NC STATE UNIVERSITY

# CSC/ECE 791 Course Syllabus

## CSC/ECE 791 – Introduction to Quantum Communications and Network

**Section 006**

**Fall 2022**

**3 Credit Hours**

## Course Description

Quantum communications is no longer a myth but a revolutionary technology that is just around the corner. This course covers the cutting-edge topics of quantum communications and network (QCN). The objective of this course is to provide students with the theoretical foundation, simulation methods, and research frontiers of QCN through pedagogical activities such as lecturing, paper reading and presentation, and projects.

As an introductory course on QCN, only minor assumptions are made in terms of students' prerequisite knowledge. The covered topics by this course include (but not limited to) quantum gates/operations, entanglement, teleportation, error control, purification, metrics for performance assessment, optical channel modeling, network graphs and quantum graph states, and quantum applications.

## Learning Outcomes

At the end of the semester, students will obtain basic knowledge about how a quantum communication system works. Students will be able to apply the mathematical tools to analyze and optimize quantum communication events. Students will design and simulate simple quantum communication systems in numerical simulators. Moreover, students will understand and assess the merits of quantum research articles in quantum communications.

## Course Structure

10 lectures, 3 presentations (individual work), 4 homework (individual work), 1 course project (team work)

## Instructors

**Jianqing Liu** - *Instructor*
**Email:** jliu96@ncsu.edu
**Web Page:** https://www.jianqingliu.net
**Phone:** 919 515 2197
**Office Location:** 2296 Engineering Building II (EB2)
**Office Hours:** Monday 2:30pm - 4:30pm

## Course Meetings

None.

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# Course Materials

## Textbooks

**Quantum Networking** - *Rodney Van Meter*
**Edition:** 1
**Cost:** 0
*This textbook is optional.*

## Expenses

None.

## Materials

**Course Handouts** - 0
*This material is required.*

**Technical Paper** - 0
*This material is required.*

# Requisites and Restrictions

## Prerequisites

CSC401: Data and Computer Communications Network (or equivalent)
ST370: Probability and Statistics for Engineers (or equivalent)
MA305: Introductory Linear Algebra and Matrices (or equivalent)

## Co-requisites

None.

## Restrictions

None.

# Transportation

This course will not require students to provide their own transportation.

# Safety & Risk Assumptions

None.

# Grading

## Grade Components

| Component | Weight | Details |
|---|---|---|
| **Grade breakout** | **100%** | Homework 10%<br>Presentation 25%<br>Final Exam 25%<br>Project 40% |

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## Letter Grades

**This Course uses Standard NCSU Letter Grading:**

| | | | | |
|---|---|---|---|---|
| 97 | ≤ | **A+** | ≤ | 100 |
| 93 | ≤ | **A** | < | 97 |
| 90 | ≤ | **A-** | < | 93 |
| 87 | ≤ | **B+** | < | 90 |
| 83 | ≤ | **B** | < | 87 |
| 80 | ≤ | **B-** | < | 83 |
| 77 | ≤ | **C+** | < | 80 |
| 73 | ≤ | **C** | < | 77 |
| 70 | ≤ | **C-** | < | 73 |
| 67 | ≤ | **D+** | < | 70 |
| 63 | ≤ | **D** | < | 67 |
| 60 | ≤ | **D-** | < | 63 |
| 0 | ≤ | **F** | < | 60 |

## Requirements for Credit-Only (S/U) Grading

Performance in research, seminar and independent study types of courses (6xx and 8xx) is evaluated as either "S" (Satisfactory) or "U" (Unsatisfactory), and these grades are not used in computing the grade point average. For credit only courses (S/U) the requirements necessary to obtain the grade of "S" must be clearly outlined.

## Requirements for Auditors (AU)

Information about and requirements for auditing a course can be found at http://policies.ncsu.edu/regulation/reg-02-20-04.

## Policies on Incomplete Grades

If an extended deadline is not authorized by the Graduate School, an unfinished incomplete grade will automatically change to an F after either (a) the end of the next regular semester in which the student is enrolled (not including summer sessions), or (b) by the end of 12 months if the student is not enrolled, whichever is shorter. Incompletes that change to F will count as an attempted course on transcripts. The burden of fulfilling an incomplete grade is the responsibility of the student. The university policy on incomplete grades is located at http://policies.ncsu.edu/regulation/reg-02-50-03. Additional information relative to incomplete grades for graduate students can be found in the Graduate Administrative Handbook in Section 3.17.G at http://www.ncsu.edu/grad/handbook/index.php

## Late Assignments

No makeup exams or late assignment will be accepted without a written excuse from your doctor, your employer, or NCSU Academic & Student affairs.

