School of Electrical Engineering and Telecommunications

Term 1, 2021
Course Outline

ELEC4633
Real Time Engineering

COURSE STAFF

Course Convener: Dr. Branislav Hredzak, Tyree 324, b.hredzak@unsw.edu.au
Tutor: Dr. Branislav Hredzak, Tyree 324, b.hredzak@unsw.edu.au
Laboratory Contact: Dr. Zhenyu Liu, Room G15A, z.liu@unsw.edu.au
Laboratory Demonstrators: To be confirmed – see Moodle

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. ALL email enquiries should be made from your UNSW student email address with ELEC4633 in the subject line, otherwise they may 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 2-3 hours of lectures each week, a 1-hour tutorial (Weeks 2,4,8,10 or Weeks 3,5,7,9) and a 3-hour laboratory session (Weeks 2,4,8,10 or Weeks 3,5,7,9).

	Day and Time	Weeks	Location
Lectures	Thu 15-18 Thu 15-17	Weeks 1-4 Weeks 5-10	Online
Tutorials	Wed 17	Weeks 3,5,7,9	Online
	Thu 14	Weeks 2,4,8,10	ElecEngG23
	Thu 14	Weeks 3,5,7,9	ElecEngG23
Labs	Tue 13-16	Weeks 2,4,8,10	ElecEng 109
	Tue 13-16	Weeks 3,5,7,9	ElecEng 109
	Wed 14-17	Weeks 2,4,8,10	Online
	Wed 14-17	Weeks 3,5,7,9	ElecEng 109
	Thu 09-12	Weeks 2,4,8,10	ElecEng 109
	Thu 09-12	Weeks 3,5,7,9	ElecEng 109
	Fri 12-3	Weeks 2,4,8,10	Online
Open labs	To be confirmed- see Moodle	Weeks 2-10	ElecEng 109

Context and Aims

Real Time Engineering is concerned with the design and implementation of computer-based real time systems and deals with the hardware and software issues associated with ensuring they work in a practical and real time sense. Broadly speaking, a system is said to be real time if it adheres to constraints in time. A real time system may be governed by a single stand-alone computer, or a computer embedded within the application itself, and hence known as an embedded system.

The aim of this course is to equip students with the necessary skills to analyse, design and implement computer-based real time systems, as well as critically evaluate their performance. Although real time systems encompass a very broad range of application areas, a central theme in this course is the application of real time computing for the purpose of signal processing and control. The course aims to give students fundamental knowledge in real time operating systems, including scheduling, kernels, and inter-process communication, as well as skills in the effective use of embedded computers.

Indicative Lecture Schedule

Period	Summary of Lecture Program
Week 1	Introduction to real-time systems, Linux and RTAI
Week 2	Multi-tasking, Q-models, pseudokernels
Week 3	Static and dynamic scheduling algorithms
Week 4	Digital control of DC motors
Week 5	Critical section, semaphores, mutexes **Mid-session test**
Week 6	Flexibility week
Week 7	Execution time prediction
Week 8	Faults characterization, management and detection. Reliability in systems **Lab assignment announcement**
Week 9	Embedded Systems and Embedded RTOS - Part 1
Week 10	Embedded Systems and Embedded RTOS - Part 2 **Lab assignment due**

Indicative Laboratory Schedule

Period	Summary of Laboratory Program
Week 2	Experiment 1
Week 3	Experiment 1
Week 4	Experiment 2
Week 5	Experiment 2 continues
Week 6	Flexibility week
Week 7	Experiment 2
Week 8	Experiment 2 continues
Week 9	Experiment 3
Week 10	Experiment 3

Assessment

Final Examination		50%
Mid-session Test		20%
Laboratory Component:	Laboratory Assignment	10%
	Laboratory Checkpoints	20%

COVID19 - Important Health Related Notice

Your health and the health of those in your class is critically important. You must stay at home if you are sick or have been advised to self-isolate by NSW health or government authorities. Current alerts and a list of hotspots can be found here. **You will not be penalised for missing a face-to-face activity due to illness or a requirement to self-isolate**. We will work with you to ensure continuity of learning during your isolation and have plans in place for you to catch up on any content or learning activities you may miss. Where this might not be possible, an application for fee remission may be discussed.

