ELEC3114
Control Systems
Course Outline – Semester 2, 2015

Never Stand Still | Faculty of Engineering | School of Electrical Engineering and Telecommunications

Course Staff

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Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. Lecturer consultation times will be advised in this course outline. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions relating to the labs and tutorials. ALL email enquiries should be made from your student email address with ELEC3114 in the subject line, otherwise they will not be answered.

Course Details

Credits

This is a 6 UoC course and the expected workload is 10–12 hours per week throughout the 13 week semester.

Contact Hours

The course consists of 3 hours of lectures, a 1-hour tutorial, a 3-hour laboratory session each week (every two weeks for each individual student), and a consultation hour with the lecturer (if required). **Attendance will be taken for lectures, tutorials and laboratories. Please only attend tutorial and lab groups that you signed up for.**

	Day	**Time**	**Location**
Lectures	Monday	16–18	MathewsThB
	Wednesday	14–15	CLB6
Tutorials	Tuesday	13–14	Quad G035
	Thursday	09–10	Webst 256
	Thursday	10–11	Webst 256
	Friday	12–13	Quad G032
Consultations	Thursday	18–19	ElecEng Room 109

The full lab schedule can be found at
http://classutil.unsw.edu.au/ELEC_S2.html - ELEC3114T2

Context and Aims

The overall course aim is for you to gain true competence in basic 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.

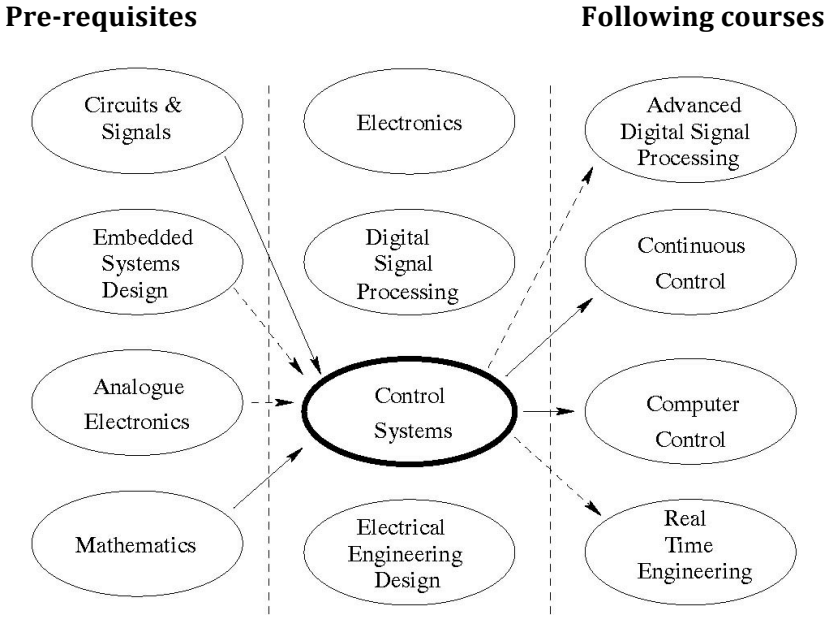
The fundamentals that will enable you to do this are

- feedback,
- the responses of linear systems to standard inputs,
- analysis of the stability of linear systems, and
- the design of linear feedback systems capable of attaining specified performance criteria.

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 the figure below. Solid arrows indicate strong pre-requisites, while dotted arrows indicate weak pre-requisites.



Pre-requisites and Assumed Knowledge

The pre-requisite for this course is ELEC2134, Circuits and Signals. It is also essential that you are familiar with MATH2069, Mathematics 2A, and MATH2099, Mathematics 2B, before this course is attempted.

Following Courses

The course is a pre-requisite for

- ELEC4631, Continuous-time control system design
- ELEC4632, Computer control systems
- ELEC4633, Real-time engineering

Learning outcomes

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

1. Recognise the response of first and second order linear systems.
2. Model simple and moderately complex control systems using transfer functions and state-space time domain descriptions.
3. Analyse the stability of a single input single output linear control system.
4. Determine the steady-state errors of a single input single output system with respect to step, ramp, and parabolic inputs.
5. Recognise Type 1, 2, 3 systems, and their steady-state errors in following step, ramp, and parabolic inputs.
6. Design feedback controllers using root locus, frequency domain, and state-space techniques to achieve a desired transient response and acceptable steady-state errors.
7. Use Matlab to do matrix manipulations, and Simulink and Quanser QUARC to analyse and execute simple control systems in the laboratory.

