

# CMSC 491

## Introduction to Quantum Computation and Information Syllabus

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<b>Catalog listing:</b>	CMSC 491
<b>Course Level:</b>	Undergraduate
<b>Prerequisites:</b>	MATH 310 with a C or better, and CMSC 401 with a C or better
<b>Instructor:</b>	Dr. Sevag Gharibian
<b>Office:</b>	E4240
<b>Phone:</b>	804-828-0407
<b>Email:</b>	sgharibian@vcu.edu
<b>Classroom:</b>	E1232
<b>Class website:</b>	<a href="http://www.people.vcu.edu/~sgharibian/courses/CMSC491/CMSC491.html">http://www.people.vcu.edu/~sgharibian/courses/CMSC491/CMSC491.html</a>
<b>Office Hours:</b>	TR 9:30-10:30

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### 1.0 – Overview (Catalog Course Description):

Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 401 with a grade of C or better and MATH 310 with a grade of C or better. Introduction to quantum mechanics; state vectors, density matrices, distance measures, no-cloning theorem. Quantum entanglement and non-local games. Quantum algorithms; teleportation, Deutsch's algorithm, Simon's algorithm, Shor's factoring algorithm, Grover's search algorithm. Quantum error correction. Physical implementations. Quantum complexity theory; Quantum Merlin Arthur, local Hamiltonians.

### 2.0 – Course Structure:

Lecture hours/week – 3

### 3.0 – Course Goals

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

- Describe and apply the four postulates of quantum mechanics.
- Design and analyze basic to advanced quantum algorithms.

- Apply the theory of error-correcting codes, both classical and quantum.
- Distinguish between types of quantum correlations, such as entanglement and non-locality.
- Prove that certain problems are hard for quantum complexity classes.

#### **4.0 – ABET Criteria Addressed:**

- a. An ability to apply knowledge of computing and mathematics appropriate to the program's student outcomes and to the discipline.
- b. An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution.
- c. An understanding of professional, ethical, legal, security and social issues and responsibilities.

#### **5.0 – Major Topics Covered:**

- Quantum mechanics; state vectors, density matrices, distance measures, no-cloning theorem.
- Quantum entanglement and non-locality; pure state versus mixed state separability, CHSH inequality, Werner States.
- Quantum algorithms; teleportation, Deutsch's algorithm, Simon's algorithm, factoring, unstructured search.
- Quantum error-correcting codes; stabilizer codes.
- Implementations of quantum computers.
- Quantum complexity theory; Quantum Merlin-Arthur, local Hamiltonians.

#### **6.0 – Textbook(s):**

Quantum Computation and Quantum Information, Nielsen and Chuang

#### **7.0 – Class Schedule:**

- Lecture: TR 12:30 pm – 1:45 pm, Engineering East Hall, Room E1232
- Midterm Exam: TBA
- Final Exam: Thursday, December 10, 1-3:50 pm, in class (E1232)

#### **8.0 – Evaluation:**

##### **General Instructions:**

*Attendance policy:*

I do not plan to associate grades with whether or not you attend class, unless a serious problem with attendance develops.

The grading scheme is below:

**Grading:**

Category	% weight
Problem sets	60%
Midterm	20%
Final exam	20%

Grading scheme:

- A:  $\geq 85\%$
- B:  $\geq 75\%$  and  $< 85\%$
- C:  $\geq 65\%$  and  $< 75\%$
- D:  $\geq 50\%$  and  $< 65\%$
- F:  $< 50\%$

**Collaboration and Cheating Policy:**

*Collaboration:*

Collaboration on homework assignments and projects is encouraged. However, do *not* simply copy one another's work. Rather, feel free to brainstorm and discuss general ideas for solutions together. Then, individually write up your own solution in your own private time.

*Citations:*

You must cite your collaborators at the start of your assignment or project. For example, if collaborating with Tina Turner, write "Note: I completed this assignment in collaboration with Tina Turner" at the start of your assignment.

*Cheating:*

Cheating is generally the act of taking credit for work you did not complete yourself. For example, if you collaborate with Angela Merkel and copy her solution rather than working through it yourself, then this constitutes cheating. Similarly, if you copy work from any source without citing it, this also constitutes cheating. The rule of thumb is never to copy solutions, but rather to work through problems (possibly collaboratively) and to phrase your final answer in your own words.

Cheating offenses are taken seriously. A first offense will result in a grade of 0 on the respective assignment or project and a warning. A second offence will result in a grade of F in the course.

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