UNSW Course Outline

ELEC9782 Special Topics in Electrical Engineering 2 - 2024

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General Course Information

Course Code : ELEC9782
Year : 2024
Term : Term 3
Teaching Period : T3
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 : Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

This is an elective course at the graduate level, covering some special or advanced topics in electrical engineering of particular interests or needs at the time. The course content varies with the changing topics.

Course Aims

The course aims to expose students to some selected topics of special interest such as new emerging areas of technological advances or industry practices in the field of electrical engineering.

Relationship to Other Courses

This is a postgraduate course in the School of Electrical Engineering and Telecommunications.

Pre-requisites and Assumed Knowledge

The pre-requisites for this course are ELEC3705 Fundamentals of Quantum Engineering and ELEC3114 Control Systems, or equivalent courses taken at other institutions. It is also essential that you are familiar with MATH2069, Mathematics 2A, and MATH2099, Mathematics 2B, before this course is attempted (they are already pre-requisites for ELEC3114). Having done ELEC4605 Quantum Devices and Computers and ELEC4631 Continuous-Time Control System Design will also be beneficial for doing this course but are not pre-requisites for the course. Students are expected to be familiar and comfortable with:

Basic quantum mechanics: Wave functions, observables, quantum expectations, Schro dinger equation, Dirac bra-ket notation, quantum measurements, quantum harmonic oscillators (ELEC3705)
Probability and statistics: Sample spaces, probability, random variables and probability distributions, standard discrete and continuous distributions, multivariate distributions, Central Limit Theorem (MATH2099)

Vector calculus: functions of several variables, multivariable calculus, scalar fields, vector fields, gradients (MATH2069)

Linear algebra: matrices, matrix inversion, matrix determinant, vectors, vector spaces, basis vectors, linearly independence, linear span of vectors, null/kernel spaces, characteristic equations, eigenvalues, eigenvectors, diagonalisation of a matrix, exponentiation of a matrix, Jordan canonical form (MATH2099)

Control systems: Laplace transform, inverse Laplace transform, transfer functions, poles and zeros, state-space modelling, feedback control (ELEC3114)

Course Learning Outcomes

Course Learning Outcomes
CLO1 : After successful completion of this course, students will gain a sound technical knowledge of the specific advanced electrical engineering topics covered in this course.

Course Learning Outcomes	Assessment Item
CLO1 : After successful completion of this course, students will gain a sound technical knowledge of the specific advanced electrical engineering topics covered in this course.	• Final Result

Learning and Teaching Technologies

Moodle - Learning Management System

Learning and Teaching in this course

Students are expected to make an effort to attend all face-to-face lectures and to catch-up and view the lecture recordings if they are unable to attend.

A high degree of independent learning is also expected from students to master the course materials outside of the face-to-face meetings during the scheduled lecture times. Especially important are learning strategies that students have to adopt:

1. Learning is effortful - you have to make the effort.
2. You have to develop your own mental models for how things work. The lecturer can give you insights, but you have to develop your own “schema”.
3. You learn from errors and from discovering misconceptions. You cannot do this just by listening or reading. You have to try things out.
4. 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.
5. Do all the tutorial problems to test your new-found understanding.
6. You learn by doing. Make sure you become competent in the laboratory. Always come prepared before attending the labs, and pace yourself to complete in-lab tasks and experiments within the assigned lab time.
7. 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

Other Professional Outcomes

Relationship to Engineers Australia Stage 1 competencies:

The Course Learning Outcomes (LOs) contribute to the Engineers Australia (National Accreditation Body) Stage I competencies as outlined below

Engineers Australia (EA), Professional Engineer Stage 1 Competencies

PE1: Knowledge and Skill Base:
PE1.1 Comprehensive, theory-based **understanding of underpinning fundamentals**: LO 1
PE1.2 Conceptual understanding of underpinning maths, **analysis**, statistics, **computing**: LO 1
PE1.3 In-depth understanding of specialist bodies of **knowledge**: LO 1
PE1.4 Discernment of knowledge development and research directions: NA
PE1.5 Knowledge of **engineering design** practice: LO 1
PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice: NA

PE2: Engineering Application Ability:
PE2.1 Application of established engineering methods to **complex problem solving**: LO 1
PE2.2 Fluent **application of engineering techniques**, tools and resources: LO 1
PE2.3 Application of systematic engineering synthesis and design processes: NA
PE2.4 Application of systematic approaches to the conduct and management of engineering projects: NA

PE3: Professional and Personal Attributes:
PE3.1 Ethical conduct and professional accountability: LO 1
PE3.2 Effective **oral and written communication** (professional and lay domains): LO 1
PE3.3 **Creative, innovative** and pro-active demeanour: LO 1
PE3.4 Professional use and management of information: NA
PE3.5 Orderly management of **self, and professional conduct**: LO 1
PE3.6 Effective team membership and team leadership: NA

This course is also designed to provide the course learning outcomes which arise from targeted graduate capabilities. The targeted graduate capabilities broadly support the UNSW and Faculty of Engineering graduate capabilities (also listed below).

