Quantum Information, Math 758Q
Instructor: George Androulakis, giorgis@math.sc.edu.
Meeting times and location: MW 12-12:50 pm, F 3:30-4:20 pm, 100% synchronous online via Blackboard.
Office hours: Immediately following the class for up to 1 hour each day or by appointment, via Blackboard.
Course web site that will contain the homework assignments: Blackboard.

Course advertisement: Quantum Information is an area that lies in the intersection of Mathematics, Physics and Computer Science. Recent applications of Quantum Information can be found in Quantum Chemistry. Physical implementations of the results of Quantum Information use the advances in Electrical Engineering. Thus the impressive recent growth and success of the field of Quantum Information lies in its interdisciplinary nature. Quantum mechanics represents our best understanding of microscopic physical phenomena and its laws are used in order to adapt Information Theory and to derive the Quantum Information Theory. Quantum Information originated when physicists started to consider how to apply the laws of Quantum Mechanics to computations. Quantum Information enables us to control and manipulate quantum systems, to study quantum phase transitions, to obtain efficient classical simulation of quantum systems whenever possible, and to develop quantum technologies for studying and simulating quantum systems, whenever classical simulation is not efficient. It also allows us to develop quantum communications, by encoding information into quantum physical systems. In this case the nature imposes the ultimate limits on communication and it is important that we understand what are the effective procedures for achieving these limits. Quantum information is also useful for developing quantum sensors, and quantum computers. For more information please see my web site for prospective graduate students.

Course description: This class will give a one-semester graduate level introduction to Quantum Information. It is mainly addressed to graduate students of Mathematics, Physics, Computer Science, Electrical Engineering and Chemistry. The students who complete the class will learn about quantum states, quantum channels, quantum entropy, quantum coding and data compression, quantum communications, channel capacities, entanglement, Bell inequalities and non-localities. The students will be introduced to many open problems in the very active area of Quantum Information.

Prerequisites: The students are expected to have a good understanding of undergraduate linear algebra (Math 544 or equivalent) and probability (Math 511 or equivalent). Prior knowledge of Quantum Mechanics and Information Theory is helpful but it is not required.

Learning Outcomes: The students who complete this class will be able to:

(1) give examples of commonly used quantum states and channels;
(2) compute distances between quantum states and channels;
(3) state the main properties of quantum entropy and compute it for commonly used quantum states;
(4) describe some quantum source encodings;
(5) give examples of quantum data compression,
(6) determine whether two given quantum states are entangled;
(7) write down some Bell inequalities that describe non-locality;
(8) give examples of quantum games where the winning probability is enhanced when the players share entanglement;
(9) describe common set-ups of quantum communications;
(10) define and compute quantum capacity for common quantum channels.

Textbook: We will use the book "The Theory of Quantum Information" by John Watrous, Cambridge University Press, (2018).

Grading: The grade will be based on homework assignments. Homework assignments will be given out weekly. The assignments will be handed in in class, and they will be returned graded in the scale $0-100$ approximately one week later. All homework assignments will be weighted equally. The grading scale will be: $[90, 100]$: A; $[80, 90)$: B+; $[70, 80)$: B; $[60, 70)$: C+, $[50, 60)$ C; $[25, 50)$: D; $[0, 25)$: F.

Exam dates and other important dates: There will be no midterm exams or final exam. The deadline to drop the course without a WF being recorded is November 4.

Tentative time allocation framework:

Weeks 1, 2, & 3	Mathematical Preliminaries
Weeks 4 & 5	Quantum States and Channels
Weeks 6, 7 & 8	Quantum entanglement, Bell inequalities, non-locality, quantum games
Weeks 9 & 10	Entropy, quantum data compression, source coding
Weeks 11 & 12	Quantum communications
Weeks 13 & 14	Quantum channel capacity

Academic integrity: The students are encouraged to discuss with each other about class materials and homework assignments. The submitted homework assignments should be completely of their own.

Attendance policy: There will be no penalty for missing classes. However, the homework assignments will be based on topics that will be discussed in class. Therefore students who will miss classes will have difficult time to complete homework assignments. Moreover, if a student cannot attend class on the due date of a homework assignment, the student should email me the assignment by the class time. Late homework assignments will not be accepted except for health reasons.

Dissability services: Reasonable accommodations will be available for students with a documented disability. If you have a disability and may need accommodations to fully participate in this class, contact the Office of Student Disability Services: 777-6142, TDD 777-6744, email sasds@mailbox.sc.edu. All accommodations must be approved through the Office of Student Disability Services.