If you are required to self-isolate and/or need emotional or financial support, please contact the Nucleus: Student Hub. If you are unable to complete an assessment, or attend a class with an attendance or participation requirement, please let your teacher know and apply for special consideration through the Special Consideration portal. To advise the University of a positive COVID-19 test result or if you suspect you have COVID-19 and are being tested, please fill in this form.

UNSW requires all staff and students to follow NSW Health advice. Any failure to act in accordance with that advice may amount to a breach of the Student Code of Conduct. Please refer to the Safe Return to Campus guide for students for more information on safe practices.

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/postgraduate course in the School of Electrical Engineering and Telecommunications. It is an elective course for students following a BE (Electrical) or (Telecommunications) program and other combined degree programs, and an elective for Computer Engineering students.

Pre-requisites and Assumed Knowledge

The subject follows on from material covered in introductory courses in real time instrumentation (ELEC3145 Real Time Instrumentation) and control systems (ELE3114 Control Systems), however these are not pre-requisites. It is assumed that students will have a basic understanding of real time concepts, will be able to program in the C+ language, and will have had a small exposure in the use of embedded and control systems.

Learning outcomes

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

1. develop high-level design strategies for a given real time design problem statement, and to be able to objectively assess the strengths and weaknesses of each strategy,
2. demonstrate an ability to think about embedded system design issues, and to design and implement simple real time embedded systems from problem specification to code generation,
3. demonstrate an understanding of real time operating system concepts, such as scheduling, multitasking and task/context switching, inter-process communication, and have a knowledge of the different types of real time kernels,
4. demonstrate an understanding of, and a basic competence in, such real time and embedded system aspects as input/output device programming, interrupt programming, and programming of microcontrollers,
5. demonstrate an understanding of issues of safety, reliability, and performance analysis, in real time embedded systems,
6. demonstrate an understanding of a real-time Linux kernel, and be able to use it to construct simple to moderately complex real-time programs.

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 Standards as outlined in ***Appendix C***.

Syllabus

Real-time operating systems and processes: Concurrent processes. Multitasking and multithreading. Interrupts. Foreground/background systems. Context switching. Types of real-time kernels. Scheduling. Static and Dynamic scheduling. Rate-monotonic and Deadline-driven scheduling. Priority inversion, the priority inheritance and priority ceiling protocols. Markov Models. Inter-process communication and memory management: Data buffering. Shared memory. Global memory. Critical regions. Semaphores. Mutual exclusion. Message passing. Memory allocation. Coding practices. Real-time embedded system design: process specification. Q-models.

State machines and systems of state machines. Date representation. Numerical issues. C language. Input/output programming. The implications of using limited resources. Implementation: Microcontrollers. RTAI real-time operating system.

TEACHING STRATEGIES

Delivery Mode

A problem-based learning approach is partly employed in delivering this course. For each section of the course, different examples of real systems are introduced in lectures as a way of explaining the concepts. The analysis, and sometimes design, for each example will lend itself in assisting students to satisfy the learning objectives above. The lab program aims to support the lecture program and provides the student with hands-on software design in interacting with and controlling real hardware. The laboratory program is challenging, and as such, students must come prepared for each laboratory in order to complete the lab program on time.

The tutorial sessions will also be problem based, with examples of real systems introduced as problem specifications for the students to design a solution. To help facilitate the solutions, tutorials will involve class discussion.

Learning in this course

You are expected to attend all lectures, tutorials, labs, and a mid-term test 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 also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending formal 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. 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.

Laboratory program

The laboratory schedule is deliberately designed to provide practical exposure to the concepts conveyed in lectures soon after they are covered in class. You are required to attend laboratory.

