Course Title: Introduction to Quantum Information Science
Course Number: ECE 445/545 - PHYC 480/581
Course Credits: 3

Instructor: Tameem Albash   **Email:** talbash@unm.edu
Office: ECE 229-B
Office hours: Tu 15:30-17:00 in ECE 229-B
Class Meeting Days: Tu/Th   **Class Time:** 11:00-12:15
Class Location/Room: DSH-231   **Term/Semester:** Fall

Course Description:
The intent of this course is to introduce students to the major ideas of Quantum Information Science (QIS), highlighting its interdisciplinary nature. It will serve the purpose of creating a common language and foundation upon which students can pursue advanced topics in QIS.

The course is designed to be self-contained, so no knowledge in quantum mechanics will be assumed. An advanced engineering mathematics background (at least on the level of ECE 300), which should include basic concepts from linear algebra such as vector spaces, linear transformations, eigenvalues, and eigenvectors, should be sufficient.

Course Goals:
The course will introduce students to the language and formalism of QIS and provide a foundation upon which students can take advanced courses.

Student Learning Outcomes (aka Objectives):
Upon completion of the course, students will have gained the necessary mathematical background for quantum states and quantum operations. They will be fluent with the "bra-ket" notation and the analysis of quantum circuits. They will be familiar with important application areas of QIS, such as quantum computing, quantum communication, and quantum metrology, and be able to implement important quantum protocols.

Textbooks/Supplies/Materials/Equipment/ Technology or Technical Requirements:
We recommend but do not require the text:
- "Quantum Computation and Quantum Information" by Michael Neilson & Isaac Chuang.

Links to other textbooks and lecture notes are provided on the course website on UNM Canvas.

Whenever possible, we will use cloud-based compute resources, which typically require some basic familiarity with Python. Basic coding skills in a scientific programming language will also be required to complete some of the assignments.

Course Requirements:
The course will be based on individual homework assignments as well as two exams and a final. Exams 1 and 2 will be oral exams. The Final Exam will be a written exam. The Homework Assignments and Exams will be different for the undergraduate and graduate sections.

Class Activity	Undergraduate	Graduate
Homework Assignments	25%	25%
Exam 1	25%	25%
Exam 2	25%	25%
Final Exam	25%	25%

Assignments will be assigned every Thursday and be due the following Thursday. All assignments are closed at the listed due date and will not be accepted late. The lowest homework grade will be excluded from the calculation of the final grade.

Grading
Final grades will be based on the sum of all possible course points as noted above.

Percentage of available points	Grade (Undergraduate)	Grade (Graduate)
90 - 100	A	A
80 – 89	B	B
70 – 79	C	C
60 - 69	D	F
< 60	F	F

Graduate students must earn a C or higher to earn credit for the course.

Course Schedule:

6 lectures (3 weeks):	Review of concepts from linear algebra using the notation of QM. Includes: "bra-ket" notation, properties of vector spaces, inner product, linear operators (Hermitian, Projectors, Unitary), outer product, eigenvectors/eigenvalues, tensor product
9 lectures (4.5 weeks):	Postulates of QM and consequences (Bell's inequality, quantum teleportation, dense coding)
2 lectures (1 weeks):	Quantum circuits (universality)
3 lectures (1.5 weeks):	Open Quantum Systems (CPTP maps, operator-sum representation)
2 lectures (1 weeks):	Distance Measures (trace distance, fidelity)

5 lectures (2.5 weeks):	Quantum Algorithms (Deutsch-Jozsa, Bernstein-Vazirani, Simon, QFT, Phase estimation, Order finding, Grover, Amplitude amplification)

COVID-19 Health Awareness

UNM is a mask friendly, but not a mask required, community. To be registered or employed at UNM, Students, faculty, and staff must all meet UNM's Administrative Mandate on Required COVID-19 vaccination. If you are experiencing COVID-19 symptoms, please do not come to class. If you have a positive COVID-19 test, please stay home for five days and isolate yourself from others, per the Centers for Disease Control (CDC) guidelines. If you do need to stay home, please communicate with me at talbash@unm.edu; I can work with you to provide alternatives for course participation and completion. UNM faculty and staff know that these are challenging times. Please let us know that you need support so that we can connect you to the right resources and please be aware that UNM will publish information on websites and email about any changes to our public health status and community response.

If you are having active respiratory symptoms (e.g., fever, cough, sore throat, etc.) AND need testing for COVID- 19; OR If you recently tested positive and may need oral treatment, call Student Health and Counseling (SHAC) at (505) 277-3136.