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 attributes (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Course description

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 up to second order: Differential equations, Laplace transforms, transfer functions, poles and zeros, state space models, modeling, first and second order systems, stability, steady-state errors, root locus, Bode and Nyquist plots, transient response analysis and design, PID control, lead-lag compensation, simple frequency response techniques. Stabilising feedback control for 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;

- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;
- Laboratory sessions, which support the formal lecture material and also provide you with practical construction, measurement and debugging skills;
- Consultations with the lecturer outside of class hours, according to the scheduled time.

Classroom and lab etiquette

- No eating and drinking in CATS classrooms and in the labs.
- Students are to work quietly in the labs to complete their work. Voices should be kept down at all times and unnecessary conversations unrelated to the lab work are discouraged and must be minimised.
- Mobile phones must be switched off and put away while in the classroom and lab.

Learning in this course

You are expected to attend all lectures, tutorials, labs, and mid-semester exams 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, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Especially important are learning strategies that you have to adopt.

- Learning is effortful - you have to make the effort.
- You have to develop your own mental models for how things work. I can give you insights, but you have to develop your own "schema".
- You learn from errors and from discovering misconceptions.
- You cannot do this just by listening or reading. You have to try things out.
- Firstly, close your books and explain and write down concepts for yourself or for friends. Check. If your concept is not complete and accurate, do it again. You learn through the tip of your pen.
- Do all the tutorial problems to test your new-found understanding.
- You learn by doing. Make sure you become competent in the laboratory. Always complete all pre-lab exercises required before attending the labs, and pace yourself to complete in-lab tasks and experiments within the assigned time checkpoints.
- The ultimate test of whether you have learned something is whether you can use it next year, or when you begin working. Only your schema are enduring. You will forget details, and setting out to simply memorise things is worthless - of minor assistance for exams only.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Introduction, Modelling in the Frequency Domain
Week 2	Modelling in the Frequency Domain
Week 3	Modelling in the Time Domain
Week 4	Time Response
Week 5	Reduction of Multiple Subsystems
Week 6	Stability **Quiz 1 (online)**
Week 7	Steady-State Errors
Week 8	Root Locus Techniques **Mid-session exam**
Week 9	Design via Root Locus
Midsession break	
Week 10	Frequency Response Techniques **Quiz 2 (online)**
Week 11	Design via Frequency Response
Week 12	Design via State Space **Lab exams**
Week 13	Review lecture **Lab exams**

Tutorial classes

You should attempt your problem sheet questions in advance of 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. Group learning is encouraged. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class. **Tutorial sessions start in Week 2 and tutorial attendance WILL be kept.**

Laboratory program

The laboratory schedule is 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 from Week 4 to Week 11. **Laboratory attendance WILL be kept, and you MUST attend all four labs.**

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
Weeks 4, 5	Introduction to Matlab, Simulink, and QUARC
Weeks 6, 7	Identification of the transfer function of a DC motor
Weeks 8, 9	Effects of gains on transient response and steady-state errors
Midsession break	
Week 10, 11	Design of a position control system
Week 12, 13	**Lab exams**

Laboratory Exemption

Students who have taken this course in S2 2014 and passed the lab component may apply for exemption from the labs. **To do this they must complete and submit the Lab Exemption Form from the School for approval by the course convener by Week 3 at the latest.** If approved, their score for the lab component from S2 2014 will be transferred to this session's score. All other students enrolled in this course for Semester 2, 2015 must take the labs. If, for medical reasons, you are unable to attend a lab (**note that a valid medical certificate must be provided to the convener)**, you will need to apply for a catch-up lab during another lab time, as agreed by the convener.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through quizzes, lab sessions, lab exam, and the mid-semester exam.

