School of Electrical Engineering and Telecommunications

Term 2, 2019
Course Outline

ELEC3114: Control Systems

COURSE STAFF

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COURSE Overview

Introduction to the course

Control Systems course is currently a third-year course offered in the School of Electrical Engineering and Telecommunications at undergraduate level. It is considered as one of the **most multidisciplinary courses** in Engineering. It is a fundamental subject heavily relying on the previous subjects in Electrical Engineering. Some would say that Control Systems course can be considered as an example of the '*marriage between theory and practice'* where the power of mathematical tools meets the real-world control engineering problems. It translates these practical problems into workable engineering solutions.

For instance,

- *Have you ever thought about how your air-conditioning system adjusts the temperature when you set your preferred value on the panel?*
- *Have ever come across or heard about Tesla car autopilot feature?*
- *Have you seen how adaptive cruise control can keep a car within a safe distance from the car ahead no matter how fast or slow they drive (see Fig. 1)?*

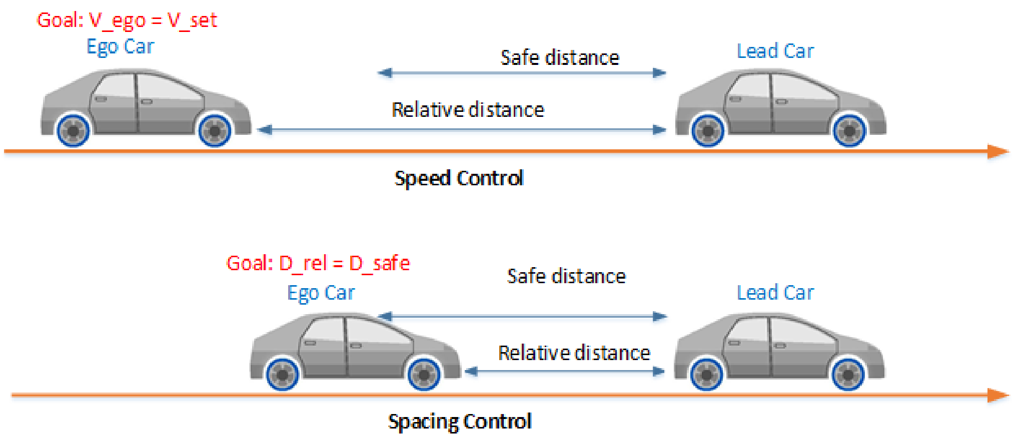

Fig. 1: Schematic of speed and distance control principles in adaptive cruise control
https://au.mathworks.com/help/mpc/examples/design-an-adaptive-cruise-control-system-using-model-predictive-control.html

If you would like to be capable to designing similar control systems in a smaller scale, the fundamentals that we are going to help you learn in this course are the key to achieving these goals. The topic of control systems is quite broad not limited to a single discipline. We are going to touch the surface of this vast topic by understanding and identifying a control system problem, its requirements and design specifications, and how to implement a proper design from scratch.

When it comes to designing a control system, there are several steps that need to be taken starting with establishing the *control goals and requirements*. Then, you need to *understand the behaviour of the process* for which the control system is being designed. After that, you work through *obtaining some mathematical model* representing similar behaviour to the process. You continue with the *analysis of the model* and *coming up with a design technique and system configuration* that suit and satisfy the control requirements as well as the *practical constraints*. The designed control system *performance must then be validated and analysed* through simulation, and finally it is *implemented on the actual process for final validation with running tests for any necessary adjustments*.

Learning in this course is going to be a challenging journey, but our aim is to cater the learning and teaching process for you in a way that transforms you to "active learners" through proven *learner-centred approaches*. We will be having several *in-class and out-of-class learning activities* to keep you *engaged* with the materials, to be *motivated* to *learn more*, and to develop *critical thinking skills* in solving engineering problems. The laboratory exercises and experiments are going to be a *crucial* part of this course as they provide you with *hands-on experience* in learning how to implement the theories of control systems in practice.

Consultations:

You are encouraged to ask questions on the course material, after the lecture class times in the first instance, via email, through online discussion forums (highly encouraged), and during tutorials and labs. Lecturer consultation times will be advised on Moodle, https://moodle.telt.unsw.edu.au/login/index.php, which is the official online learning management system (LMS) used at UNSW. You may also be interested in using other online platforms outside Moodle to communicate with your peers who currently take the course or have taken it before, such as Discord. ALL email enquiries should be made from your student email address with *ELEC3114* in the subject line; otherwise they will be answered by delay.