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

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.
- Developing citizens who can apply their discipline in other contexts, are culturally aware and environmentally responsible, through interdisciplinary tasks, seminars and group activities

Additional Course Information

Summary of the Course

ELEC9782 gives an introduction to control theory for quantum systems. Coverage includes open-

loop and closed-loop (feedback) control methods. It reviews relevant concepts from the theory of open quantum systems, quantum measurement theory and stochastic control theory. The course takes a multidisciplinary approach and will draw upon relevant concepts from physics, systems and control, and mathematics and mathematical physics. Close connections between stochastic control for classical Markov processes and measurement quantum feedback control will be highlighted. The course will run over 10 weeks and is aimed at postgraduate students already familiar with quantum mechanics, for instance via the courses ELEC3705 and/or ELEC4605, and basic control systems, such as covered in ELEC3114. Materials will be presented at an advanced introductory level, emphasising mastery of basic concepts and methods, supported by illustrations given in the simplest settings to help develop an intuitive understanding. The course will help prepare students for deeper self-study or to take on more advanced courses.

Course Aims

The aims of the course are to:

1. Introduce open-loop optimal control of quantum systems
2. Introduce filtering and stochastic control theory for stochastic dynamical systems
3. Introduce open quantum systems and generalised quantum measurements
4. Introduce measurement quantum feedback control
5. Introduce a unified view of stochastic control and measurement quantum feedback control 6. Develop the ability to simulate open-loop and quantum feedback control in Matlab

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Final Result Assessment Format: Individual	100%	

Assessment Details

Final Result

Assessment Overview

The assessment will be divided into sub-assessment items that will vary with the special topic that is covered in the course in a particular term. The sub-assessments aim to evaluate a

student's level of understanding and mastery of the course materials. The sub-assessments may include group research and presentation. Marks for sub-assessment items will be awarded based on the correctness of the response and against specific criteria in a marking guide. Formal individual feedback on submitted sub-assessment items, excluding any final exam component, will be provided within two weeks of their submission.

Course Learning Outcomes

- CLO1 : After successful completion of this course, students will gain a sound technical knowledge of the specific advanced electrical engineering topics covered in this course.

Detailed Assessment Description

Please see the section on 'General assessment information' for further information on the assessment components.

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
For more information on Generative AI and permitted use please see here.

General Assessment Information

For T3 2024, the assessment components are:

1. Quiz 1 (10%)

   Marks will be assigned according to correctness of the responses. All workings must be included in the submission. Any plagiarism is a serious academic misconduct that will entail a heavy penalty. Per UNSW policy, late quiz submissions will attract a deduction of 5% of the full marks per day that they are late. Submissions late by five days or more will receive a mark of zero.
2. Mid-term exam (25%).

   The mid-term examination is a take home exam that will test your general understanding of the course material and is designed to give you feedback on your progress through the course. Questions may be drawn from any course material up to the end of Week 5. It will consist of longer analytical questions and Matlab simulations.
   Marks will be assigned according to correctness of the responses. All workings must be

included in the submission. Any plagiarism is a serious academic misconduct that will entail a heavy penalty.

Late mid-term exam submissions will incur a deduction of 10% of the full marks per hour block that they are late up to five hours. No marks will be awarded for submissions when it is late by five hours or more.

3. Quiz 2 (10%)

   Marks will be assigned according to correctness of the responses. All workings must be included in the submission. Any plagiarism is a serious academic misconduct that will entail a heavy penalty. Per UNSW policy, late quiz submissions will attract a deduction of 5% of the full marks per day that they are late. Submissions late by five days or more will receive a mark of zero.

4. Final exam (55%)

   The final exam for this course will be a take home exam with a duration and submission time that will be advised in Week 10. The examination tests analytical and critical thinking and general understanding of the course material. Questions may be drawn from any aspect of the course and will involve simulation in Matlab.

   Marks will be assigned according to the correctness of the responses. Marks will be assigned according to correctness of the responses. All workings and codes must be included in the submission. Any plagiarism is a serious academic misconduct that will entail a heavy penalty.

   Late mid-term exam submissions will incur a deduction of 10% of the full marks per hour block that they are late up to five hours. No marks will be awarded for submissions when it is late by five hours or more.