Quiz 1 (online)	**Multiple choice quiz on Moodle to test your understanding of analytical course materials up to Week 5.**	**1%.**
Laboratory Practical Experiments	**Based on completion of lab preparation assignments and tasks in each lab module.**	**6%**
Mid-Session Exam	**Written 1 hour examination to test your ability to do analytical calculations relating to materials up to Week 6.**	**20%**
Quiz 2 (online)	**Multiple choice quiz on Moodle to test your understanding of analytical course materials from Week 6 up to Week 9.**	**1%**
Lab Exams	**Written exams based on lab preparation exercises (if any) and tasks that should be completed during the lab sessions.**	**10%, must be passed to pass course (lab exam score of at least 50%)**
Final Examination	**Written 3 hour examination covering all lecture, tutorial, and, possibly, laboratory materials.**	**62%**

To pass the course you must pass the lab exam, and once you pass the lab exam you will need to score at least 50 overall (out of 100) in the course to pass it.

Quizzes

The two quizzes are given to provide you with some early feedback on some sections of the course. They will be multiple choice and will be conducted online on Moodle at specific dates and time windows, as will be announced in class and on Moodle. The quizzes must be completed during the allocated time once they are started. Marks will be assigned according to the correctness of the responses.

Laboratory Assessment

Laboratories are primarily about learning, and the laboratory assessment 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 store.

It is essential that you complete the laboratory preparation before coming to the lab. You will be recording your observations/readings in your lab book first and then completing and submitting the results sheet before leaving the lab.

After completing each experiment, your work will be assessed by the laboratory demonstrator. Both the results sheet and your lab book will be assessed by the laboratory 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 your lab work, and your understanding of the topic covered by the lab.

Laboratory Exam

To check that you have achieved the practical learning outcomes for the course, you will be examined in the laboratory. Laboratory exams are closed book practical exams that include a test of your understanding of concepts and analytical calculations. The exam questions will be based on what you have learned in your laboratory classes and lectures, and marks will be awarded for the correct understanding of practical and relevant theoretical concepts, and correct use of Matlab.

Mid-Session Exam

The mid-session examination 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 course material up to the end of week 6. 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. No calculators are necessary nor allowed for the midsession exam.

Final Exam

The exam in this course is a standard closed-book 3 hour written examination, comprising four 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.

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes						
Assessment	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Quiz 1	✓	✓	-	-	-	-	-
Laboratory practical assessments	✓	✓	✓	-	✓	✓	✓
Mid-session exam	✓	✓	✓	-	-	-	-
Quiz 2	-	-	-	✓	✓	✓	-
Lab exams	✓	✓	✓	-	✓	✓	✓
Final exam	✓	✓	✓	✓	✓	✓	-

Course Resources

Textbooks

The following textbook is prescribed for the course:

N. S. Nise, *Control Systems Engineering*, John Wiley & Sons, **6th or 7th Edition**.

Students are strongly encouraged to purchase a copy of this book as it provides coverage of the topics in the syllabus. An E-Book (electronic) version of this text is also available from Wiley and can be purchased from the Wiley link:
http://au.wiley.com/WileyCDA/WileyTitle/productCd-EHEP002908.html (7th edition)

Reference books

- G. F. Franklin, J. D. Powell and A. Emami-Naeini, *Feedback Control of Dynamic Systems*, Addison Wesley, 1994.
- R. C. Dorf and R. H. Bishop, *Modern Control Systems*, Prentice Hall, 2001.
- G.C. Goodwin, , S. F. Graebe and M. E. Salgado, *Control System Design*, Prentice Hall, 2001.

Lecture notes/slides

Lecture notes/slides from lectures that summarise the content of the chapters from the textbook will be posted on Moodle. **These slides are provided by permission of the publisher John Wiley & Sons exclusively for personal use by students enrolled in the course. Please do not distribute and post the slides to public webpages outside of Moodle.**

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php.

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

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 http://www.lc.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://my.unsw.edu.au/student/atoz/ABC.html), and particular attention is drawn to the following:

Workload

It is expected that you will spend at least **ten to twelve 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.

Keeping Informed

Announcements may be made during classes, via email (to your student email address) or via online learning and teaching platforms like Moodle. From time to time, UNSW will send important announcements via these media without providing any paper copy. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW within 3 working days of the assessment**, not to course or school staff. For more detail, consult https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

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 Course and Teaching Evaluation and Improvement Process. 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.

Improvements implemented to this course in S1 2015 include:

- Weekly tutorials.
- Two demonstrators per lab, with a ratio of 10 students/lab demonstrator.

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:
http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures
https://my.unsw.edu.au/student/atoz/ABC.html

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 Attributes

The course delivery methods and course content addresses a number of core UNSW graduate attributes, 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.

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	✓