Keeping Informed: All announcements regarding the course and its assignments will be made via Moodle. Announcements may also be made during lectures, but everything will be formally posted on the "**Course Announcements**" **forum** in **ELEC3114 Moodle page**. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Contact Hours

The course consists of the following (all classes are run **every week**):

- **4 hours** of **lecture** (two 2-hour of face-to-face lecture sessions from Week 1 to Week 10);
- **2 hours** of face-to-face **tutorial** (one hour of normal tutorial and one hour of *flipped* tutorial from Week 2 to Week 10);
- **2 hours** of online **tutorial** (from Week 2 to Week 10);
- **2 hours** of **laboratory** (from Week 3 to Week 10).

Session	Day	Time	Location
Lectures (W1 – W10)	Monday*	11am - 1pm	Rex Vowels Theatre (K-F17-LG3) Click here for the map
	Wednesday	1pm - 2pm	
Tutorials (W2 – W10)	Tuesday to Friday	Check Your Timetables**	
Laboratories (W3 – W10)	Monday to Friday	Check Your Timetables**	Lab 109 in Level 1 EE&T Building (G17) Click here for the map

* Due to **Public Holiday** on **Monday** of **Week 2**, the final 2-hour lecture will be on Mon of **Week 11**
** The full **tutorial** and **lab schedules** can be found at: http://classutil.unsw.edu.au/ELEC_T2.html#ELEC3114T2 or at http://timetable.unsw.edu.au/2019/ELEC3114.html .

Context and Aims

The overall course aim is for you to gain true competence in and understanding of basics of control systems, and to learn how to:

- examine a physical process and identify its main features in terms of signals and blocks;
- assess whether it may be difficult or easy to control the process;
- specify a reasonable control performance;
- design a simple controller to achieve that performance, and
- design and use simple controllers for laboratory processes.

The fundamentals that will enable you to do this are:

- feedback and feedforward concepts;
- the response of linear time-invariance (LTI) systems to standard inputs;
- the analysis of the stability in linear systems, and
- the design of linear feedback systems capable of achieving specified performance criteria.

Indicative Lecture Schedule

Week	Summary of Lecture Program
Week 1	Introduction to Control Systems – Laplace Transform Revision
Week 2 & 3	Mathematical Modelling in Frequency Domain and Time Domain (State Space or State Variable Models) – System Linearization
Week 3 & 4	Time Response of LTI Systems – Feedback Control System Characteristics
Week 4 & 5	Stability of LTI Systems – Steady State Error and Feedforward Control
Week 5 & 6	Root Locus Technique – PID Control Analysis and Design
Week 6	***Mid-term Exam (second lecture time of week 6)***
Week 7 & 8	State Variable Feedback Systems (State Feedback and Observer Designs) – Optimal State Feedback using LQR (Linear Quadratic Regulator)
Week 9 &10	Frequency Response Methods
Week 11	***Catch-up lecture (Monday, due to public holiday in Week 2)***

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
Week 1	*No Lab*
Week 2	*No Lab*
Week 3	Lab Experiment 1: MATLAB & Simulink Training
Week 4	Lab Experiment 2: DC Motor Modelling with Load
Week 5	Lab Experiment 3: Flexible Joint Robotic Arm Modelling
Week 6	***Catch-up lab***
Week 7	Lab Experiment 4: DC Motor Speed Control
Week 8	Lab Experiment 5: DC Motor Position Control
Week 9	Lab Experiment 6: Flexible Joint Robotic Arm Control
Week 10	***Catch-up lab***

Assessment

1. Mid-term exam (1 hour): …………………………………………………	30 %
2. Laboratory assessments: ……………………………………………	20 %
3. Online quizzes: …………………………………………………………..	10 %
4. Final exam (2 hours): ………………………………………………	40 %
Total:	**100%**

- The **mid-term exam** is tentatively scheduled in **Week 6** with during the second lecture on **Wed 10th July**.
- The date of the **final exam** will be announced by the University.
- You **MUST** at least achieve **10%** out of **20%** of total **lab assessment** to **pass the course.**
- You **MUST** at least achieve **16%** out of **40%** of the total **final exam paper** mark to **pass the course**.

For further details on each assessment task, please refer to the Assessment section on Page 7.

COURSE DETAILS

Credits

This is a 6 UoC course and the expected workload is 15 hours per week throughout the 10-week term.