Grading Basis

Standard

Requirements to pass course

To pass the course, students are required to achieve a minimum total course mark of 50.

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 9 September - 15 September	Lecture	Introduction to the course and quantum control systems
	Lecture	Review of basic quantum mechanics Hilbert spaces, wave functions, Schroedinger equation, Heisenberg picture, interaction picture, quantum expectations, composite quantum systems, qubits, Dyson series, time-ordered exponentials, density operators, Bloch sphere
Week 2 : 16 September - 22 September	Lecture	Open-loop optimal control of quantum systems Open-loop optimal quantum control by gradient ascent, applications
	Lecture	Modern probability theory and stochastic processes Probability spaces, random variables, expectations and conditional expectations, jointly Gaussian random variables, stochastic processes, Markov processes, white noise, Wiener process (Brownian motion)
	Assessment	Quiz 1 released
Week 3 : 23 September - 29 September	Lecture	Modern probability theory and stochastic processes (continued)
	Lecture	Modern probability theory and stochastic processes (continued)
	Assessment	Quiz 1 submission due.
Week 4 : 30 September - 6 October	Lecture	Filtering theory and stochastic control Ito's formula, stochastic differential equations, flitering theory, Kalman filter, optimal stochastic control, linear quadratic Gaussian (LQG) control
	Lecture	Filtering theory and stochastic control (continued)
Week 5 : 7 October - 13 October	Lecture	Open quantum systems Completely positive maps, quantum operations, Kraus representation, decoherence Note: Due to Monday Labour Day holiday in Week 5 the Monday or Wednesday lecture will be relocated to a different day in that week.
	Lecture	Quantum measurements Projective measurements, projection-valued measures, positive operator-valued measures, sequential measurements, quantum non-demolition (QND) measurements, quantum conditional expectations Note: Due to Monday Labour Day holiday in Week 5 the Monday or Wednesday lecture will be relocated to a different day in that week.
	Assessment	Mid-term exam released.
Week 6 : 14 October - 20 October	Other	There are no lectures during the Flexibility Week (Week 6). Students are strongly encouraged to use this week to review course materials up to and including Week 5.
Week 7 : 21 October - 27 October	Lecture	Quantum measurements (continued)
	Lecture	Continuous-variable systems and free travelling quantum fields Quantum harmonic oscillators, quantum Gaussian states of multi-mode oscillators, free travelling quantum fields, quantum Gaussian states of free travelling fields
	Assessment	Mid-term exam submission due.
Week 8 : 28 October - 3 November	Lecture	Quantum input-output systems Quantum white noise, quantum stochastic differential equations, quantum Markov models, Lindblad master equation, linear quantum systems, physical examples
	Lecture	Quantum input-output systems (continued)
	Assessment	Quiz 2 released.
Week 9 : 4 November - 10 November	Lecture	Quantum input-output systems (continued)
	Lecture	Quantum filtering and feedback control Quantum filtering, quantum Kalman filter, measurement quantum feedback control, quantum LQG control, applications
	Assessment	Quiz 2 submission due.
Week 10 : 11 November - 17 November	Lecture	Quantum filtering and feedback control (continued)
	Lecture	Review lecture

Attendance Requirements

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

General Schedule Information

There will be 2 x 2 hour in-person lectures scheduled for each week of the course from Weeks 1 to 5 and Weeks 7 to 10. There will also be self-guided tutorials introduced in Term 3 2024, where students independently attempt set tutorial problems and then view video recordings of the solutions of selected problems. The self-guided tutorials will be made accessible on the course Moodle page.

Course Resources

Prescribed Resources

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).

Lecture notes

Some lecture notes will be supplied and posted on Moodle.

Recommended Resources

Further texts and references

Part of the course will be drawn from and use contents from some of the following references. They are in general useful as references for the course

1. M. Nielsen and I. Chuang, Quantum Information and Computation, 10th anniversary edition, Cambridge University Press, 2010

2. H. M. Wiseman and G. J. Milburn, Quantum Measurement and Control, Cambridge University Press, 2010.

3. H. I. Nurdin and N. Yamamoto, Linear Dynamical Quantum Systems: Analysis, Synthesis and Control, Springer, 2017

4. A. Bagchi, Optimal Control of Stochastic Systems, Pearson, 1994

Besides this, some materials will be based upon papers that will be posted on Moodle.

Additional Costs

None.

Course Evaluation and Development

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, new self-guided tutorial materials and video recordings as additional support for students' independent learning will be introduced in the delivery of this course in Term 3 2024.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Hendra Nurdin		G17 Level 3 R315	x57556	TBA	No	Yes

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 polices. 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 Plagarism

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