Course Information

Course Number:	MATH 657
Course Title:	Quantum Computation and Quantum Information Theory
Section:	TBD
Time:	TBD
Location:	TBD
Credit Hours:	3

Instructor Details

Instructor:	TBD
Office:	TBD
Phone:	TBD
E-Mail:	TBD
Office Hours:	TBD

Course Description

This is a one-semester introduction to quantum computation and quantum information theory, emphasizing its mathematical aspects. Topics to be covered: (1) classical and probabilistic computation, (2) the Miller-Rabin algorithm for primality testing, (3) an introduction to the quantum mechanics needed for quantum computation, (4) the quantum algorithms of Grover, Simons, and Shor, (5) classical information theory including Shannon's noiseless and noisy channel theorems, (6) an introduction to quantum information theory.

Course Prerequisites

MATH 309, MATH 311, or MATH 323; MATH 411; MATH 415; or approval of instructor.

Course Learning Outcomes

Upon successful completion of this course, students should be able to:

- Compare models of computation, both classical and quantum
- Define in detail the "surprising" quantum phenomena of super-dense coding, quantum teleportation, and Bell's "paradox".
- Define in detail the quantum algorithms of Grover, Simon and Shor
- Define the concept of data compression in noiseless channels
- Compute Shannon entropy and understand its use in Shannon's channel theorems
- Define the density operator formulation of quantum mechanics and it’s applications in quantum information theory
- Compute and know how to utilize von Neumann entropy

Textbook and/or Resource Materials

Primary Textbook:
Landsberg, Quantum Computation and Quantum information
(AMS, GSM 243)

Additional Texts:
Nielsen and Chuang, Quantum Computation and Quantum information
(Cambridge)
Kitaev, Shen, and Vyalyi, Classical and Quantum Computation
(AMS, GSM 47)
Watrous, The Theory of Quantum Information (Cambridge)

Grading Policy

Grades will be based on ten written homework assignments (70%) and on in-class presentations (30%). Homework problems will primarily come from the primary textbook, with additional problems from other sources. The problems will largely consist of proofs and computations of examples. Homework assignments will be due approximately every 10 days. In-class presentations will be due every four to five weeks. They will primarily consist of explaining solutions of the assigned homework to the rest of the class. There will also be an option for the student to present supplementary material to the class in consultation with the instructor.

A: 90% - 100%
B: 80% - 89%
C: 70% - 79%
D: 60: - 69%
F: 0% - 59%

Late Work Policy

The acceptance of late work and any associated penalties will be left up to the discretion of the instructor for the course.

Work submitted by a student as makeup work for an excused absence is not considered late work and is exempted from the late work policy (Student Rule 7).

Course Schedule

- Week 1: Algorithms and Complexity, Discrete Fourier Transform
- Week 2: Classical Computation via Circuits and Reversible Circuits
- Week 3: Probabilistic Computation
- Week 4: Quantum Mechanics as a Generalization of Probability
- Week 5: Super Dense Coding, Quantum Teleportation, and Bell's "Paradox"
- Week 6: Algorithms of Grover and Simon

- Week 7: Elementary Number Theory Needed for the Algorithms
- Week 8: The Miller-Rabin Algorithm and Introduction to Shor's Algorithm
- Week 9: Shor's Algorithm
- Week 10: Data Compression
- Week 11: Entropy and Shannon's Noiseless and Noisy Channel Theorem
- Week 12: Density Operator Formulation of Quantum Mechanics
- Week 13: Linear Algebra Needed for Quantum Information
- Week 14: Quantum Channels and the Quantum Noiseless
- Week 15: von Neumann Entropy

University Policies

Attendance Policy

The university views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments.

Please refer to Student Rule 7 in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy

Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in Student Rule 7, or other reason deemed appropriate by the instructor.

Please refer to Student Rule 7 in its entirety for information about makeup work, including definitions, and related documentation and timelines.

Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" (Student Rule 7, Section 7.4.1).

"The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" (Student Rule 7, Section 7.4.2).

Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. (See Student Rule 24.)

Academic Integrity Statement and Policy

"An Aggie does not lie, cheat or steal, or tolerate those who do."

"Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that

student. Students must keep appropriate records at all times. The inability to authenticate one's work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case" (Section 20.1.2.3, Student Rule 20).

Texas A&M at College Station
You can learn more about the Aggie Honor System Office Rules and Procedures, academic integrity, and your rights and responsibilities at aggiehonor.tamu.edu.

Americans with Disabilities Act (ADA) Policy

Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact the Disability Resources office on your campus (resources listed below) Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible.

Texas A&M at College Station
Disability Resources is located in the Student Services Building or at (979) 845-1637 or visit disability.tamu.edu.

Title IX and Statement on Limits to Confidentiality

Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit gender-based discrimination and sexual harassment, including sexual assault, sexual exploitation, domestic violence, dating violence, and stalking.

With the exception of some medical and mental health providers, all university employees (including full and part-time faculty, staff, paid graduate assistants, student workers, etc.) are Mandatory Reporters and must report to the Title IX Office if the employee experiences, observes, or becomes aware of an incident that meets the following conditions (see University Rule 08.01.01.M1):

- The incident is reasonably believed to be discrimination or harassment.
- The incident is alleged to have been committed by or against a person who, at the time of the incident, was (1) a student enrolled at the University or (2) an employee of the University.

Mandatory Reporters must file a report regardless of how the information comes to their attention – including but not limited to face-to-face conversations, a written class assignment or paper, class discussion, email, text, or social media post. Although Mandatory Reporters must file a report, in most instances, a person who is subjected to the alleged conduct will be able to control how the report is handled, including whether or not to pursue a formal investigation. The University's goal is to make sure you are aware of the range of options available to you and to ensure access to the resources you need.

Texas A&M at College Station

Students wishing to discuss concerns related to mental and/or physical health in a confidential setting are encouraged to make an appointment with University Health Services or download the TELUS Health Student Support app for 24/7 access to professional counseling in multiple languages. Walk-in services for urgent, non-emergency needs are available during normal business hours at University Health Services locations; call 979.458.4584 for details.

Students can learn more about filing a report, accessing supportive resources, and navigating the Title IX investigation and resolution process on the University's Title IX webpage.

Statement on Mental Health and Wellness

Texas A&M University recognizes that mental health and wellness are critical factors influencing a student's academic success and overall wellbeing. Students are encouraged to engage in healthy self-care practices by utilizing the resources and services available through University Health Services. The TELUS Health Student Support app provides access to professional counseling in multiple languages anytime, anywhere by phone or chat, and the 988 Suicide & Crisis Lifeline offers 24-hour emergency support at 988 or 988lifeline.org.

Texas A&M College Station
Students needing a listening ear can contact University Health Services (979.458.4584) 24-hour emergency help is also available through the 988 Suicide & Crisis Lifeline (988) or at 988lifeline.org.

Campus-Specific Policies

Statement on the Family Educational Rights and Privacy Act (FERPA)

FERPA is a federal law designed to protect the privacy of educational records by limiting access to these records, to establish the right of students to inspect and review their educational records and to provide guidelines for the correction of inaccurate and misleading data through informal and formal hearings. Currently enrolled students wishing to withhold any or all directory information items may do so by going to howdy.tamu.edu and clicking on the "Directory Hold Information" link in the Student Records channel on the MyRecord tab. The complete FERPA Notice to Students and the student records policy is available on the Office of the Registrar webpage.

Items that can never be identified as public information are a student's social security number, citizenship, gender, grades, GPR or class schedule. All efforts will be made in this class to protect your privacy and to ensure confidential treatment of information associated with or generated by your participation in the class.

Directory items include name, UIN, local address, permanent address, email address, local telephone number, permanent telephone number, dates of attendance, program of study (college, major, campus), classification, previous institutions attended, degrees honors and awards received, participation in officially recognized activities and sports, medical residence location and medical residence specialization.