



UNSW Course Outline

ELEC3145 Real Time Instrumentation - 2024

Published on the 21 May 2024

General Course Information

Course Code : ELEC3145

Year : 2024

Term : Term 2

Teaching Period : T2

Is a multi-term course? : No

Faculty : Faculty of Engineering

Academic Unit : School of Electrical Engineering & Telecommunications

Delivery Mode : In Person

Delivery Format : Standard

Delivery Location : Kensington

Campus : Sydney

Study Level : Undergraduate

Units of Credit : 6

Useful Links

[Handbook Class Timetable](#)

Course Details & Outcomes

Course Description

Real Time Instrumentation aims to equip students with the necessary and additional computing and hardware skills to be able to work with and design real-time computer systems that are connected as instrumentation and control devices to other electrical and mechanical circuits.

The course is problem-based so that students will address the issues associated with and concepts behind building a simple real-time computer system. The course revises the concepts of interrupts, introduces the concept of real-time computing, and discusses why time is important and how it is incorporated into a design, multitasking and multithreading, and simple interprocess communication. Students will learn about and be exposed to various devices that provide an interface between a computer and the environment. Fundamental signal processing and control will be covered, including discrete-time processing, signal filtering and conditioning, state machines, PID control, and numerical integration. Although the course will exercise analytical skills, there is a strong emphasis on practical implementation using a real-time operating system and using the C programming language to interface with and control real hardware.

Course Aims

The aims of the course are:

1. To develop an understanding of what real-time is and its importance in many diverse areas of engineering.
2. To introduce operating system concepts such as interrupts, multitasking, and data communication.
3. To develop an understanding of the fundamentals of discrete-time systems, their significance and their representation on digital computers using C programming.
4. To introduce a basic understanding of physical instrumentation devices, including A/D and D/A converters.
5. To develop an understanding of fundamental systems theory concepts, including differential equations, transfer functions, state-space, numerical integration, and simple feedback (PID) control.
6. To develop skills in dealing with the various parts of a simple real-time instrumentation and control system using the real-time operating system RTLinux.

Relationship to Other Courses

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:

A satisfactory performance in either COMP1911: Computing 1A or COMP1917: Computing 1, or

equivalent, is a required pre-requisite for basic programming skills. Basic competency in First Year Mathematics is assumed. In addition, an introductory knowledge of C-programming will be required for the Laboratory Component.

Course Learning Outcomes

| Course Learning Outcomes |
|--|
| CLO1 : Apply difference equations and discrete-time transfer functions as a means of describing discrete-time systems and determining their stability. |
| CLO2 : Demonstrate use of transfer functions, state-space, and block diagrams to describe and manipulate continuous time systems. |
| CLO3 : Apply numerical methods such as Runge-Kutta integration and operator substitution for solving differential equations on a digital computer. |
| CLO4 : Explain what PID control is and how to implement in a digital computer. |
| CLO5 : Demonstrate basic real-time operating system concepts, including interrupt processing, multitasking, and inter-process communication, with the RTAI operating system. |
| CLO6 : Explain the use of A/D and D/A converters, and their operation. |

| Course Learning Outcomes | Assessment Item |
|--|---|
| CLO1 : Apply difference equations and discrete-time transfer functions as a means of describing discrete-time systems and determining their stability. | <ul style="list-style-type: none"> • Mid-term exam • Final exam |
| CLO2 : Demonstrate use of transfer functions, state-space, and block diagrams to describe and manipulate continuous time systems. | <ul style="list-style-type: none"> • Mid-term exam • Final exam |
| CLO3 : Apply numerical methods such as Runge-Kutta integration and operator substitution for solving differential equations on a digital computer. | <ul style="list-style-type: none"> • Mid-term exam • Final exam |
| CLO4 : Explain what PID control is and how to implement in a digital computer. | <ul style="list-style-type: none"> • Laboratory assessment • Final exam |
| CLO5 : Demonstrate basic real-time operating system concepts, including interrupt processing, multitasking, and inter-process communication, with the RTAI operating system. | <ul style="list-style-type: none"> • Laboratory assessment • Final exam |
| CLO6 : Explain the use of A/D and D/A converters, and their operation. | <ul style="list-style-type: none"> • Laboratory assessment • Final exam |

Learning and Teaching Technologies

Moodle - Learning Management System | Microsoft Teams

Learning and Teaching in this course

You are expected to attend all lectures, workshops, 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 also encouraged. UNSW assumes that self-directed study of this kind is undertaken in addition to attending formal classes throughout the course.

