Carleton University Department of Electronics

Fall 2025

ELEC5703: Introduction to Quantum Communications

Introduction

In this course we will cover the core concepts, technical implementations, practical challenges and some emerging technologies for real-world quantum communications. Topics could include linear algebra, quantum mechanics based on photons, qubits, entangled states, quantum key distribution, quantum repeaters. The application to real-world implementation could cover topics including optical fibre and free-space channels, error correction, clocking and synchronization and integration into classical networks. Students may be expected to contribute lectures or seminars on selected topics.

Course Description and Requirements

Course Description:
Prerequisite(s): None
Lectures: 3 hours per week.
Laboratory and problem analysis: 0 hours per week

Instructor

Professor: Connor Kupchak
Email: connor.kupchak@carleton.ca
Course Webpage: on Brightspace

Textbook:

1) Quantum Physics: An Introduction Based on Photons. A.I. Lvovsky Springer ISBN-13: 978-3662565827 ebook: $54.99 USD (**Mandatory**)

2) Quantum Communications https://arxiv.org/pdf/2311.02367 M. Hajdusek and R. Van Meter Free (**Mandatory**)

Lecture Outline

In person, Mondays and Wednesdays 11:35 am – 12:50 pm, SA 411
The following topics will be covered during the course lectures with an approximate schedule:
Week 1: Review of Introductory Linear Algebra
Week 2: Advanced Linear Algebra Concepts and Intro to Quantum Mechanics (Assignment 1)
Week 3: Polarization of light and Operators
Week 4: Photon Measurement and Detection Techniques (Assignment 2)
Week 5: Quantum Cryptography
Week 6: Local Measurements, Causality and Entanglement

Week 7: Midterm
Week 8: Quantum Teleportation (Assignment 3)
Week 9: Quantum Repeaters
Week 10: Practical Problems and Implementations
Week 11: Practical Problems and Implementations (Assignment 4 – Modeling Project)
Week 12: Class Presentations

Self-Declaration form and Deferred Term work

Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for submitting a self-declaration form no later than three (3) days after the date/deadline of term work including test/midterm, labs, assignments. Any alternate arrangements made with the instructor for submission of term work should be made as soon as possible but within 3 days of the missed due date. If this is not possible after discussion with the instructor, alternate arrangements must be made before the last day of classes in the term as published in the academic schedule.

Instructors can require (or not) the student to submit the self-declaration form. Include the following statement if you require the student to submit a completed self-declaration form:

> **Consult with the instructor no later then 3 days after any missed course work or midterm examination.**
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> or
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> **Contact the instructor with the completed self-declaration form no later than 3 days after the date/deadline of term work including test/midterm, labs, assignments.**

Evaluation and Grading Scheme

Assignments (3): 25%

Midterm (1): 20%

Modeling Project: 10%

Class Presentation: 10%

Final Exam: 35%

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a) Final Exam: **Final exams are for evaluation purpose and will not be returned to students.** Final Exam will be closed book with use of scientific calculator. You will be permitted one (2-sided) page of notes to bring into the exam.
b) **Late Assignments:** Assignments are expected to be handed in on Brightspace by the deadline indicated on the assignment. Failure to hand the assignment in on Brightspace prior to the closing time of the assignment could result in a grade reduction for that assignment.
c) Class presentation: All students enrolled in the course are required to do an in-class presentation about a quantum networks model.. A selection of possible networks will be posted on Brightspace, once an model is selected, no one else can choose it. You **will not be expected** to be an expert about the

entire model but you **are expected** to understand the main concept of the model and how it relates to quantum communications. You are encouraged to relate what we have learned in this course and try to apply it to the concept of the model. Most of all, treat this as an opportunity for yourself in trying to learn something new and how to explain it to others (and yourself!)

You will be judged on the following criteria:

1. Use of visual aids 30%

2. Organization 40%

3. Clarity of the delivery and engagement with audience 30%

Learning Outcomes

Upon successful completion of this course, students will be able to:
1) Teach the student the nomenclature of quantum mechanics with respect to quantum communications.
2) Teach the student to understand the basics of quantum communications and the critical aspects.
3) Application of this knowledge to real-world scenarios for practical applications. This may involve the use of computer simulations.

Academic Integrity and Plagiarism

a) Please consult the Faculty of Engineering and Design information page about the Academic Integrity policy and our procedures: https://carleton.ca/engineering-design/current-students/fed-academic-integrity. Violations of the Academic Integrity Policy will result in the assignment of a penalty such as reduced grades, the assignment of an F in a course, a suspension or, expulsion.

b) One of the main objectives of the Academic Integrity Policy is to ensure that the work you submit is your own. As a result, it is important to write your own solutions when studying and preparing with other students and to avoid plagiarism in your submissions. The University Academic Integrity Policy defines plagiarism as "presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own." This includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source.

Examples of violations of the policy include, but are not limited to:

- Any submission prepared in whole or in part, by someone else;
- Using another's data or research findings without appropriate acknowledgment;
- Submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own;
- Failing to acknowledge sources of information through the use of proper citations when using another's work and/or failing to use quotations marks; and
- Unless explicitly permitted by the instructor in a specific course, the use of generative AI and similar tools to produce assessed content (such as text, code, equations, images, summaries, videos, etc.).

The instructor understands the benefits of AI use in learning and development. However, use of AI for the full generation of documents and text is not permitted. Students are required to disclose any AI use in

their submitted use. Acceptable examples include: grammar and spelling checks, sentence clarity and obtaining deeper insight into course material that is justified by the student.

As our understanding of the uses of AI and its relationship to student work and academic integrity continue to evolve, students are required to discuss their use of AI in any circumstance not described here with the course instructor to ensure it supports the learning goals for the course.

Academic Accommodations

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

Pregnancy obligation: Contact us with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form (click here).

Religious obligation: Contact us with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details click here.

Academic Accommodations for Students with Disabilities: The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send us your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, contact us, if needed, to ensure that accommodation arrangements are made.

You should request your academic accommodations in the Ventus Student Portal, for each course at the beginning of every term. For in-term tests or midterms, please request accommodations at least two (2) weeks before the first test or midterm.

Please consult the PMC website for the deadline to request accommodations for formally-scheduled exams (if applicable).

Survivors of Sexual Violence: As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: https://carleton.ca/equity/sexual-assault-support-services

Accommodation for Student Activities: Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Contact us with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist: https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf