

**San José State University**  
**Department of Electrical Engineering**  
**EE 226, Cryogenic Nanoelectronics, Section 1, Spring 2022**

**Course and Contact Information**

Instructor:	Dr. Hiu Yung Wong
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Office Hours:	Mon: 9:00am-10:30am, Wed: 4:15pm-5:45pm, or by appointment
Class Days/Time:	Monday and Wednesday 3:00 pm-4:15 pm
Classroom:	ENG 401
Prerequisites:	Graduate students or with instructor consent

**Course Format**

**Faculty Web Page and MYSJSU Messaging**

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on the [Canvas Learning Management System course login website](http://sjsu.instructure.com) at <http://sjsu.instructure.com>. You are responsible for regularly checking with your official email (the email address stored on your MySJSU account) and the messaging system through [MySJSU](http://my.sjsu.edu) at <http://my.sjsu.edu> (or other communication systems as indicated by the instructor) to learn of any updates.

**Course Description**

This course introduces the cryogenic electronics and circuits used in emerging technologies, such as quantum computers. Basic technologies to achieve a cryogenic environment will be introduced followed by a review of Complementary Metal-Oxide-Semiconductor (CMOS) device physics. Silicon and other semiconductor cryogenic properties will then be discussed. Device properties at cryogenic temperatures including quantum effects will also be discussed. The class will then cover semiconductor quantum dot qubit and the readout and control device and circuits. Finally, Josephson Junction and Rapid Single Flux Quantum (RSFQ) circuits will be discussed. Students will design a quantum computer peripheral circuit in the class project.

**Course Learning Outcomes (CLO)**

CLO1: Able to describe the technical challenges and opportunities in cryogenic electronics

CLO2: Able to describe the new device physical phenomena appear at cryogenic temperature

CLO3: Able to describe how to manipulate quantum computer qubit with CMOS compatible circuits

CLO4: Able to contrast the difference between room temperature and cryogenic temperature devices and circuits

CLO5: Able to describe the operating principles of RSFQ circuits and their advantages and disadvantages

Upon successful completion of this course, students will be able to:

1. Demonstrate an understanding of the fundamentals of Electrical Engineering, including its mathematical and scientific principles, analysis, and design.
2. Demonstrate the ability to apply the practice of Engineering in real-world problems.

## Required Texts/Readings

### Textbook

- No textbook required. Use lecture notes.

### Other Readings

- Practical Cryogenics: An Introduction to Laboratory Cryogenics, Nicholas Howard Balshaw, Oxford Instruments (UK), 1996.
- 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)
- Principles of Superconductive Devices and Circuits, Theodore Van Duzer, Pearson; 2nd edition (January 6, 2008)
- Device and Circuit Cryogenic Operation for Low Temperature Electronics, Editors: Balestra, Francis, Ghibaud, G. (Eds.), Springer US, 2001
- Introduction to Superconducting Circuits, A. M. Kadin, John Wiley & Sons, 1998

**Library Liaison:** Rachel Silverstein, [rachel.silverstein@sjsu.edu](mailto:rachel.silverstein@sjsu.edu)

## 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.”

## Final Examination or Evaluation

Exams will be closed book. However, 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	30%
Midterm Exam	20%
Final Exam	20%
Project	30%

## 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

## Classroom Protocol

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

## University Policies

Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs' [Syllabus Information web page](http://www.sjsu.edu/gup/syllabusinfo/) at <http://www.sjsu.edu/gup/syllabusinfo/>"

## 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.

# EE 226, Cryogenic Devices and Integrated Circuits, Spring 2022\*\*\*

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

Week	Class	Seminar	Assignment	Project
1	1	Introduction/ Cryogenic Basics		
	2	Cryogenic Basics		
2	1	Review of CMOS Device Physics		
	2	Review of CMOS Device Physics		
3	1	Review of CMOS Device Physics	Assignment 1 due	
	2	Review of CMOS Device Physics		
4	1	Cryogenic Material Properties (Bandgap, mobility, etc.)		
	2	Cryogenic Material Properties (Bandgap, mobility, etc.)		
5	1	Carrier Freezeout/ Mott Transition/ Field ionization		
	2	Carrier Freezeout/ Mott Transition/ Field ionization	Assignment 2 due	
6	1	Subthreshold Swing, Threshold Voltage, Kink Effect		
	2	Subthreshold Swing, Threshold Voltage, Kink Effect		
7	1	Quantum Effect		
	2	Quantum Effect		
8	1	Review	Assignment 3 due	
	2	Midterm		
9	1	Semiconductor qubit and Quantum Dot		
	2	Semiconductor qubit and Quantum Dot		
10	1	Spring Recess		
	2	Spring Recess		
11	1	Qubit Control Device/Circuits		
	2	Qubit Control Device/Circuits		
12	1	Qubit Sensing Device/Circuits		

	2	Qubit Sensing Device/Circuits		
13	1	Josephson Junction	Assignment 4 due	
	2	Josephson Junction		
14	1	RSFQ Circuit		
	2	RSFQ Circuit		
15	1	RSFQ Circuit		
	2	RSFQ Circuit		Project Due
16	1	Review		
	2	Final Exam		