UNSW Course Outline

TELE9757 Quantum Communications - 2024

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General Course Information

Course Code : TELE9757
Year : 2024
Term : Term 1
Teaching Period : T1
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, Postgraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

This course is aimed at Engineers and Physicists wishing to understand the exciting new world of Quantum Communications. Quantum Communications and Quantum Networks are anticipated to be the core networking technologies of the 21st century. In fact, these

communication systems have already appeared in the commercial world in many variations. This course introduces the keys concepts important for understanding, testing, analyzing, and improving the performance of quantum communication networks. It will have a particular focus on actual quantum networks currently being deployed and the use of such networks for secure information transfer. Designed from an engineering perspective the course will first introduce the basic quantum physics that underlies quantum communication principles. It will then introduce and explore the key concepts that drive quantum communications such as Quantum Entanglement, Quantum Teleportation, The No Cloning Theorem, Quantum Cryptography; Privacy Amplification, and Error Correction for Quantum Keys.

Course Aims

The main aim of this course is to develop amongst students from different backgrounds a solid understanding of the key concepts and principles that underpin the emerging and exciting new world of quantum communications. The course introduces the key concepts important for understanding, testing, analysing and improving the performance of quantum communication networks. It will have particular focus on actual quantum networks currently being deployed and the use of such networks for secure information transfer. Designed from an engineering perspective the course will first introduce the basic quantum physics that underlies quantum communication principles. It will then introduce and explore the key concepts that drive quantum communications.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Explain the theory, concepts and challenges of quantum mechanics as applied to communications.
CLO2 : Explain the theory, concepts and challenges of transferring quantum information over a network.
CLO3 : Explain how applications operate over quantum communication channels.
CLO4 : Explain why quantum communications is a vital new technology that will only grow in importance within the engineering world.
CLO5 : Explain and participate in discussions on the underlying principles of quantum networks, and be able to design and simulate the behaviour of quantum networks.
CLO6 : Carry out calculations which determine the performance of a quantum network.
CLO7 : Review and communicate via written reports the novelty and usefulness of quantum communication research papers appearing in engineering journals.

Course Learning Outcomes	Assessment Item
CLO1 : Explain the theory, concepts and challenges of quantum mechanics as applied to communications.	• Mid-term Test • Final Examination
CLO2 : Explain the theory, concepts and challenges of transferring quantum information over a network.	• Mid-term Test • Final Examination
CLO3 : Explain how applications operate over quantum communication channels.	• Mid-term Test • Final Examination
CLO4 : Explain why quantum communications is a vital new technology that will only grow in importance within the engineering world.	• Lab Work
CLO5 : Explain and participate in discussions on the underlying principles of quantum networks, and be able to design and simulate the behaviour of quantum networks.	• Lab Work
CLO6 : Carry out calculations which determine the performance of a quantum network.	• Mid-term Test • Final Examination
CLO7 : Review and communicate via written reports the novelty and usefulness of quantum communication research papers appearing in engineering journals.	• Lab Work • Mid-term Test

Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360

Learning and Teaching in this course

Students are required to attend all classes even though lectures will be recorded (via Echo 360 on Moodle page). Some labs will be run during these class hours.

Other Professional Outcomes

Engineers Australia, Professional Engineer Stage 1 Competencies

The course learning outcomes (CLOs) contribute to your development of EA competencies:

PE1: Knowledge and Skill Base

- PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals: CLO 1
- PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing: CLO 2
- PE1.3 In-depth understanding of specialist bodies of knowledge: CLO 3
- PE1.4 Discernment of knowledge development and research directions: CLO 7
- PE1.5 Knowledge of engineering design practice: CLOs 3, 4
- PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice CLO 5

PE2: Engineering Application Ability

- PE2.1 Application of established engineering methods to complex problem solving: CLO 6
- PE2.2 Fluent application of engineering techniques, tools and resources: CLOs 2,6
- PE2.3 Application of systematic engineering synthesis and design processes: CLO 4
- PE2.4 Application of systematic approaches to the conduct and management of engineering projects: CLO 7

PE3: Professional and Personal Attributes

- PE3.1 Ethical conduct and professional accountability CLO 7
- PE3.2 Effective oral and written communication (professional and lay domains): CLO 7
- PE3.3 Creative, innovative and pro-active demeanour CLO 5
- PE3.4 Professional use and management of information: CLO 7
- PE3.5 Orderly management of self, and professional conduct: CLOs 5, 7
- PE3.6 Effective team membership and team leadership: CLO 5

Additional Course Information

Course ResourcesTextbooksPrescribed textbook

Protecting Information: From Classical Error Correction to Quantum Cryptography, S. Loepp & W. K. Wooters, Cambridge Press, 2006

Reference books

- Quantum Computation and Quantum Information, M. Nielsen and I. L. Chuang, Cambridge Press, 2006.

On-line resourcesMoodle

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).

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Mid-term Test Assessment Format: Individual	20%	
Lab Work Assessment Format: Individual	20%	
Final Examination Assessment Format: Individual	60%	

Assessment Details

Mid-term Test

Assessment Overview

The midterm exam covers lecture topics from the first half of the term. Length of exam will be 2 hours. Marking will be done with a rubric. Formal feedback will be provided within ten days of the exam.

Course Learning Outcomes

- CLO1 : Explain the theory, concepts and challenges of quantum mechanics as applied to communications.
- CLO2 : Explain the theory, concepts and challenges of transferring quantum information over a network.
- CLO3 : Explain how applications operate over quantum communication channels.
- CLO6 : Carry out calculations which determine the performance of a quantum network.
- CLO7 : Review and communicate via written reports the novelty and usefulness of quantum communication research papers appearing in engineering journals.

