CSE439 Course Information Fall 2026

Instructor:

Dr. Kenneth W. Regan, 326 Davis Hall, 645-4738, `regan@buffalo.edu`

Office Hours:

Regan, Tue. 2–3pm (after class), Wednesdays 1–3pm, Fridays 1–2pm.

Lectures:

TuTh 12:30–1:50pm, in Alumni 88.

Examinations:

- Two *prelims*, the first on **Thu., 10/8**, in class period.
- One *cumulative* 3-hr. final.

1 Required Reading

(1) Text: R.J. Lipton and K.W. Regan, *Introduction to Quantum Computing Via Linear Algebra*, MIT Press. Second Edition 2020. *Intended coverage:* Chapters 1–14, plus section 18.1, possibly excepting chapter 12.

(2) Supplemental materials on linear algebra in scientific computing, TBA (will be freely given).

(3) The *CSE439 Piazza page*. Although all official course information will be given in lectures, you may catch it first here, as well as information about the problem sets. Students are invited to post queries of general interest. Please do not, however, post answers unless and until cleared with the instructor.

(4) There will also be an *Autolab* page, primarily for grading...

(5) The *course webpage* will be for "static" information: syllabus info and notes and posted problem sets and answer keys, material that can be relied on not to change.

2 Organization and Course Policies

Homework will consist solely of biweekly problem sets—all due on *Thursdays* (midnight "stretchy") unless circumstances intervene. There are no programming projects or labs, but some homework exercises will involve one or (choice of) more quantum circuit simulators.

Assignments must be submitted *as PDF files* (not MS Word files) in order to work with *CSE Autograder*. All submissions must have your *name and ID#* on them. They must be clearly legible on the PDF.

My (KWR) general policy is that *late work is not acceptable*. In return, you get an answer key shortly afterward, and a relatively quick turnaround of graded work before the next problem set is due. In an exceptional situation, you may contact me *beforehand* about a possible extension.

The course will be graded on a total-points system. Letter grades will also be given for individual exams and some assignments, as a help in telling you where you stand, but only the point totals will have official significance. The weighting of grades in this course is:

Homework:	35%
Prelims:	30%
Final:	35%

Instructors reserve the right to 5% leeway in weighting while assigning the final letter grade. This is most typically done for students who do markedly well on the final exam, when it may be treated as if it were worth 40% for that student. This will only be done to an individual student's advantage, and will have no effect on others' grades. Academic honesty and attendance are two prerequisites for this policy to be applicable.

Homework and all exams are designed for a curve with $\geq$ 90% = A, 84–89% = A-, 78–83 = B+, 72–77% = B, 66–71% = B-, 60–65% = C+, 54–59% = C, 48–53% = C-, 42–47% = D+, 36–41% = D, and $<$ 36% = F. Grades will be "curved" only if something systematic happens to make clear that expectations on a problem were misplaced or snow happened or the allocated time was too short. Having course points sum to 667 makes the thresholds for the final course grades into nice, round numbers: 600/667 for an A, 560 for an A-, 520 for a B+, 480 for a B, 440 for a B-, 400 for a C+, 360 for a C, 320 for a C-, 280 for a D+, and 240 for a D and a pass.

2.1 Goals and Outcomes

The highlights of the course are the classic quantum algorithms and applications: Deutsch(-Jozsa)'s and for proven but conditional quantum advantage, Shor's for a proven algorithm with unconditional and spectacular but unproven quantum advantage, Grover's for moderate advantage (that I think is illusory), and the CHSH Game—which recently won a Nobel Prize for *experimentally proven* quantum advantage. Also quantum teleportation, "superdense coding" (which is definitely illusory), what can and cannot be cloned, and other shorter topics. The course will stop short of covering quantum information theory, quantum error-correction, secure key transfer, quantum walks, and the Harrow-Hassidim-Lloyd (HHL) algorithm (the last two are later advanced chapters in the text).

A running theme will be attempts to simulate quantum systems classically. The notion of "quantum advantage" is measured against such attempts. A classically-feasible emulation of Shor's algorithm would, to be sure, break most of the world's currently installed cryptography. This will segue into the treatment of classical linear algebra methods in the final weeks, including the Singular Value Decomposition (SVD). Tensor networks and the power of AI systems may also come into play here.

The goals are aligned with the ABET criteria (1) "Analyze a complex computing problem and apply principles of computing and other relevant disciplines to identify solutions," and (2) "Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline." The problems in this course are intrinsically "complex" in the sense that quantum mechanics is; they begin as small and simple as possible but progress to the larger-scale applications named above. We also reference the criterion numbered 6 in section 4 of https://cse.buffalo.edu/~knepley/classes/cse439/Syllabus.html) for CSE396 and related theory courses: at the end you should be able to "apply mathematical foundations, algorithmic principles, and CS theory to model and design systems"—in particular quantum systems—"with comprehension of the tradeoffs involved in design choices."

