SJSU SAN JOSÉ STATE UNIVERSITY

Charles W Davidson College of Engineering · Electrical Engineering

Quantum Computing Architectures Section 01

EE 274

Spring 2025 3 Unit(s) 01/23/2025 to 05/12/2025 Modified 01/11/2025

Contact Information

Instructor:	Dr. Hiu Yung Wong
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Office Hours:	Thursdays 6:30pm-7:30 pm or email for appointment

Course Description and Requisites

Introduces the hardware implementations of qubits. Josephson Junction superconducting qubit, spin qubit in quantum dots, trapped ion qubit, photonic qubit, and other types of physical qubits will be discussed. The manipulation and read-out techniques of the qubits will be covered.

Prerequisite(s): EE 225 or PHYS 161 or instructor approval.

Letter Graded

Classroom Protocols

Students are required to be in class on time and no use of cell phone during the class.

Course Learning Outcomes (CLOs)

CLO1: Differentiate the pros and cons of various physical qubits

CLO2: Solve superconducting quantum circuit using the abstraction in circuit quantum electrodynamic

CLO3: Explain the physical mechanisms of qubit manipulation and read-out in various architectures

CLO4: Design quantum circuit using Computer-Aided-Design (CAD) tools

Course Materials

Textbook

- Quantum Computing Architecture and Hardware for Engineers. Hiu Yung Wong, Springer International Publishing, 2025. (Connect to SJSU VPN and can be downloaded from https://link.springer.com/book/9783031782183 (https://link.springer.com/book/9783031782183))
- Introduction to Quantum Computing: From a Layperson to a Programmer in 30 Steps. Hiu Yung Wong, Springer International Publishing, 2024. (Connect to SJSU VPN and can be downloaded from https://link.springer.com/book/10.1007/978-3-031-36985-8 (https://link.springer.com/book/10.1007/978-3-031-36985-8))

Other Recommended Readings

Quantum Mechanics:

- Modern Quantum Mechanics, J. J. Sakurai and J.J. Napolitano, Cambridge University Press, 2017 (available as a print book in SJSU library).

Physics of Qubit Elements:

- Quantum Information and Quantum Optics with Superconducting Circuits, Juan Jose Garcia Ripoll, Cambridge University Press, 2022.
- Atomic Physics, C. J. Foot, Oxford University Press, 2005 (eBook available in our library).
- Quantum Transport: Introduction to Nanoscience, Y. V. Nazarov and Y. M. Blanter, Cambridge University Press, 2009. (available in both a print and multi-user e-book version through the SJSU library collection)
- Introduction to Superconducting Circuits, A. M. Kadin, John Wiley & Sons, 1998

Quantum Computing Theory and Algorithms:

- Quantum Computer Science: An Introduction, N.D. Mermin, 2016.
- Quantum Computation and Quantum Information: 10th Anniversary Edition, M. Nielson and I. Chang, Cambridge University Press, 2011 (available as a print book in SJSU library).

Library Liaison: Jane Dodge: jane.dodge@sjsu.edu

Course Requirements and Assignments

Prerequisites:	EE225 or PHYS 161 or instructor approval

Faculty Web Page and MYSJSU Messaging

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on Canvas Learning Management System course login website at http://sjsu.instructure.com. You are responsible for regularly checking with the messaging system through MySJSU on Spartan App Portal http://one.sjsu.edu to learn of any updates. For help with using Canvas see Canvas Student Resources page.

Course Requirements and Assignments

Students are expected to attend all classes and participate actively in the seminar, submit the assignments and project reports on time and attend the mid-term and final exams. Assignments and Project Reports must be submitted on time to receive full credit. Late submission of Assignments and Project Reports within 3 days after the due date will only receive half of the credits. No credits will be given after the late submission due date.

Review the following policy about your responsibility:

- Office of Graduate and Undergraduate Programs' Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/

"Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally three hours per unit per week) for instruction, preparation/studying, or course related activities, including but not limited to internships, labs, and clinical practica. Other course structures will have equivalent workload expectations as described in the syllabus."

Course Project

Students will use Qiskit Metal with HFSS to design and optimize superconducting qubit circuits.

