions to computer lab exercises will be made available in the Moodle page for MTRN3020.

UNSW Library website: https://www.library.unsw.edu.au/
Moodle: https://moodle.telt.unsw.edu.au/login/index.php

8. 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 continuous assessment by way of quizzes to provide feedback from very early during the course.

9. 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

10. Administrative matters and links

All students are expected to read and be familiar with School guidelines and polices, available on the intranet. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address
- Computing Facilities
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Student Equity and Disabilities Unit
- Health and Safety
- Lab Access
- Makerspace
- UNSW Timetable
- UNSW Handbook
- UNSW Mechanical and Manufacturing Engineering

Appendix A: Engineers Australia (EA) Competencies

Stage 1 Competencies for Professional Engineers

	Program Intended Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing
	PE1.3 In-depth understanding of specialist bodies of knowledge
	PE1.4 Discernment of knowledge development and research directions
	PE1.5 Knowledge of engineering design practice
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex 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
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability
	PE3.2 Effective oral and written communication (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