Relationship to Other Courses

This is a 3rd year course in the School of Electrical Engineering and Telecommunications. It is a core/elective course for students following a BE (Electrical) or (Telecommunications) program and other combined degree programs. Related courses are shown in Fig. 2 below. Solid arrows indicate hard pre-requisites, while dashed arrows indicate soft pre-requisites.

Pre-requisites and Assumed Knowledge

The pre-requisites for this course are Mathematics 2A, Mathematics 2B, MATH2069, MATH2099, and ELEC2134 Circuits and Signals. It is also essential that you are familiar with ELEC3104 Digital Signal Processing and ELEC2142 Embedded Systems Designs before this course is attempted.

Following Courses

This course is a pre-requisite for ELEC4631 Continuous-time control system design, ELEC4632 Computer control systems, ELEC4633 Real-time engineering, and ELEC4123 Electrical Design Proficiency.

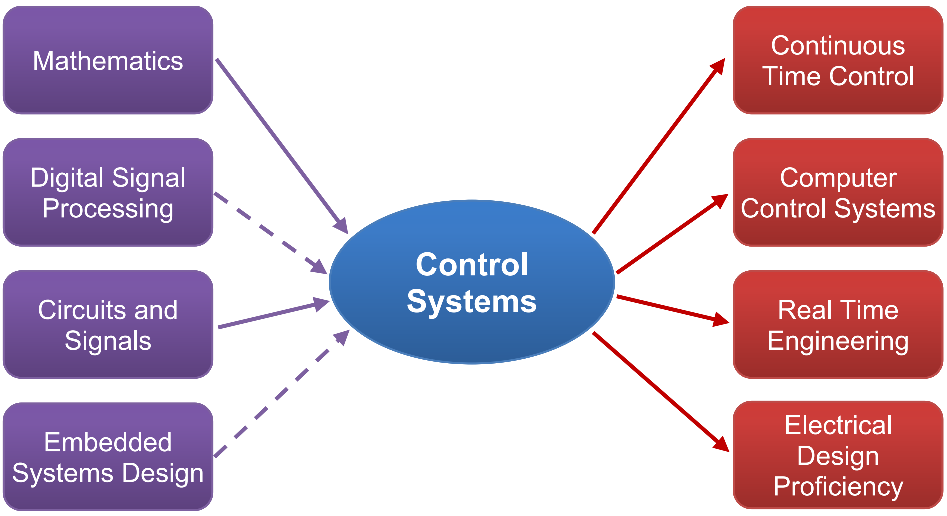

Fig. 2: Relationship of ELEC3114 to other courses.

Learning outcomes (LO)

After successful completion of this course, you should be able to:

LO1. identify an approximate linear/linearized model for a physical dynamic system.

LO2. analyse linear time-invariant (LTI) systems in both time domain and frequency domain.

LO3. understand the concept of control systems stability and feedback control systems.

LO4. apply time-domain and frequency-domain techniques to analytically design linear control systems.

LO5. acquire practical skills in applying control systems theories through hands-on and in-depth experience in laboratory.

LO6. utilize software tools to help with analysis, design, evaluation, and implementation of control systems for real-world applications in both simulation and real-time environment.

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in ***Appendix A***. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus

Recognition of what a control system is, and the distinction between simple and complex control systems. Analysis and design tools for dealing with simple control systems: Differential equations, Laplace transforms, transfer functions, poles and zeros, state space models, modelling, first and second order systems, stability, steady-state errors, root locus, Bode and Nyquist plots, transient response analysis and design, PID control, lead-lag compensators, simple frequency response techniques. Stability of feedback control system via analysis of transfer function and state-space models.

TEACHING STRATEGIES

Delivery Mode

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- **Formal face-to-face lectures**, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding, as well as online learning activities through "*Lecture Recordings+*" to recap the prior knowledge at the beginning of the lectures and reflection on contents learned during the lectures as *formative learning activities* (*not graded*);
- **Tutorials**, which allow for practicing problem solving techniques and troubleshooting the problems you might have in understanding lecture material, as well as performing *formative learning activities* through *flipped* tutorials;
- **Laboratory sessions**, which support the formal lecture material and provide you with practical construction, measurement and debugging skills;
- **Recorded lecture videos**, which support the scheduled face-to-face lectures for revision purposes. Please note that watching recordings is **no substitute** for attending the classes, where live questions can be asked. Please note that *having access to recorded lectures does not imply improved exam preparation*, *without significant and consistent additional self-directed study throughout the term;*
- **Online weekly quizzes,** which allows you to review the lecture topics by completing small periodic quizzes online and assess your progress and performance in the course.

