King Fahd University of Petroleum and Minerals

College of Computing and Mathematics

Computer Engineering Department

COE 466: Quantum Architecture & Algorithms

Term 241

Course Information

- Lectures: UTR, 9:00-10:00 AM
- Office hours: UT 10-11 AM (or by appointment)
- Web page:
  - Blackboard page

Course Description

Review on Quantum Mechanics: Vector Space, Superposition; Classical bits, Quantum bits, and quantum states, Quantum circuits and micro-architecture, Programming quantum computers, Quantum protocols, Quantum machine learning, Applications of quantum computing.

Course Objectives

The objective of this course is to

- To provide comprehensive understanding of how quantum computers work from computer science and engineering perspective
- To introduce the state-of-the-art quantum computing tools and technologies

Prerequisites (COE292 Or ICS102 Or ICS103) And (MATH208 Or PHYS210 Or MATH202 Or MATH225)

Textbook

1. T. Wong, 2022. Introduction to Classical and Quantum Computing. Rooted Grove, USA (link)

References

1. Noson S. Yanofsky and Mirco A. Mannucci. 2008. Quantum Computing for Computer Scientists (1st. ed.). Cambridge University Press, USA
2. Johnson, Eric R., Nic Harrigan, and Mercedes Gimeno Segovia. Programming Quantum Computers: Essential Algorithms and Code Samples. O'Reilly Media, Incorporated, 2019.
3. Quantum Computation and Quantum Information: 10th Anniversary Edition by Michael A. Nielsen and Isaac L. Chuang Publisher: Cambridge University Press

Learning Outcomes

After taking this course, students will have the ability to

1. *Identify* the differences between conventional and quantum computing
2. *Explain* the circuits and architecture of quantum computers
3. *Identify potential applications suitable for quantum computers*
4. *Design and implement basic quantum computing applications*

Evaluation (Tentative)

Class Work		40 %
– Class participation	(5%)	
– 4 Homework prog. assignments	(20%)	
– 5 Quizzes	(15%)	
Project		15%
Major Exam (15/10/2024)		20%
Final Exam		25%

List of Topics

The following schedule is **tentative** and subject to changes

List of Topics	Weeks	Contact Hours	Reference
Classical Information and Computing: Bits, Digital gates, and circuits	1	3	Chapter 1
Qubits: Superpositions, measurement, single qubit gates, and circuits	1	3	Chapter 2
Quantum Programming languages: QASM and high-level languages	1	3	Chapter 5
Representing quantum states using linear algebra	1	3	Chapter 3
Multiple qubits: multiple qubit gates, and circuits	2	6	Chapter 4
Entanglement and Quantum Protocols	1	3	Chapter 6
Quantum Algorithms: Oracle-based and procedural	3	9	Chapter 7
Quantum data compression, error correction, and Fault-tolerance.	1	3	Chapter 4
Applications: Quantum Internet, Quantum Key Distribution, Quantum Machine Learning	1	3	Chapter 6
Qubit Control and Measurement: Microwave pulses, qubit characterization	2	6	Handouts/slides
Total	14	42	

Course Policies

- **Coursework includes** participation, online/in-class discussions and activities, attendance, homework assignments, and quizzes. Active learning is implemented in this class. Students are expected to be positively engaged in the learning process.

- **Course Website & Participation:** Students are required to periodically check the course website and download course material as needed
    - Blackboard will be used for communication and interaction, posting and submitting assignments, posting grades, posting sample exams, etc.
    - It is expected that you get benefit of the discussion board by raising questions or answering questions put by others.

- **Attendance:** Regular attendance is a university requirement.
    - Attendance will be checked at each lecture.
    - Missing 20% of the classes will result in an automatic DN grade (without warning).
    - Late arrivals will disrupt the class session, and may be counted as a miss if repeated.
    - If you find yourself unable to attend a class, email the instructor ahead of time for better planning and management of the class. If you fail to do so, send your email as soon as you get a chance and provide your excuses if any.
    - Every unexcused absence may lead to a loss of 0.5% of total grade.

- **Late assignments** are subjected to late-penalty.
    - Late submission will result in deducing 10% per day of the assignment grade. For example, the assignment will be graded out of 80% if the assignment is submitted two days after the due date.

- **Re-grading policy:** if you have a complaint about any of your grades, discuss it with the instructor no later than 3 days of distributing the grades (except for the final). Only legitimate concerns on grading should be discussed.

- **Office Hours:**
    - Students are encouraged to use the office hours to clarify and understand the material. Use the Blackboard (Bb) for quick points and homework questions.
    - For urgent issues, use emails instead of Bb-mails, please indicate COE426 in the "Subject" field of your email (e.g. COE426: Quiz1 score is missing).

- **Academic honesty:**
    - Students are expected to abide by all the university regulations on academic honesty.
    - Cheating will be reported to the Department Chairman.
    - Although collaboration and sharing knowledge is highly encouraged, copying others' work without proper citation, either in part or full, is considered plagiarism. Whenever in doubt, review the university guidelines or consult the instructor.

- **Courtesy:**
    - Students are expected to be courteous toward their classmates and the instructor throughout the duration of this course (in-class and online).
    - Side-talks and text-messages during the class are prohibited.