Other Professional Outcomes

Engineers Australia (EA), Professional Engineer Stage 1 Competencies

The Course Learning Outcomes (CLOs) contribute to your development of the following EA competencies:

PE1: Knowledge and Skill Base:

PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals: CLO 1, 2, 3, 4, 5

PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing: CLO 1

PE1.3 In-depth understanding of specialist bodies of knowledge: CLO 1, 2, 5

PE1.4 Discernment of knowledge development and research directions: n/a

PE1.5 Knowledge of engineering design practice: CLO 3, 5, 6

PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice: n/a

PE2: Engineering Application Ability:

PE2.1 Application of established engineering methods to complex problem solving: CLO 3, 4, 5, 6

PE2.2 Fluent application of engineering techniques, tools and resources: CLO 1, 4, 5, 6

PE2.3 Application of systematic engineering synthesis and design processes: CLO 3, 4, 5

PE2.4 Application of systematic approaches to the conduct and management of engineering projects: n/a

PE3: Professional and Personal Attributes:

PE3.1 Ethical conduct and professional accountability: n/a

PE3.2 Effective oral and written communication (professional and lay domains): CLO 5

PE3.3 Creative, innovative and pro-active demeanour: CLO 5

PE3.4 Professional use and management of information: n/a

PE3.5 Orderly management of self, and professional conduct: n/a

PE3.6 Effective team membership and team leadership: n/a

Additional Course Information

Assessments

Assessment Structure

| Assessment Item | Weight | Relevant Dates |
|--|--------|--|
| Laboratory assessment Assessment Format: Individual | 20% | Start Date: Not Applicable Due Date: Not Applicable |
| Mid-term exam Assessment Format: Individual | 20% | Start Date: Not Applicable Due Date: Not Applicable |
| Final exam Assessment Format: Individual | 60% | Start Date: Not Applicable Due Date: Not Applicable |

Assessment Details

Laboratory assessment

Assessment Overview

The assessment of the laboratory will consist of a mark given for checkpoint(s). 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. It is recommended that you maintain a lab book for recording your observations.

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. Assessment marks will be awarded according to how much of the lab you were able to complete, your understanding of the experiments conducted during the lab, and the quality of the code you wrote during your lab work.

Course Learning Outcomes

- CL04 : Explain what PID control is and how to implement in a digital computer.
- CL05 : Demonstrate basic real-time operating system concepts, including interrupt processing, multitasking, and inter-process communication, with the RTAI operating system.
- CL06 : Explain the use of A/D and D/A converters, and their operation.

Mid-term exam

Assessment Overview

The mid-term exam in this course is a one-hour written examination that 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 the laboratory material, and will definitely contain numerical and analytical questions. Marks will be assigned according to the correctness of the responses. Verbal class-wide feedback will be given during lectures and individual feedback will also be provided upon request.

Course Learning Outcomes

- CL01 : Apply difference equations and discrete-time transfer functions as a means of describing discrete-time systems and determining their stability.
- CL02 : Demonstrate use of transfer functions, state-space, and block diagrams to describe and manipulate continuous time systems.
- CL03 : Apply numerical methods such as Runge-Kutta integration and operator substitution for solving differential equations on a digital computer.

Final exam

Assessment Overview

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 the laboratory). Marks will be assigned according to the correctness of the responses.

Course Learning Outcomes

- CL01 : Apply difference equations and discrete-time transfer functions as a means of describing discrete-time systems and determining their stability.
- CL02 : Demonstrate use of transfer functions, state-space, and block diagrams to describe and manipulate continuous time systems.
- CL03 : Apply numerical methods such as Runge-Kutta integration and operator substitution for solving differential equations on a digital computer.
- CL04 : Explain what PID control is and how to implement in a digital computer.
- CL05 : Demonstrate basic real-time operating system concepts, including interrupt processing, multitasking, and inter-process communication, with the RTAI operating system.
- CL06 : Explain the use of A/D and D/A converters, and their operation.

General Assessment Information

For all assessment tasks, if you are unable to attend 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 percentage will be increased by the percentage of the assessment. For example, the final exam will be assessed for 80% instead of 60%, in case of missing the mid-term exam.

