ELEC4632
Computer Control Systems
Course Outline – Term 3, 2019

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

Course Staff

Course Convener:	Professor Andrey Savkin	Room 341	a.savkin@unsw.edu.au
Consultation Time:	Tuesday 11:00 – 12:00		
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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 during lectures. You are welcome to email the tutor or laboratory demonstrator, who can answer your questions on this course and can also provide you with consultation times. ALL email inquiries should be made from your student email address with ELEC4632 in the subject line, otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Course Summary

Contact Hours

The course consists of 2 or 3 hours of lectures, a 1-hour tutorial each week and a 3-hour laboratory session each fortnight.

	Days	Time	Location
Lectures	Tuesday	12:00 - 15:00 (week 1-4) 12:00 - 14:00 (week 5-10)	Law Th G04
Tutorials	TBA	TBA	TBA

Context and Aims

Aims of the course: Provide an introduction to computer control systems from both an input/output and a state space point of view. Provide an introduction to pole placement and optimal design methods, nonlinear digital systems, digital control of biomedical systems, and digital control of wind power systems.

The course covers the design of practical control systems intended for implementation using digital controllers and embedded systems.

Particular topics include:

1. Digital control systems, mathematical models of digital systems, discrete-time systems, stability analysis of linear discrete-time systems;

2. Digital controller synthesis, digital PID controllers, dead beat controllers, design of digital controllers, state-space models, observability and controllability, pole placement design, Ackermann's formula, design of state estimators and output feedback controllers, digital control system characteristics, robustness, reduction of parameter variations and external disturbances by feedback;

3. Nonlinear discrete-time systems, stability of singular points of nonlinear discrete-time systems, linearization of non-linear discrete-time systems, Lyapunov functions;

4. Optimal design methods, dynamic programming (Bellman optimality principle), linear quadratic optimal control, model predictive control;

5.Digital control of biomedical systems, digital control of wind power systems, case studies. Case studies present examples of recent state-of-the-art engineering research and include:

Case study 1: Non-invasive estimation and deadbeat control of pulsatile flow in an implantable rotary blood pump for heart failure patients;

Case study 2: Model predictive control of hemodynamic variables during hemodialysis;

Case study 3: Modelling and LQR/dead beat control of heart rate response to treadmill exercise;

Case study 4: Model predictive control for wind power smoothing with controlled battery energy storage;

Case study 5: Maximizing income of a wind power plant integrated with a battery energy storage system using dynamic programming.

Aspects of implementation are constantly emphasized.

Assessment

Laboratory Practical Experiments	20%
Mid-term Exam	20%
Final Exam (2 hours)	60 %

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 4th year course in the School of Electrical Engineering and Telecommunications. It is an elective course.

Prerequisites and Assumed Knowledge

The prerequisite for this course is ELEC3114. It is essential that you are familiar with a standard introductory undergraduate course on control engineering such as ELEC3114 before this course is attempted.

Learning outcomes

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

1.Develop mathematical models for linear computer control systems.

2.Analyse stability of linear discrete-time control systems.

3.Analyse observability and controllability of linear discrete-time control systems.

4.Design digital control systems using input-output approach.

5.Design digital control systems using pole placement state space approach.

6.Design digital control systems using optimal control approach.

7.Analyse stability of singular points of non-linear discrete-time systems.

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

Examples of digital control systems, differences and similarities between digital and analog control systems, discrete-time systems, stability analysis, observability and controllability, state space models, digital PID controllers, pole placement design, digital control systems characteristics, nonlinear discrete-time systems, optimal control design methods, discrete-time filters, identification, case studies.

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.

Learning in this Course

You are expected to attend all lectures, tutorials, labs, and the 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, 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.

Tutorial Classes

You should attempt all of 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. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class. In addition, during the tutorial class, 1–2 new questions that are not in your notes may be provided by the tutor, for you to try in class. These questions and solutions may not be made available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

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 2 to Week 13. Laboratory attendance WILL be kept, and you MUST attend at least 80% of labs. Because of the heavy pressure on laboratory resources, time and personnel, it will be very difficult for the School to reschedule laboratories once missed. The laboratory time-table and schedule produced by the School Office will therefore be followed strictly.

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 for Term 3, 2019 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 apply for a catch-up lab during another lab time, as agreed by the laboratory coordinator.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the term. Ongoing assessment occurs through the lab checkpoints and the mid-term exam.

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 stores.

It is essential that you complete the laboratory preparation before coming to the lab. You are required to write the aim of the experiment and draw the circuit diagram if any in your lab book. This will be verified and signed by your demonstrators in 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 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.

Mid-Term Exam

The mid-term 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 (lecture and tutorials) up to the end of week 5. It may contain questions requiring some knowledge of theoretical material, and will definitely contain numerical and analytical questions. Marks will be assigned according to the correctness of the responses.

The mid-term exam will be given in week 6. All the details will be announced two weeks in advance.

Final Exam

The exam in this course is a standard closed-book 2 hour written examination, comprising six 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 (lectures and tutorials), unless specifically indicated otherwise by the lecturer. It will contain questions requiring some knowledge of theoretical material, and numerical and analytical questions. 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**
Laboratory practical assessments	✓	✓	✓	✓	✓		
Mid-term exam		✓	✓	✓			
Final exam		✓	✓	✓	✓	✓	✓

Course Resources

Textbooks

Prescribed textbook

- Astrom, K.J. and Wittenmark, B. Computer-Controlled Systems. Prentice-Hall, 2004.

Reference books

- Dorf, R.C. and Bishop, R.H. Modern Control Systems. Addison Wesley, 1998.
- Franklin, Powell, and Workman. Digital Control of Dynamic Systems. Addison-Wesley, 2000.
- B.C. Kuo, Digital Control Systems, Saunders College Publishing, 2002.

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: 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://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.

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://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 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.

In particular, several practical case studies have been developed based on past students' feedback. Furthermore, tutorial materials have been updated and improved.

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

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.
- 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 home 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	