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 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 (see lab manual), lab assignment 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.

It is essential that you complete the laboratory preparation before attending the lab. After completing each experiment, your work will be assessed by the laboratory demonstrator.

All experiments are done in ElecEng 109 or online. Students are only required to attend 4 lab sessions (see Contact Hours on page 1 for details). Each student will carry out 3 lab experiments, and each experiment is made up of a series of checkpoints. This component of the assessment is 20%. Each mark will be grudgingly given, based on completion of the checkpoint, the answers to specific checkpoint related questions, a sufficient understanding of the work done and concepts explored, and a satisfactory record (via a lab code) of the checkpoint completion; unsatisfactory records will not be rewarded, and the decision of the tutor will be final. Partial marks for each checkpoint may be given.

There may be open labs run in weeks 2 to 10 outside of regular lab hours-please see Moodle for details.

Mid-Session Test

There will be a mid-session test in Week 5 (date, time, and location to be advised in Moodle). 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 material already covered in the course schedule. Marks will be assigned according to the correctness of the responses.

Note: If you are unable to attend the mid-session test you can apply for special consideration. If the special consideration is granted, the assessment will be carried over to the final exam, i.e. the final exam will be assessed for 70% instead of 50%.

Laboratory Assignment

The assignment allows self-directed study leading to the solution of partly structured problems. Marks will be assigned according to how completely and correctly the problems have been addressed, the quality of the code written for the assignment (must be attached to the report), and the understanding of the course material demonstrated by the report.

More information will be provided in Week 8, however the assignment will be due at the end of Week 10. *Late reports will attract a penalty of 20% per day* (including weekends).

Final Exam

The exam in this course is a two-hour written examination, comprising several 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). 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**
Laboratory Assignment	✓	✓	✓	✓	✓	✓
Laboratory Checkpoints	✓	✓	✓	✓	✓	✓
Mid-session test	✓	✓	✓		✓	
Final exam	✓	✓	✓	✓	✓	✓

COURSE RESOURCES

Textbooks

The following is a list of books used as references during the course. Each book tends to place an emphasis on different areas of real time systems design, and as such, there is no one book that can be prescribed a standalone text.

- James K. Peckol, Embedded Systems: A Contemporary Design Tool, Wiley, 2008.
- Steven F. Barrett, Daniel J. Pack, Embedded Systems: Design and Applications with the 68HC12 and HCS12, Prentice Hall, 2005.
- Jane W. S. Liu, Real-Time Systems, Prentice Hall, 2000.
- Alan C. Shaw, Real-Time Systems and Software, Wiley, 2001.
- Daniel W. Lewis, Fundamentals of Embedded Software: Where C and Assembly Meet, Prentice Hall, 2002.

- Phillip A. Laplante, Seppo J Ovaska, Real-Time Systems Design and Analysis – Tools for the Practitioner, IEEE Press, 2012.

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and 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.

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/policy), 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 formal classes and *independent, self-directed study*. In periods where you 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.

Based on the myExperience process feedback additional access to the lab room ElecEng 109 may be arranged this year.

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 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 Stage 1 Competency Standards

Competency Standards		Learning Outcomes
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	1,2,3,4,6
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	5
	PE1.3 In-depth understanding of specialist bodies of knowledge	3,4,6
	PE1.4 Discernment of knowledge development and research directions	
	PE1.5 Knowledge of engineering design practice	1,2,3,4,5,6
	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	1,2,3,4,5,6
	PE2.2 Fluent application of engineering techniques, tools and resources	1,2,3,4,6
	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	5
	PE3.2 Effective oral and written communication (professional and lay domains)	1
	PE3.3 Creative, innovative and pro-active demeanour	
	PE3.4 Professional use and management of information	1,2
	PE3.5 Orderly management of self, and professional conduct	
	PE3.6 Effective team membership and team leadership	