Syllabus: CS 639 - Systems Architecture for Quantum Computers

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Course Description

This course delves into the systems architecture of quantum computers, emphasizing the software system stack, programming models, and hardware architecture. The course combines theoretical foundations with practical applications through homework assignments and a group project.

Instructor Information

- **Instructor:** Swamit Tannu
  Email: swamit@cs.wisc.edu

  Office- CS 6373
- **Office Hours:** Thursdays 10 – 11.30 AM over Zoom (More info on Canvas)

Course Details

- **Time:** Tuesdays and Thursdays, 1:00 PM – 2:15 PM
- **Location:** ENGR HALL 2317
- **Prerequisites:** CS/ECE 252, MATH 340, or equivalent courses

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Weekly Schedule and Topics

Week Number	Date	Topic/Instructor	Date	Topic/Instructor	Homework
Week 1	21-Jan-25	Intro and Logistics	23-Jan-25	Superposition	
Week 2	28-Jan-25	Qiskit Tutorial + Quantum Circuits	30-Jan-25	Entanglement	
Week 3	4-Feb-25	Noise on Quantum Computers	6-Feb-25	Quantum Simulators	HW1 Due (15%)
Week 4	11-Feb-25	Building Quantum Functions	13-Feb-25	Grover's Algorithm	
Week 5	18-Feb-25	Quantum Fourier Transform	20-Feb-25	Variational Quantum Algorithms-I	HW2 Due (10%)

Week 6	25-Feb-25	Variational Quantum Algorithms-II	27-Feb-25	Intro to Quantum Compilers	
Week 7	4-Mar-25	Quantum Circuit Optimizations	6-Mar-25	Moving Data on Quantum Computers	
Week 8	11-Mar-25	Noise Mitigation	13-Mar-25	Quantum Control Architecture-I	HW3 Due (15%)
Week 9	18-Mar-25	Quantum ISA	20-Mar-25	Project Ideation and Planning	
Spring Break	Mar 22 – 30	**No Classes**			
Week 10	1-Apr-25	Quantum Control Architecture-II	3-Apr-25	Quantum Error Correction (QEC)	HW4 Due (15%)
Week 11	8-Apr-25	QEC Decoders	10-Apr-25	Fault-Tolerant Quantum Computer (FTQC) Architecture	
Week 12	15-Apr-25	Universality + FTQC Synthesis	17-Apr-25	FTQC Resource Estimation	
Week 13	22-Apr-25	FTQC Mapping and Routing	24-Apr-25	Challenges in Realizing QEC	
Week 14	29-Apr-25	Project Presentation	1-May-25	Project Presentation	Slides + Q&A (15%)

Assessments

1. **Homework (55%)**
    - Individual assessments distributed throughout the semester.
2. **Group Project or Literature Survey (35%)**
    - Topics may include quantum compilation, control architecture, or quantum systems.
    - Deliverables include a written report and a class presentation.
3. **Class Participation (10%)**
    - Engagement with instructors, TAs, and peers (including contributions on Piazza).

Grading Breakdown

Assessment	Weight
Homework Assignments	55%
Group Project/Survey	35%
Class Participation	10%

Grade cutoffs -

A ~91+

AB ~85+

B ~80+

BC ~75+

C ~70+

We will use relative grading in this class, so the point thresholds are approximate and can move by up to 2% in a positive or negative direction.

Course Policies

- **Late Submissions:** Late homework submissions will incur a penalty of 10% per day for up to two days. After two days, submissions will not be accepted.
- **Collaboration:** Discussions are encouraged, but all submitted work must reflect individual understanding.
- **Honor Code:** All students are expected to uphold the University of Wisconsin Student Honor Code. Instances of plagiarism or academic dishonesty will result in disciplinary action.
- Collaboration:

You are encouraged to discuss the questions with classmates, people online, or even tools like ChatGPT.

- Academic Integrity:

Copy-pasting answers without understanding them is strictly prohibited and violates the University of Wisconsin Student Honor Code.

- Accountability:

Instructors may ask you to clarify your submissions to ensure you understand the underlying concepts. Failure to explain your answers will be treated as a violation of the honor code.

Resources and Tools

- **Programming Framework:** Qiskit (installation and tutorials will be provided).
- **Canvas & Piazza:** Course announcements, Q&A, and discussions.
- **Office Hours:** Thursdays 10.00 AM to 11.30 AM over Zoom (More details on Canvas).

Contact Information

- For course-related queries, email the instructor at **swamit@cs.wisc.edu**.