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## Attendance Policy

For complete attendance and excused absence policies, please see http://policies.ncsu.edu/regulation/reg-02-20-03

### Attendance Policy

Attendance is not required. Lectures will be recorded.

### Absences Policy

None.

### Makeup Work Policy

None.

### Additional Excuses Policy

None.

## Academic Integrity

### Academic Integrity

Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct found at http://policies.ncsu.edu/policy/pol-11-35-01

### Honor Pledge

Your signature on any test or assignment indicates "I have neither given nor received unauthorized aid on this test or assignment."

## Digital Course Components

Students may be required to disclose personally identifiable information to other students in the course, via digital tools, such as email or web-postings, where relevant to the course. Examples include online discussions of class topics, and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

**Digital Course Components:** Moodle

## Accommodations for Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG02.20.01) (https://policies.ncsu.edu/regulation/reg-02-20-01/).

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## Non-Discrimination Policy

NC State provides equal opportunity and affirmative action efforts, and prohibits all forms of unlawful discrimination, harassment, and retaliation ("Prohibited Conduct") that are based upon a person's race, color, religion, sex (including pregnancy), national origin, age (40 or older), disability, gender identity, genetic information, sexual orientation, or veteran status (individually and collectively, "Protected Status"). Additional information as to each Protected Status is included in NCSU REG 04.25.02 (Discrimination, Harassment and Retaliation Complaint Procedure). NC State's policies and regulations covering discrimination, harassment, and retaliation may be accessed at http://policies.ncsu.edu/policy/pol-04-25-05 or https://oied.ncsu.edu/divweb/. Any person who feels that he or she has been the subject of prohibited discrimination, harassment, or retaliation should contact the Office for Equal Opportunity (OEO) at 919-515-3148.

## Course Schedule

**NOTE:** The course schedule is subject to change.

### Week 1 — 08/22/2022 - 08/26/2022

Topics: Introduction, Course Overview;

Reading: Lec 1

### Week 2 — 08/29/2022 - 09/02/2022

Topics: Quantum Notation, Gates, and Operators;

Reading: Lec 2

### Week 3 — 09/05/2022 - 09/09/2022

**No class, Labor Day**

### Week 4 — 09/12/2022 - 09/16/2022

Topics: Interference, Mixed States, and Fidelity;

Reading: Lec 3

### Week 5 — 09/19/2022 - 09/23/2022

Topics: Entanglement, Teleportation, and Superdense Coding;

Reading: Lec 4

### Week 6 — 09/26/2022 - 09/30/2022

Topics: Physical Components for Quantum Communications;

Reading: Lec 5

### Week 7 — 10/03/2022 - 10/07/2022

Topics: Paper Presentation 1;

Reading: Papers from Read List 1 in Moodle

### Week 8 — 10/10/2022 - 10/14/2022

**No Class, Fall Break**

## Week 9 — 10/17/2022 - 10/21/2022

Topics: Quantum Noises, Quantum Error Correction, and Entanglement Purification;

Reading: Lec 6

## Week 10 — 10/24/2022 - 10/28/2022

Topics: Quantum Repeaters, Entanglement Swapping;

Reading: Lec 7

## Week 11 — 10/31/2022 - 11/04/2022

Topics: Paper Presentation 2;

Reading: Papers from Read List 2 in Moodle

## Week 12 — 11/07/2022 - 11/11/2022

Topics: Graph States and Routing in Quantum Networks;

Reading: Lec 8

## Week 13 — 11/14/2022 - 11/18/2022

Topics: Advanced Topic 1: Continuous-Variable Quantum Communications;

Reading: Lec 9

## Week 14 — 11/21/2022 - 11/25/2022

Topics: Advanced Topic 2: Quantum Applications (QKD, Quantum Clock Synchronization);

Reading: Lec 10

## Week 15 — 11/28/2022 - 12/02/2022

Topics: Paper Presentation 3;

Reading: Papers from Read List 3 in Moodle

## Week 16 — 12/05/2022 - 12/09/2022

Topics: Project Demo and Final Exam;

Reading: Comprehensive