Learning in this course

You are expected to *attend all lectures*, *tutorials, labs*, and mid-term exam in order to maximise learning. You must prepare well for your laboratory classes and your lab work will be assessed. In addition to the lecture notes/video, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. *Group learning is highly encouraged*. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Tutorial classes

Tutorial classes are scheduled for **2 hours per week starting from Week 2.** You should try to attempt all the problem sheet questions before attending the tutorial classes. The importance of *adequate preparation prior to each tutorial cannot be overemphasized*, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation.

Three different modes of tutorials will be provided in ELEC3114.

1. _Face-to-face normal tutorials_. The **first hour** of the tutorial session will be run as normal tutorial sessions where the tutor explains to the students how to work out the given problems. The worked-out solutions will be provided on Moodle after the tutorial classes.
2. _Face-to-face flipped tutorials (new)_. The **second hour** of the tutorial session will be run in **flipped mode**. These tutorials function in a *collaborative manner* where students are encouraged to *work in groups* (4 to 5) and try to solve the given problems by applying their learnings from the lectures and other tutorials. The given problems in these tutorials would cover some sample exam questions from previous years as well as more advanced problems (could be online questions). The *tutors will mentor* the students to solve the questions correctly, and if necessary, they would help out by explaining the problem-solving techniques for more challenging questions to the whole class. It is highly recommended that students *work out the problems toward the final solution collaboratively* and in a *team-work manner*. The solutions of some of the challenging online problems *MAY NOT* be provided after the tutorial, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.
3. _Online tutorial videos_. These are pre-recorded solutions of typical tutorial questions, that can be watched at your own time and pace. It is strongly suggested that you attempt to solve the questions of these tutorials before watching the videos and then observe the methods and theory used in each question. It is expected that you spend *at least two hour per week* on solving and watching these tutorials.

Laboratory program

The laboratory classes are scheduled for **2 hours per week starting from Week 3.** The lab experiments are deliberately designed to provide practical, hands-on exposure to the concepts conveyed in lectures soon after they are covered in class. You are required to attend laboratory. Laboratory *attendance WILL be kept*.

Laboratory Exemption

There is **NO** laboratory exemption for this course. Regardless of whether equivalent labs have been completed in previous courses, all students enrolled in this course must take the labs. If, for medical reasons, (note that a valid medical certificate must be provided) you are unable to attend a lab, you will need to request to attend the catch-up labs, arranged by the head lab demonstrator.

ASSESSMENT

The assessment scheme in this course reflects the intention to assess your learning progress through the term and make sure they are *constructively aligned with Learning Outcomes*. Ongoing summative assessment occurs through the lab checkpoints (see lab manual), mid-term exam, online quizzes.

Laboratory Assessment

Laboratories are primarily about both theoretical and practical learning, and the laboratory assessment **worth 20%**. You must achieve **at least 10% out of 20%** of tola lab mark to ***PASS*** the course. It is designed mainly to check your knowledge as you progress through each stage of the laboratory tasks. You are required to maintain a **lab book** for recording your observations. A lab book is an A4 size notebook containing a mix of plain pages and graph sheets. You have to purchase your own lab book from any stores.

There are *6 lab experiments* which are scheduled for **2 hours per week** with each containing:

- _Pre-lab Exercises._ You ***MUST*** *complete* the Pre-lab exercises before attending the lab. They include both simple analytical questions and simulation exercises using *MATLAB/Simulink* program. You must have your analytical solutions written in your lab book for marking purposes as well as having your simulation codes and results.
- _Lab Exercises_. You are expected to *work in pairs*. You are required to maintain *a lab book* for recording your observations. The NEW lab manual has spaces to write down your results, workings, and answers to the questions. You MUST keep them in your lab book along with your other writings and observations from lab experiments.

NOTE: It is of **paramount importance** that you _complete the Pre-lab exercises before coming to each lab_ *since the content of Lab experiments relies on the Pre-lab work.* It would ***NOT be feasible*** to finish the experiments in time if you have NOT completed the Pre-lab exercises beforehand. You should *NOT expect* lab demonstrator to sacrifice their time to help you do the Pre-labs in the lab which would be otherwise utilised to mark and help those who have done their Pre-lab exercises completely. It is OK to sit and complete the Pre-Lab exercises with your groupmate and your friends collaboratively. But, any attempt to *COPY* the results from others without trying to learn how the questions should be solved, or how the simulations should be done will result in a *ZERO MARK* for that lab. The UNSW rules and policies on plagiarism are provided in OTHER MATTERS section this document.

Laboratory guidance videos are available on Moodle to help you get familiar with lab equipment and how to conduct the experiments and doing simulations.

After completing each experiment, your work will be assessed by the lab demonstrator. Both the simulation/ practical results and your lab book will be assessed by the lab demonstrator. Assessment marks will be awarded according to your preparation (completing set preparation exercises and correctness of these or readiness for the lab in terms of pre-reading), how much of the lab you were able to complete, your understanding of the experiments conducted during the lab, the quality of the code you write during your lab work (according to the guidelines given in lectures), and your understanding of the topic covered by the lab.

Online Quizzes

Each week starting from **Week 3**, there will be one or two online quizzes related to the materials covered in the previous weeks of the course. There are two types of online quizzes:

- *Review quiz.* These are weekly quizzes to review the content delivered in the previous week. Once the quiz is made available online, you can complete the quiz at your own convenience. The *deadline* for each of review quizzes is **one week** from its opening date. The length of each quiz may vary depending of the difficulty level. You can have *unlimited attempts* for each of review quizzes before it is closed. The overall mark for review quizzes is **worth 5%**.
- *Normal quiz*. These are more challenging quizzes happening three of four times during the term. Once the quiz is made available online you will have **maximum three/3 attempts** to complete the quiz. The *deadline* for each of normal quizzes is **one week** from its opening date. The overall mark for normal quizzes is **worth 5%**.

Your *highest mark* from your attempts on both types of quizzes will be your final mark for each quiz. The *average mark* of the quizzes will account for the total mark of this assignment. The online quizzes overall mark is **worth 10%**.

Mid-term Exam

The mid-term examination is **worth 30%.** It tests your general understanding of the course material and is designed to give you feedback on your progress through the analytical components of the course. Questions may be drawn from any material already covered in the course schedule. It may contain questions requiring some (not extensive) knowledge of laboratory material and will definitely contain numerical and analytical questions. Marks will be assigned according to the correctness of the responses.

Final Exam

The exam in this course is a standard closed-book 2-hour written examination, comprising five compulsory questions. University approved calculators are allowed. The examination tests analytical and critical thinking and general understanding of the course material in a controlled fashion. Questions may be drawn from any aspect of the course (including laboratory), unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. *Please note that you must PASS the final exam in order to PASS the course (necessary condition), which means you must achieve at least* ***40 marks out of 100 total mark of final exam paper*** *which is equivalent to* ***16% out of 40%*** *of Final Exam contribution to total course mark.* Then, all other assessments will be added up (assuming you have attained minimum 10% out of 20% of Lab mark as another necessary condition for passing the course), and if your total course mark is ***above or equal to 50%,*** you will pass the course.

Optional Project

We are working on preparing a project for those who are eager to learn more on building a full-scale control system to regulate an output voltage of the DC generator/motor setup via microcontroller. This will a valuable experience which prepare students for ELEC3117 and ELEC4123. It could potentially have some bonus marks depending on the level of the delivery, but it is still under review and may NOT be ready to roll out for this term.

Relationship of Assessment Methods to Learning Outcomes

Learning outcomes / *Assessment*	LO1	LO2	LO3	LO4	LO5	LO6
Laboratory assessments	✓	✓	✓	✓	✓	✓
Online quizzes	✓	✓	✓	✓	-	✓
Mid-term exam	✓	✓	✓	✓	-	-
Final exam	✓	✓	✓	✓	-	-

Relation of Learning and Teaching Activities to Learning Outcomes

Theme	**Review of prior knowledge** **(Pedagogy: Think, Pair, Share)**
Key Learning Outcomes	Retrieving the learnings and knowledge from previous lecture or prerequisite knowledge from previous courses, serving as a recap in both individual and group form. (LO1 to LO4 and LO6)
Activity	1) You participate in short online questionnaire individually; 2) No answer is given straight away (in some cases only whether it is right or wrong); 3) are are asked to share your workings and solution with a peer next to you to discuss how you did it and try to get the correct answer; 4) The correct answer is revealed shortly after your discussion with peers; 5) Short discussion and feedback by the lecturer.
Timing	• In-class activity at the beginning of the lecture; • Between 5 to 10 minutes.
Assessment	This activity is a Formative Assessment (not graded).