Assessment Length

2 hours

Assessment information

This exam will be multiple choice via Moodle, with marks returned next day.

Lab Work

Assessment Overview

The laboratory work covers the lecture material. You will be expected to take 3 laboratories during the course. Marking of you laboratory reports will be done with a rubric. Formal feedback will be provided within ten days of the final laboratory.

Course Learning Outcomes

- CLO4 : Explain why quantum communications is a vital new technology that will only grow in importance within the engineering world.
- CLO5 : Explain and participate in discussions on the underlying principles of quantum networks, and be able to design and simulate the behaviour of quantum networks.
- CLO7 : Review and communicate via written reports the novelty and usefulness of quantum communication research papers appearing in engineering journals.

Assessment information

This will be turned in via the Moodle web site at end of week 11.

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students can see Turnitin similarity reports.

Final Examination

Assessment Overview

The final exam will be a written exam and the assessment of it will be based on a rubric. The final exam covers lecture topics from the entire course. The length of the exam will be two hours.

Course Learning Outcomes

- CLO1 : Explain the theory, concepts and challenges of quantum mechanics as applied to communications.
- CLO2 : Explain the theory, concepts and challenges of transferring quantum information over a network.
- CLO3 : Explain how applications operate over quantum communication channels.
- CLO6 : Carry out calculations which determine the performance of a quantum network.

Assessment Length

2 hours

Assessment information

The final exam in this course is a standard closed-book 2 hour written examination, comprising five compulsory questions. Calculators are not 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 unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. Please note that you must pass the final exam in order to pass the course.

General Assessment Information

Assessment (details)

- Final Examination (60%): The examination is of two-hour duration, covering all aspects of the course that have been presented in lectures. This exam will assess both understanding and analytical skills. You must pass this exam to pass course.
- Mid-Session Test (20%): The mid-session test will last about 1.5 hours and will be held in week 6. It will cover material covered in the course in week 1 to 5, and will test your conceptual understanding of this material, as well as your ability to apply the concepts to solving problems. This is a compulsory test.
- Laboratory Work (20%): Student groups (maximum three) will be charged with conducting a QKD experiment and delivering a technical report. Details how this operates will be given in first class.
- Bonus Marks. A few bonus marks may be available for additional class participation – details in class. Note the combined bonus marks for any student will not exceed 5% of final class mark.
- Late reports and missed tests. There will be zero marks awarded for late reports or missed tests - unless previously authorised by corse convener.

Grading Basis

Standard

Requirements to pass course

50% total class marks and at least 50% in final exam

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 0 : 5 February - 11 February	Reading	No Class during "O" week - but requested to look at course content on Moodle
Week 1 : 12 February - 18 February	Lecture	Introductory Lecture. Who wants to be a “Quantum Engineer”? Why study Quantum Communications and Quantum networks? What’s wrong with classical networks? What Quantum physics will we cover in the course? Overview of Commercial Quantum Networks. The future is now. What “real engineers” are now building. Overview of current Quantum networks both deployed commercially and those currently in prototype.
Week 2 : 19 February - 25 February	Lecture	Photon Polarization. Maxwell’s equations revisited. Applications of polarization in Quantum Networks. General Quantum Variables and Qubits. Applications of quantum variables in Quantum Networks.
Week 3 : 26 February - 3 March	Lecture	Composite Quantum Systems. Applications of quantum systems in Quantum Networks.
Week 4 : 4 March - 10 March	Lecture	Quantum Entanglement. Why Einstein was wrong and right at same time. Why is entanglement important for Quantum Communications. Quantum Teleportation. An application of composite qubits and entanglement.
Week 5 : 11 March - 17 March	Lecture	Quantum Communications. Superdense coding. Breaking the classical information barrier. The Bennett-Brassard Protocol for Quantum key distribution.
Week 6 : 18 March - 24 March	Assessment	Review of material covered thus far and Midterm.
Week 7 : 25 March - 31 March	Lecture	The Bennett-Brassard Protocol for Quantum key distribution revisited - the missing steps. Quantum Error Corrections for Quantum Keys. Error correcting codes once quantum physics is thrown in.
Week 8 : 1 April - 7 April	Lecture	Review of Classical Error Correcting Codes. Hamming distance, Linear Codes, Generator Matrices, and all that jazz [reviewed by yourself]. Classical error correction for quantum key reconcilliation.
Week 9 : 8 April - 14 April	Lecture	Privacy Amplification. Why classical error correction leaks information to a potential adversary and how to combat this with privacy amplification.
Week 10 : 15 April - 21 April	Lecture	Review and discussion on final exam preparation.

Attendance Requirements

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

General Schedule Information

All classes will be in-person at scheduled published class times. They will be recorded but your attendance in class will be required.

Course Resources

Prescribed Resources

On-line resourcesMoodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials, host forums and occasionally quizzes. Assesemnet (including labs) 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).

Main Text: Protecting Information: From Classical Error Correction to Quantum Cryptography, S. Loepp & W. K. Wooters, Cambridge Press, 2006.

https://www.cambridge.org/core/books/protecting-information/C47D4C179628B6AA23297867ACC323E7

[Avialble Free Onlne via a UNSW Library Account]

Recommended Resources

Secondary Text: Quantum Computation and Quantum Information, M. Nielsen and I. L. Chuang, Cambridge Press, 2006.

(Not required - but a useful more detailed text)

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 via the myExperience 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.

Based on feedback from previous year, an optional laboratory component has been added to this year's course.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Robert Malaney		R407	293856580	Tuesday 6-10pm	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