

Santa Clara University
Department of Electrical and Computer Engineering
Aleksandar I. Zecevic
Fall 2023

ELEN 162: Quantum and Parallel Algorithms for Scientific Computing
TEXT: Aleksandar Zecevic, *Quantum and Parallel Computing: A Tale of Two Paradigms*, Amazon KDP, 2022. ISBN: 979-8788504056

SYLLABUS

WEEK	TOPICS	CHAPTER
1	Review of linear algebra and matrix theory	1
2	Matrix norms and functions of matrices	1
	Overview of functional analysis	1
3	Basic principles of quantum mechanics	2
4	Quantum gates	3
	Deutsch's and Grover's algorithm	4
5	Quantum Fourier transforms and eigenvalue estimation	4
6	Introduction to Number theory	5
	Cryptology and public key encryption	
MIDTERM		
7	The order finding problem	6
	Quantum algorithm for prime factorization	6
8	Fundamentals of parallel computing	8
	Parallel algorithms for solving large systems of equations	9
9	Sparse matrices and elimination graphs	9
	The minimal degree ordering	9
	Decomposition algorithms	9
10	Iterative methods and their parallelization	10

LEARNING OUTCOMES

Students who successfully complete this course should be able to:

1. Understand the basic principles of quantum mechanics and their application to quantum computing.
2. Describe the operation of basic quantum gates.
3. Understand number theoretic concepts and results that pertain to order finding and public key encryption
4. Apply quantum algorithms to solve the order finding problem, and determine prime factors of large numbers.
5. Distinguish between different types of parallel architectures and describe how they handle inter-processor communications.
6. Apply elimination graphs and the minimal degree algorithm to optimize the LU factorization of sparse matrices.
7. Apply graph theoretic decomposition algorithms to parallelize the solution of large sparse system of equations.
8. Compare different iterative techniques and evaluate their suitability for parallel computing.

GRADING

The course grade will be based on four criteria – homework, midterms, projects and the final exam.

Homework:	30%
Midterm:	35%
Project 1:	20%
Project 2:	15%

LABS

The lab component of this course consists of two projects. The work should be done by teams of two students, and each team should submit a *single* project report. Since these projects are an integral part of the course (and represent 35% of the overall course grade), the lab grade will be the same as the grade for the lecture portion of the course.

GENERAL INFORMATION

OFFICE:	SCDI 4025 – O
OFFICE HOURS:	Tuesdays and Thursdays, 4:00-5:00, and by appointment.
PHONE:	(408) 554-2394
E-MAIL:	azecevic@scu.edu
WEBSITE:	http://www.engr.scu.edu/~azecevic/

Academic Integrity Pledge:

The Academic Integrity pledge is an expression of the University's commitment to fostering an understanding of—and commitment to—a culture of integrity at Santa Clara University. The Academic Integrity pledge, which applies to all students, states:

“I am committed to being a person of integrity. I pledge, as a member of the Santa Clara University community, to abide by and uphold the standards of academic integrity contained in the Student Conduct Code.”

Academic integrity is part of your intellectual, ethical, and professional development. I expect you to uphold the principles of this pledge for all work in this class. I will clarify expectations on academic integrity as needed for assignments and exams. If you have questions about what is appropriate on any assignment, please let me know before you hand in work. For more resources about ensuring academic integrity in your work, including the appropriate use of course sharing sites such as Chegg, see this site created by the SCU Library at <https://libguides.scu.edu/academic-integrity> or visit www.scu.edu/academic-integrity.

Safety Measures

In order to meet our learning objectives, we will adhere to the highest standards for safety and mutual respect. I expect everyone to adhere to current university mask mandates at all times; to make their best attempt to make themselves heard when asking questions or contributing to discussions; and refrain from eating or drinking in class. It is expected that everyone will follow university guidelines about health and public safety measures outlined in the emails that was sent to students and their families on August 31, 2021.

Office of Accessible Education

If you have a documented disability for which accommodations may be required in this class, please contact the Office of Accessible Education (oea@scu.edu, <http://www.scu.edu/oea>) as soon as possible to discuss your needs and register for accommodations with the University. If you have already arranged accommodations through OAE, please be sure to request your accommodations through your myOAE portal and discuss them with me during my office hours within the first two weeks of class.

To ensure fairness and consistency, individual faculty members are required to receive verification from the Office of Accessible Education before providing accommodations. OAE will work with students and faculty to arrange proctored exams for students whose accommodations include double time for exams and/or assistive technology. Students with approved accommodations of time-and-a-half should talk with me as soon as possible. The Office of Accessible Education must be contacted in advance

(at least two weeks notice recommended) to schedule proctored examinations or to arrange other accommodations.

In light of shifting health advisories related to COVID-19, exams may be administered online. Students with approved testing accommodations should contact me (at least two weeks notice recommended) prior to an exam date to notify me of their intent to use their testing accommodations on the upcoming exam to ensure their accommodations are effectively implemented.

Discrimination, Harassment and Sexual Misconduct (Title IX)

Santa Clara University is committed to providing a safe learning environment for all students that is free of all forms of discrimination, sexual harassment, and sexual violence. SCU has dedicated staff trained to support you in navigating campus resources, accessing health and counseling services, providing academic and housing accommodations, helping with legal protective orders, and filing a formal complaint with the university or with law enforcement. Here are key resources:

Confidential Survivor Advocate, (408) 551-3307;
Counseling & Psychological Services (CAPS), (408) 554-4501; and
Equal Opportunity and Title IX Office, (408) 551-3043.

Wellness Statement and Mental Health Resources

Jesuit education is grounded in concern for the whole person—mind, body, and spirit—and SCU has many resources and programs to support you. Resources that assist with mental wellness and mindfulness can be found through the Cowell Center and Campus Ministry, to name but a few.

University students may experience stressors or setbacks from time to time that can impact both their academic experience and their personal well-being. These may include academic pressure or challenges associated with relationships, mental health, alcohol or other drugs, identities, finances, etc.

If you are experiencing difficulties, seeking help is a courageous thing to do for yourself and those who care about you. If you are concerned with your progress in this class, please contact me so that we can find solutions together. Drahnman Center can also offer support with issues regarding your academic progress more broadly. For personal concerns, SCU offers many resources, some of which are listed on the Cowell Center website.