King Fahd University of Petroleum and Minerals

College of Computer Science and Engineering
Computer Engineering Department

COE 466: Quantum Architecture and Algorithms

Term 201

Course Information

- Lectures: Monday & Wedensday, 12:30-13:45 PM
- "Virtual" office hours: MW 2-3PM for calls on Teams (or send me on Teams and I will try to accommodate your Qs online)
- Web page:
  - Blackboard page
  - https://faculty.kfupm.edu.sa/COE/mfelemban/COE466/201

Course Description

An introduction to the model of quantum computation, quantum processors, quantum circuits and instruction sets, quantum programming languages, quantum Fourier transform, quantum error correction, quantum algorithms, and applications of quantum computing

Course Objectives

The objective of this course is to

- Provide basic understanding of how quantum computers work from computer science and engineering perspective
- Introduce the state-of-the-art architecture and algorithms of quantum computing

Prerequisites COE292 (or ICS 102 or ICS 103) and MATH208 (or PHYS210 or MATH225 or MATH 302)

Textbook

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.

References

3. Quantum Computation and Quantum Information: 10th Anniversary Edition by Michael A. Nielsen and Isaac L. Chuang Publisher: Cambridge University Press
4. Scott Aaronson. 2013. Quantum Computing since Democritus. Cambridge University Press, USA.
5. N. David Mermin. 2007. Quantum Computer Science: An Introduction. Cambridge University Press, USA.

Learning Outcomes

After taking this course, students will have the ability to

1. *Describe* the differences between conventional and quantum computing
2. *Explain* how quantum computers work
3. *Design and implement* basic quantum computing algorithms and applications
4. *Analyse the complexity of* quantum computing algorithms

Evaluation (Tentative)

Course Work		50 %
– Attendance and class participation	(7%)	
– in-class and online discussion	(8%)	
– Homework prog. assignments	(20%)	
– Quizzes	(15%)	
Oral assessment		10%
Major Exam		15%
Final Exam		25%

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 Quantum Mechanics; history and basic concepts, Concept of quantization and quantized states.
2. Linear Vector Space; Matrices and Operators, Tensor Products.
3. Superposition, The Stern-Gerlach experiment and Young's double-slit experiment.
4. Qubits and Quantum States
5. Quantum gates, circuits, and processors.
6. Quantum Programming Languages: Assembly programming and PyQuil.
7. Quantum algorithms: search, factorization, and Fourier transform.
8. Quantum data compression, error correction, and Fault-tolerance.
9. Quantum machine learning.
10. Applications: Quantum Internet, Quantum Key Distribution.

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.