King Fahd University of Petroleum and Minerals

College of Computing and Mathematics
Computer Engineering Department

COE 530: Quantum Computer and Architecture

Term 252

Course Information

- Lectures: Sunday & Tuesday, 20:10-21:05
- Location: Building 248-125 (HIVE)
- Office hours: UT 6:30-7:30 PM (or send me on Teams and I will try to accommodate your Qs online)

Course Description

Digital logic: logic gates, combinational digital circuits. Computer organization: Instruction set architecture. Quantum gates. Quantum circuits. Quantum architecture. Quantum Programming. Quantum Compilers. Qubit control and measurement. Quantum Benchmarking.

Prerequisites

Graduate level

Course Objectives

The course objectives are to:

- Provide to the students a comprehensive understanding of how quantum computers work from computer science and engineering perspective.
- Introduce to the students to the state-of-the-art quantum computing architecture.

Course Learning Outcomes

After taking this course, students will have the ability to

1. Identify the differences between conventional and quantum computers architecture.
2. Explain the circuits and architecture of quantum computers.
3. Apply qubit control and measurement techniques to enhance the computational capabilities.
4. Implement and test a diverse range of basic quantum computing algorithms.
5. Evaluate and benchmark the performance of quantum computing.
6. Discuss potential applications suitable for quantum computers.

Textbook

1. Hiu Yung Wong, 2025, Quantum Computing Architecture and Hardware for Engineers: Step by Step
2. Marilyn Wolf, 2017, The Physics of Computing.
3. Thomas Wong. 2021. Introduction to Classical and Quantum Computing.
4. Alan Salari, 2023, Microwave Techniques in Superconducting Quantum Computers.

References

1. Johnson, Eric R., Nic Harrigan, and Mercedes Gimeno Segovia. Programming Quantum Computers: Essential Algorithms and Code Samples. O'Reilly Media, Incorporated, 2019.
2. Quantum Computation and Quantum Information: 10th Anniversary Edition by Michael A. Nielsen and Isaac L. Chuang Publisher: Cambridge University Press
3. Yongshan Ding and Frederic T. Chong. Quantum Computer Systems: Research for Noisy Intermediate-Scale Quantum Computers. Synthesis Lectures on Computer Architecture 2020 15:2, 1-227
4. N. David Mermin. 2007. Quantum Computer Science: An Introduction. Cambridge University Press, USA.
5. Heim, B., Soeken, M., Marshall, S. et al. Quantum programming languages. Nat Rev Phys 2, 709–722 (2020). https://doi.org/10.1038/s42254-020-00245-7
6. Noson S. Yanofsky and Mirco A. Mannucci. 2008. Quantum Computing for Computer Scientists (1st. ed.). Cambridge University Press, USA

Evaluation (Tentative)

Prog. assignments	20%	
Quizzes	15%	
Term project	20%	
Midterm Exam	20%	(Week 8)
Final Exam	25%	(Date TBD by registrar)

List of Topics

The following schedule is tentative and subject to changes. More details will be announced in the class and course website/Blackboard.

1. Introduction to digital gates and circuits
2. Computer organization and assembly language
3. Quantum architecture: gates and circuits
4. Programming quantum computers
5. Quantum transpilers
6. Controlling quantum systems: pulse programming, microwave engineering
7. Quantum benchmarking
8. Applications of quantum computing