Grading Information

Final Examination or Evaluation

Students are allowed to bring a calculator and a page of aid sheet. There will be no make-up exam and those absent will receive no credit. Students must write their answers clearly in an organized fashion. Further instructions will be provided during exams. The course is based on letter grading and the grading percentage breakdown is as follow:

Grading Information

Assignment 40%

Midterm Exam 15%

Final Exam 20%

Project 25%

Determination of Grades

- Every assignment has equal weight (totally 30% of the final score)
- Assignment and Project reports must be submitted on time to receive full credit. Late submission: Half of the credit will be given if submitted within 3 days after the due date. No credit will be given if submitted after the late submission due date.

Grading Breakdown:

A = 100 to 93 points

A minus = 92 to 88 points

B plus = 87 to 84 points

B = 83 to 79 points

B minus = 78 to 75 points

C plus = 74 to 72 points

C = 71 to 69 points

C minus = 68 to 65 points

D plus = 64 to 62 points

D = 61 to 59 points

D minus = 58 to 55 points

F = 55 points or lower

EE Department Honor Code

The Electrical Engineering Department will enforce the following Honor Code that must be read and accepted by all students.

"I have read the Honor Code and agree with its provisions. My continued enrollment in this course constitutes full acceptance of this code. I will NOT:

- Take an exam in place of someone else, or have someone take an exam in my place
- Give information or receive information from another person during an exam
- Use more reference material during an exam than is allowed by the instructor
- Obtain a copy of an exam prior to the time it is given
- Alter an exam after it has been graded and then return it to the instructor for re-grading
- Leave the exam room without returning the exam to the instructor."

Measures Dealing with Occurrences of Cheating

- Department policy mandates that the student or students involved in cheating will receive an "F" on that evaluation instrument (paper, exam, project, homework, etc.) and will be reported to the Department and the University.

• A student's second offense in any course will result in a Department recommendation of suspension from the University.

University Policies

Per University Policy S16-9 (PDF) (http://www.sjsu.edu/senate/docs/S16-9.pdf), relevant university policy concerning all courses, such as student responsibilities, academic integrity, accommodations, dropping and adding, consent for recording of class, etc. and available student services (e.g. learning assistance, counseling, and other resources) are listed on the Syllabus Information (https://www.sjsu.edu/curriculum/courses/syllabus-info.php) web page. Make sure to visit this page to review and be aware of these university policies and resources.

Course Schedule

Class Days/Time:	TuTh 7:30PM - 8:45PM
Classroom:	Engineering Building 403

****The schedule is subject to change with advance notice on Canvas.*

Week		Seminar	Assignment	Project
1	21-Jan	No Class		
	23-Jan	Introduction		
2	28-Jan	Review of Linear Algebra		
	30-Jan	Review of Quantum Gates		
3	4-Feb	Pauli Matrix and Density Matrix		
	6-Feb	Density Matrix		
4	11-Feb	Block Sphere		
	13-Feb	Bloch Sphere and Density Matrix and Decoherence		
5	18-Feb	Spin in an external Magnetic Field		
	20-Feb	Spin in an external Magnetic Field	Assignment 1 due on 2/23	
6	25-Feb	Spin in external Magnetic Field: Rabi Oscillation		
	27-Feb	Spin in External Magnetic Field: Formalism		
7	4-Mar	Spin in rotation magnetic field		
	6-Mar	Spin Qubit	Assignment 2 due on 3/9	
8	11-Mar	Spin Qubit		
	13-Mar	Midterm		

9	18-Mar	Midterm Review and 2 qubit gate		
	20-Mar	Lagrangian, Hamiltonian, Quantization of SHO		Project Start
10	25-Mar	Superconducting devices, Second quantization and Circuit QED		
	27-Mar	Second quantization, Superconducting devices		
11	1-Apr	Spring Recess		
	3-Apr	Spring Recess		
12	8-Apr	Quantization of LC Tank		
	10-Apr	Cooper Pair Box Quantization	Assignment 3 due on 4/13	
13	15-Apr	Cooper Pair In a Box		
	17-Apr	Charge Qubit		
14	22-Apr	EPR		
	24-Apr	SC qubit gates		
15	29-Apr	Microwave components		
	1-May	Trapped Ions		
16	6-May	Photonic Qubit		
	8-May	Quantum Error Correction	Assignment 4 due on 5/4	Project due
Final Exam	20-May	Tuesday, May 20, 7:45-9:45 PM		