

# CS 4134 – Quantum Computation and Information Processing

## Assignment 2

Virginia Tech Department of Computer Science, Spring 2026  
Instructor: Sumeet Khatri

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**Issue date:** Thursday, February 5, 2026

**Due date:** Tuesday, February 10, 2026

**Instructions:** Please show all of your work. Your grade will be based not only on getting the correct answer, but having a complete solution. You may work in collaboration with others, but you must write your own solutions, in your own words. Use of AI tools is not prohibited, but be prepared to explain your solutions and demonstrate your understanding to me on the board upon request at any time. Sticking to the deadline is to your benefit, but there is no late penalty. If you would like the assignment to count towards your final grade, then submit it before the final day of class in May. Submit a physical copy in class or an electronic copy via Canvas.

**Grading:** You will start from a grade of 100%. For every missed step, unclear or unexplained step, and mistake, you will lose two points, with a maximum of 10 points of deduction per problem. Unattempted problems result in a four-point deduction.

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1.
  - (a) State the definition of a  $d \times d$  Hermitian matrix in dimension  $d \in \{2, 3, \dots\}$ .
  - (b) Write down the most general form of a  $2 \times 2$  Hermitian matrix.
  - (c) Prove that every  $d \times d$  Hermitian matrix has real eigenvalues.
  
2. Draw a Bloch sphere and label the following locations.
  - (a) Where a qubit is  $|0\rangle$  and  $|1\rangle$ .
  - (b) Where a qubit is  $|+\rangle$  and  $|-\rangle$ .
  - (c) Where a qubit is  $|+i\rangle$  and  $|-i\rangle$ .
  
3.
  - (a) State the three-part mathematical definition of a density operator, and explain each part of the definition.
  - (b) State the mathematical definition of the purity of a quantum state.
  - (c) Write down an example of a pure quantum state for one qubit.