LoboRESPECT Advocacy Center (505) 277-2911 can offer help with contacting faculty and managing challenges that impact your UNM experience.

Accommodation Statement:

UNM is committed to providing equitable access to learning opportunities for students with documented disabilities. As your instructor, it is my objective to facilitate an inclusive classroom setting, in which students have full access and opportunity to participate. To engage in a confidential conversation about the process for requesting reasonable accommodations for this class and/or program, please contact Accessibility Resource Center at arcsrvs@unm.edu or by phone at 505-277-3506.

Support: Contact me at talbash@unm.edu or in office/check-in hours and contact Accessibility Resource Center (https://arc.unm.edu/) at arcsrvs@unm.edu (505) 277-3506.

Credit hour statement

This is a three credit-hour course. Class meets for two 75-minute sessions of direct instruction for fifteen weeks during the Fall 2022 semester. Please plan for a minimum of six hours of out-of-class work (or homework, study, assignment completion, and class preparation) each week.

Title IX Statement:

Our classroom and our university should always be spaces of mutual respect, kindness, and support, without fear of discrimination, harassment, or violence. Should you ever need assistance or have concerns about incidents that violate this principle, please access the resources available

to you on campus. Please note that, because UNM faculty, TAs, and GAs are considered "responsible employees" by the Department of Education, any disclosure of gender discrimination (including sexual harassment, sexual misconduct, and sexual violence) made to a faculty member, TA, or GA must be reported by that faculty member, TA, or GA to the university's Title IX coordinator. For more information on the campus policy regarding sexual misconduct, please see: https://policy.unm.edu/university-policies/2000/2740.html.
Support: LoboRESPECT Advocacy Center and the support services listed on its website, the Women's Resource Center and the LGBTQ Resource Center all offer confidential services and reporting.

Academic Integrity Statement:
Each student is expected to maintain the highest standards of honesty and integrity in academic and professional matters. The University reserves the right to take disciplinary action, up to and including dismissal, against any student who is found guilty of academic dishonesty or otherwise fails to meet the standards. Any student judged to have engaged in academic dishonesty in course work may receive a reduced or failing grade for the work in question and/or for the course. Academic dishonesty includes, but is not limited to, dishonesty in quizzes, tests, or assignments; claiming credit for work not done or done by others; hindering the academic work of other students; misrepresenting academic or professional qualifications within or without the University; and nondisclosure or misrepresentation in filling out applications or other University records.
UNM has policies to preserve and protect you and the academic community available in the Student Pathfinder as well as in the Faculty Handbook. These include policies on student grievances D175 (undergraduates) and D176 (graduate and professional students), academic dishonesty (D100), and respectful campus (CO9). Please ask for help in understanding and avoiding plagiarism (passing the work or words of others off as your own work or words) or other forms academic dishonesty. Doing something dishonest in a class or on an assignment can lead to serious academic consequences. Come talk with me about your concerns or needs for academic flexibility or talk with support staff at one of our student resource centers before you do something that may endanger your career.

Citizenship and/or Immigration Status:
All students are welcome in this class regardless of citizenship, residency, or immigration status. Your professor will respect your privacy if you choose to disclose your status. As for all students in the class, family emergency-related absences are normally excused with reasonable notice to the professor, as noted in the attendance guidelines above. UNM as an institution has made a core commitment to the success of all our students, including members of our undocumented community. The Administration's welcome is found on our website: http://undocumented.unm.edu/.

Safety:
UNM offers several resources to help keep Lobos safe.

LoboGuardian, https://loboguardian.unm.edu is a mobile app that increases user safety by creating a virtual safety network of friends and family. The entire UNM campus has blue light emergency phones. UNM Police Department, tel.: (505) 277-2241, offers a free escort service for safety.

Lobo Alerts https://loboalerts.unm.edu is UNM's emergency text messaging system that can inform you of any occurrences that impact safety.

Get Help Now at https://loborespect.unm.edu/Get%20Help%20now/ index.html

LoboRespect Advocacy Center, for concerns such as sexual misconduct, hate/bias, bullying, hazing.

Student Health Services https://shac.unm.edu provides counseling and health services to all students.

Land Acknowledgement:

Founded in 1889, the University of New Mexico sits on the traditional homelands of the Pueblo of Sandia. The original peoples of New Mexico Pueblo, Navajo, and Apache since time immemorial, have deep connections to the land and have made significant contributions to the broader community statewide. We honor the land itself and those who remain stewards of this land throughout the generations and also acknowledge our committed relationship to Indigenous peoples. We gratefully recognize our history. Resource: [Division for Equity and Inclusion](#).