NEW YORK CITY COLLEGE OF TECHNOLOGY
CITY UNIVERSITY OF NEW YORK
SOCIAL SCIENCE DEPARTMENT

Section Number: Instructor:

Email Address: Office hours:

Course Name: PHYS 2609 – Introduction to Quantum Computing

Credit Hours: 4 credit (4 hour)

Co/Prerequisite: PHYS 2443 or PHYS 2607

Course Description: The course provides an introduction to the field of quantum computing. While very much a technology of the future, the course will examine some of the possibilities that the quantum world offers in advancing the capabilities of computers and how our notion of information has evolved. Topics covered include elements of Boolean algebra and classical logic gates, qubits and hypothesis of quantum mechanics, introduction to quantum algorithms, quantum teleportation and it application, quantum entanglement, statistical and adiabatic quantum computation, physical realizations of logic quantum gates in quantum system.

Text:

- **An introduction to Quantum Computing** by *Phillip Kaye, Raymond Laflamme and Michele Mosca Oxford University Press*
- Quantum Computing, Noson Yanofsky, Mirco Mannucci, Cambridge University Press.
- Lecture notes will be distributed
  Complementary text:
- **Introduction to Quantum Computers** by *Gennady Berman, Gary Doolen, Ronnie Mainieri and Vladimir Tsifrinovich, Word Scientific*

Grading Procedures

Reading and homework assignments	20%
Two midterm exams	40%
Course Project (short essays and presentation)	20%
Final exam	20%

HOMEWORK ASSIGNMENTS and COURSE PROJECT
Percent of Grade: 20%+20%

The course will consists of weekly lectures that will showcase some of the major developments in the field. Students will be assigned chapter reading and homework problems for each topic in the course. The goal of the homework assignment is to assess and stimulate students' qualitative and quantitative understanding of the relevant concepts. Each student will have to submit a separate assignment. The ideas and discussions broached during lectures will be further reinforced in tutorials where students will undertake to solve problems and make oral presentations of the Course project. Assessment activities will include presentation of tutorial exercises and short quizzes. Students will be expected to present their material during tutorial classes in an interactive mode. Students, in groups of two or three, will also be expected to carry out literature reviews of selected journal articles and present their work during tutorial sessions.

In Class Exams
Percent of grade: 60%

Two non-cumulative midterm exams. An average of the two examinations will count 40% toward your total PHYS 2609 grade. A cumulative final examination will count 20% toward total PHYS 2609 grade. The exams will cover reading assignments, lectures, and classroom discussions.

Course Weekly Calendar

Week	Topic
1	Course overview. Elements of Boolean Algebra and Binary System
2	Classical Logic Gates and Logic gate symbols (AND gate, OR gate, NOT gate, NAND gate, NOR gate, EXOR gate, EXNOR gate)
3	Circuit Models
4	Linear Algebra and Dirac Notation • Hilbert Space • Operators • The Spectral theorem • Functions of Operators, Tensor Products • The Schmidt Decomposition Theorem
5	Qubits and hypothesis of Quantum mechanics • The state of a quantum system • Time evolution postulate • Superposition and composite System • Measurement postulate • Mixed states and general quantum operation
6	Quantum model of computation • Quantum gates (one and two qubits gate) • Universal set of quantum gates • Measurements with quantum circuits
7	Exam; Superdense coding
8	Quantum Entanglement

9	Introduction to Quantum algorithms • Phase kick-back • The Deutsch Algorithm • The Deutsch-Jozsa Algorithm • Quantum phase estimation and quantum Fourier Transformation.
10	Introduction to Quantum algorithms • Eigenvalue Estimation and finding orders • Shor's algorithm • Algorithms based on amplitude amplification. Grover's quantum Search algorithm • Search without knowing the success probability.
11	Exam 2. Quantum Error Correction.
12	Statistical Quantum computation.
13	Statistical Quantum computation. Adiabatic Quantum Computation
14	Physical realizations of logic quantum gates in Quantum System (based on homework) • Ion Trap Quantum Computer. • Solid State Spin Quantum Computer. • Superconductor Quantum Computer. • Topological Quantum Computer. • Liquid State Quantum Computer
15	Course project presentation. Final exam

Attendance Policy:
In accordance with college policy, the maximum number of permissible absences is set at 10% of the number of class meetings scheduled for the semester. Absence beyond 10% of the number of class meetings schedule for the semester may result in a "WU" grade.

NEW YORK CITY COLLEGE OF TECHNOLOGY POLICY ON ACADEMIC INTEGRITY

St*u*dents and all others who work with information, ideas, texts, images, music, inventions, and other intellectual property owe their audience and sources accuracy and honesty in using, crediting, and citing sources. As a community of intellectual and professional workers, the College recognizes its responsibility for providing instruction in information literacy and academic integrity, offering models of good practice, and responding vigilantly and appropriately to infractions of academic integrity. Accordingly, academic dishonesty is prohibited in The City University of New York and at New York City College of Technology and is punishable by penalties, including failing grades, suspension, and expulsion. The complete text of the College policy on Academic Integrity may be found in the catalog.

Grading Policy:

A	93-100	C+	77-79.9
A-	90-92.9	C	70-76.9
B+	87-89.9	D	60-69.9
B	83-86.9	F	0-59.9
B-	80-82.9		

Course-specific learning outcomes

Upon completion of this course a student will be able to:

1. Describe the basic principles that underlie quantum computing and gain insights into some of the fascinating revolutions that are currently taking place.
2. Discuss main ideas of quantum computing and quantum algorithms.
3. Explain the physical realizations of logic quantum gates in quantum system.
4. Critically analyze some of the amazing implications of the quantum world for quantum computing.

General education learning outcomes

Upon completion of this course a student will be able to:

1. Describe the elements of the scientific method and its significance to scientific discoveries, the development of models, and the formulation of scientific theories.
2. Employ pictorial, graphical and mathematical methods to simplify and solve problems relevant to real-world applications.
3. Acquire and practice basic laboratory skills including gathering, analyzing and interpreting data.
4. Practice communication and writing skills in class discussions and independent project work.

Pathways learning outcomes

Upon completion of this course a student will be able to:

1. Describe the elements of the scientific method and its significance to scientific discoveries, the development of models, and the formulation of scientific theories.
2. Employ pictorial, graphical and mathematical methods to simplify and solve problems relevant to real-world applications.
3. Acquire and practice basic laboratory skills including gathering, analyzing and interpreting data.
4. Practice communication and writing skills in class discussions and independent project work.

Accessibility Statement

City Tech is committed to supporting the educational goals of enrolled students with disabilities in the areas of enrollment, academic advisement, tutoring, assistive technologies and testing accommodations. If you have or think you may have a disability, you may be eligible for reasonable accommodations or academic adjustments as provided under applicable federal, state and city laws. You may also request services for temporary conditions or medical issues

under certain circumstances. If you have questions about your eligibility or would like to seek accommodation services or academic adjustments, please contact the Center for Student Accessibility by phone 718-260-5143, or online at http://www.citytech.cuny.edu/accessibility/ .