Under the umbrella of these criteria, specific goals and abilities within the course include: constructing basic quantum circuits, expressing their operation using linear algebra, expressing their results using Boolean logic, analyzing the correctness and complexity of the larger quantum algorithms, and understanding and critquing the extent to which they provide *quantum advantage* for solving certain important computational problems. All course assignments and examinations involve one or more of these elements. A further indirect goal is competency to use quantum-modeling software and interfaces, such as IBM's *Qiskit*, while instruction will feature the Wybiral and *Quirk* quantum circuit simulators. Finally, ABET outcome (3) "Communicate effectively in a variety of professional contexts," is addressed by the course's attention to physics (Chapter 14), the use of simulation software, critical evaluation of quantum performance, and the final weeks on classical linear algebraic methods and their potential to "de-quantize" applications.

2.2 Academic Honesty

A university is a *community*, and every community has values and rules that go hand-in-hand with membership in the community. At universities one rule is the standard of *academic honesty* as it has been understood and followed for **all** of the past millennium. This rule is not written down in a standard text such as Magna Carta or the Constitution, but is the same for every educational institution even though they all have individual statements of it. At bottom it is *honesty*. Different cultures and institutions may have different rules and expectations, but all have the principle of abiding by the local rules, and of not misrepresenting the nature of one's work. Students are required to read and abide by the University and CSE statements of the rules:

https://catalogs.buffalo.edu/content.php?catoid=17&navoid=863#academic-integrity

engineering.buffalo.edu/computer-science-engineering/information-for-students/undergraduate-program/cse-undergraduate-academic-policies/cse-academic-integrity-policy.html

In this course, all assignments will be individual, and the *rule* takes a particularly simple form: All assignments must be *your own work*. This term does not need a definition or legal parsing. Tens of thousands have graduated from my *alma mater* with no exam proctors or vetting, just needing to sign "This represents my own work in accordance with University regulations" on every exam paper or major submission. The only difficulty is for those actively (and quite justifiably) seeking help on assignments. The Department has a reasonable guideline tailored to programming projects at the above URL. Note that it is absolute that *writeups* of assignments must be completely your own production—in this course that is especially meaningful because *formal presentation* of solutions is an important course subject and goal in itself. I will talk about "reasonable discussion" of problems in class at some convenient and good time.

Well over half the cheating I used to catch on single problem sets were [*claimed to be*] one student copying off another who couldn't attend class and asked the "trusted friend" to submit for him/her. In such cases the University considers *both* students to be culpable, and my measures reflect this policy. There can be some leniency for "first offenses," but anything more serious is liable for an automatic F in the course and/or explusion from the Department (*cum*-University). The use of *Autograder* obviates this mechanism, but the philosophy remains. The much more serious recent technological development is students sending photos of their work to other students via smartphone—then the guilt of the enabler is sharper.

2.3 Policy on Improper Distribution of Material

All materials prepared and/or assigned by me for this course are for the students' educational benefit. Other than for permitted collaborative work, students may not photograph, record, reproduce, transmit, distribute, upload, sell or exchange course materials, without my prior written permission. This especially goes to say that answer keys—which will be given by non-public links—may not be uploaded to "course helper" sites. But the prohibition applies also to lecture notes (even though posted in public), discussion prompts, study aids, posted sample tests, and any other course-specific presentation materials, packets, or handouts. Violation of this policy may not only subject a student to a finding of "academic dishonesty" under the Academic Integrity policy and/or disciplinary charges under the Student Code of Conduct, but also constitute copyright infringement in violation of federal or state law..

2.4 Medical Emergencies

Accommodations for medical emergencies will be made on a case-by-case basis. Requests for extensions based on medical emergencies must be accompanied by documentation of the emergency from student health services, for which see

http://www.buffalo.edu/studentlife/who-we-are/departments/health.html.

2.5 Accessibility Resources

If you have any disability which requires reasonable accommodations to enable you to participate in this course, please contact the Office of Accessibility Resources in 60 Capen Hall, 716-645-2608 and also the instructor of this course during the first week of class. The office will provide you with information and review appropriate arrangements for reasonable accommodations, which can be found on the web at: http://www.buffalo.edu/studentlife/who-we-are/departments/accessibility.html.

2.6 Incompletes and Withdrawals

This course shall follow strictly the University's standard for incompletes: they are only to make up work missed owing to circumstances beyond a student's control, and they are given only when a student has enough points to pass the course with already-completed work (i.e., no "I/F" grades). An "Administrative Withdrawal" after the "R" date is available only to students who withdraw from *all* their courses in a given term.

3 Chapters Covered

The textbook was originally conceived as the shortest path to Simon's, Shor's, and Grover's algorithms using only linear algebra and basic numerical analysis: no physics concepts or notation, not even quantum circuits. It was to be a 60–80 page "Springer Brief." MIT Press gave a better deal and concept for an under-200-page text that included quantum circuits and advanced algorithms building on quantum walks. The Second Edition added physics coverage and the HHL Algorithm.

In keeping with the general role of quantum computing and partnerships across the University (and SUNY on the whole), this course will yes teach the physics side. The first half of Chapter 14 will be blended into the basic chapters 1–4. The coverage will also emphasize linear algebra topics that arise, even before the coverage of the Spectral Theorem and SVD. Shor's Algorithm may be skimmed more than in past terms, in order to make more time for tensor networks and/or other recent developments at the end.

Accordingly, the coverage is chapters 1–11 and 14 interleaved, skim/skipping chapter 12 but including 13, and then supplemental notes on classical linear algebra and the SVD.