

CS 4134 – Quantum Computation and Information Processing

Assignment 8

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

Name:

Date: Thursday, April 23, 2026 (in class)

Due: End of class!

Number of problems: 3

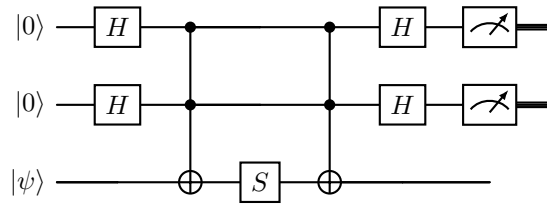
Instructions: Please show all of your work. Your grade will be based not only on getting the correct answer, but having a complete solution. You may work in collaboration with others and ask the instructor for help. Use of AI tools is not prohibited, but remember that the assignments are preparation for the exam — so if you use AI, use it wisely! Use it to learn.

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 10-point deduction. You must submit the assignment with at least one problem attempted in order to get a grade. Blank submissions will receive a grade of zero.

For the grader only

Problem	1	2	3	Final Score
Score				

1. Consider the following circuit:

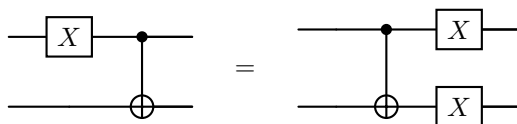


The state vector $|\psi\rangle$ is arbitrary, and the final measurement is in the Pauli- Z basis.

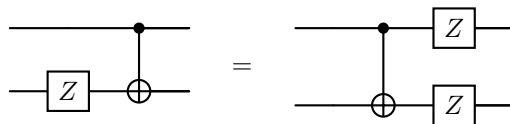
- (a) Show that the probability of both measurement outcomes being 0 is $\frac{5}{8}$.
- (b) Calculate the state of the third qubit conditioned on each of the four measurement outcomes.

2. Prove the following circuit identities.

(a) $\text{CNOT}(X \otimes \mathbb{1}) = (X \otimes X)\text{CNOT}$.



(b) $\text{CNOT}(\mathbb{1} \otimes Z) = (Z \otimes Z)\text{CNOT}$.



3. Starting from the $|0\rangle$ state vector, describe what gate(s) we would need to apply in order to generate the following state vectors. Provide justification. (*Hint:* Hadamard, rotation gates, and phase gates of the form $S(\theta) = \begin{pmatrix} 1 & 0 \\ 0 & e^{i\theta} \end{pmatrix}$, $\theta \in \mathbb{R}$, are sufficient.)
- (a) $\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$.
 - (b) $\frac{1}{\sqrt{2}}(|0\rangle - |1\rangle)$.
 - (c) $\frac{1}{\sqrt{2}}(|0\rangle - i|1\rangle)$.
 - (d) $\cos(\theta/2)|0\rangle + \sin(\theta/2)|1\rangle$, for an arbitrary $\theta \in \mathbb{R}$.
 - (e) $\frac{1}{\sqrt{2}}(|0\rangle + e^{i\theta}|1\rangle)$, for an arbitrary $\theta \in \mathbb{R}$.