Grading Basis

Standard

Course Schedule

| Teaching Week/Module | Activity Type | Content |
|------------------------------|---------------|---|
| Week 0 : 20 May - 26 May | Other | |
| Week 1 : 27 May - 2 June | Lecture | Real Time and Discrete Time Systems, Control Systems Modelling |
| | Workshop | Discrete-Time Systems |
| Week 2 : 3 June - 9 June | Lecture | State-Space Techniques |
| | Laboratory | Lab 1 - MATLAB for Discrete-Time Systems |
| | Workshop | Linear Differential Equations and Block Diagrams |
| Week 3 : 10 June - 16 June | Lecture | Numerical Methods, PID Control |
| | Laboratory | Lab 2 – Numerical Methods in C and MATLAB |
| | Workshop | Numerical Methods |
| Week 4 : 17 June - 23 June | Lecture | Digital Controller Realisations |
| | Laboratory | Lab 3 – Linux and the GNU C compiler |
| | Workshop | State Space and Linear Systems |
| Week 5 : 24 June - 30 June | Lecture | Real Time Systems |
| | Laboratory | Lab 4 – RTAI and Real-Time Clock |
| | Workshop | Multi-threaded Programs and RTAI |
| | Assessment | Mid-term exam |
| Week 6 : 1 July - 7 July | Other | |
| Week 7 : 8 July - 14 July | Lecture | Interrupts and Task Switching |
| | Laboratory | Lab 4 – continues |
| | Workshop | Interrupts |
| Week 8 : 15 July - 21 July | Lecture | RTAI and Task Scheduling |
| | Laboratory | Lab 4 – continues / Lab 5 – Real-Time Analog Data Acquisition in RTAI |
| | Workshop | A/D and D/A converters |
| Week 9 : 22 July - 28 July | Lecture | Inter-Process Communication |
| | Laboratory | Lab 5 – continues |
| | Workshop | Simple Feedback Control Systems (PID Control) |
| Week 10 : 29 July - 4 August | Lecture | A/D and D/A Conversion |
| | Laboratory | Lab 5 – continues |
| | Workshop | Numerical Representations |

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

General Schedule Information

The course consists of 2-3 hours of lectures each week, a 1-hour workshop every week, and a 3-hour laboratory session every week.

Lectures start in Week 1, workshops in Week 1, and laboratories in Week 2.

Course Resources

Prescribed Resources

None.

Recommended Resources

None of the texts gives an authoritative coverage of material in this course. However, there are several books that will be helpful for particular parts of the course. The first two will be useful for ELEC3145, and provide useful background material in real-time concepts, however will not be useful for those parts of the course dealing with digital filters and systems theory. Students may also consider purchasing a suitable C/C++ reference book.

Reference books:

- Alan C. Shaw, Real-Time Systems and Software, Wiley, 2001.
- Phillip A. Laplante, Real-Time Systems Design and Analysis - An Engineer's Handbook, IEEE Press, 1992.
- K. J. Astrom, B. Wittenmark, Computer-Controlled Systems: Theory and Design, 2nd edition, Prentice-Hall, 1990.
- Cay Horstmann, Computing Concepts with C++ Essentials, edition, Wiley, 2003.

Course Evaluation and Development

Feedback on the course is gathered periodically using various means, including the UNSW myExperience process, informal discussions with students inside and outside of class, and the School's Student/Staff meetings. Your feedback is taken seriously, and continual improvements are made to the course based, in part, on such feedback.

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 open labs will be arranged this year.

Staff Details

| Position | Name | Email | Location | Phone | Availability | Equitable Learning Services Contact | Primary Contact |
|-----------|-------------------|-------|----------|----------|--------------|-------------------------------------|-----------------|
| Convenor | Branislav Hredzak | | TETB 324 | 93854895 | See Moodle | No | Yes |
| Lab staff | Yirui Deng | | | | | No | No |

Other Useful Information

Academic Information

I. Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's [Special Consideration page](#).

II. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and policies. In particular, students should be familiar with the following:

- [Attendance](#)
- [UNSW Email Address](#)
- [Special Consideration](#)
- [Exams](#)
- [Approved Calculators](#)
- [Academic Honesty and Plagiarism](#)
- [Equitable Learning Services](#)

III. Equity and diversity

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at

the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: <https://www.unsw.edu.au/engineering/student-life/student-resources/program-design>.

Note: This course outline sets out the description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle or your primary learning management system (LMS) should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagiarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism, visit: student.unsw.edu.au/plagiarism. The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also

be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;
- Online quizzes where answers are released to students on completion;
- Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

[Engineering Student Support Services](#) – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

[Engineering Industrial Training](#) – Industrial training questions

[UNSW Study Abroad](#) – study abroad student enquiries (for inbound students)

[UNSW Exchange](#) – student exchange enquiries (for inbound students)

[UNSW Future Students](#) – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

School-specific Information

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.

Use of AI for assessments

Your work must be your own. If you use AI in the writing of your assessment, you must acknowledge this and your submission must be substantially your own work. More information can be found on this [website](#).

Workplace Health & Safety (WHS)

WHS for students and staff is of utmost priority. Most courses involve laboratory work. You must follow the [rules about conduct in the laboratory](#). About COVID-19, advice can be found on this [website](#).

School Contact Information

Consultations: Lecturer consultation times will be advised during the first lecture. 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 enquiries should be made from your student email address with ELEC/TELExxxx 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.

Student Support Enquiries

[For enrolment and progression enquiries please contact Student Services](#)

Web

[Electrical Engineering Homepage](#)