Theme	**Reflection on the depth of content learning** **(Pedagogy: Think, Pair, Share)**
Key Learning Outcomes	Retrieval practice to reflect on the depth of what students learn from the content they receive in the lecture as well as keeping students engaged in the class. (LO1 to LO4, LO6)
Activity	1) You participate in short online questionnaire individually; 2) No answer is given straight away except that whether it is right or wrong; 3) You are asked to share your workings and solution with a peer next to you to discuss how you did it and try to get the correct answer; 4) The correct answer is revealed shortly after your discussion with your peers; 5) Short discussion and feedback by the lecturer.
Timing	• In-class activity during the lecture • Maximum 5 minutes (up to 3 times)
Assessment	This activity is a Formative Assessment (not graded)

Theme	Flipped tutorial sessions (Pedagogy: Think, Pair, Share)
Key Learning Outcomes	Practicing on problem solving techniques in self-directed and/or groupwork mode. (LO1 to LO4, LO6)
Activity	1) Some exercise related to the topic of the tutorial are solved first to revise the content and problem-solving techniques (regular tutorial); 2) Then, some challenging exercises are given; 3) You are asked to form groups to work on questions and share your workings and solutions with the group to discuss how you did it and try to get the correct answer; 4) You have access to the final answer only; 5) Mentors and tutor are around to help you with resolving difficulties in solving questions; 6) You reflect and comment on your peer solutions in a group as part of the activity; 7) The detailed working solutions may not be provided after the session.
Timing	• In-class activity during tutorial session • 2nd hour of the 2-hour tutorial
Assessment	This activity is a Formative Assessment (not graded)

COURSE RESOURCES

Textbooks

Prescribed textbook

- N. S. Nise, *Control Systems Engineering*, 7th or 8th Edition, John Wiley & Sons.
- R.C. Dorf and R.H., Bishop, *Modern Control Systems*, 13th Edition., Harlow: Pearson

The majority of the content in the lectures will be from the first textbook, but some of the contents are adopted from the second textbook, and in some few cases, from some other reference textbook. When a second or other reference textbooks are used in lecture slides, they will be cited for clarity

Reference books

- M. W. Spong, S. Hutchinson, and M. Vidyasagar, *Robot Modeling and Control*. Hoboken, NJ: John Wiley and Sons, 2006
- G. F. Franklin, J. D. Powell and A. Emami-Naeini, *Feedback Control of Dynamic Systems*, Addison Wesley, latest edition.
- G.C. Goodwin, S. F. Graebe and M. E. Salgado, Control System Design, Prentice Hall, latest edition

On-line resources

Lecture slides and lecture recordings, lab guidance videos, tutorial questions and solutions, lab manuals and all related MATLAB and Simulink files will be available on Moodle.

Mailing list

Announcements concerning course information will be given in the lectures and/or on Moodle and/or via email (which will be sent to your student email address).

OTHER MATTERS

Dates to note

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

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.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://student.unsw.edu.au/guide), 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 face-to-face classes and *independent, self-directed study*. In periods where you need to 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.

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.

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.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the online student survey myExperience. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods.

As part of these evaluations, in Term 2 of 2019, the following new improvements will be introduced:

- *There has been **a complete overhaul** of laboratory exercises. There are now total 6 completely redesigned lab experiments with increased focus on connecting theory to practical aspects of control systems.*
- *A new virtual 360 Lab tour video enabling students to use it as a map of the lab and its equipment. The lab guidance videos are integrated with the virtual lab tour allowing students to click on each equipment and watch the related video and download/read relevant documents.*
- *Introduction of flipped tutorials for students to work on more challenging problems in team-based learning mode.*
- *Newly designed weekly online quizzes for content revision purposes as well as ongoing progress check by students.*
- *An optional project for students who wants to learn more about practical aspects of the course.*

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

APPENDICES

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

Appendix B: UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the laboratory experiments and interactive checkpoint assessments and lab exams during the labs.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.
- Developing digital and information literacy and lifelong learning skills through assignment work.
- Developing ethical practitioners who are collaborative and effective team workers, through group activities, seminars and tutorials.
- Developing independent, self-directed professionals who are enterprising, innovative, creative and responsive to change, through challenging design and project tasks.

Appendix C: Engineers Australia (EA) Professional Engineer Competency Standard

	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	✓