Exercises

1	2	3	4	5	6

1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6
7	7	7	7	7	7	7
8	8	8	8	8	8	8
9	9	9	9	9	9	9
0	0	0	0	0	0	0

Surname, First name

KEN3241 Introduction to Quantum Computing
Resit KEN3241

Program: Bachelor Data Science and Artificial Intelligence

Course code: KEN3241
Examiners: Dibenedetto Domenica
Date/time: Friday 02-02-2024, 13h00-15h00
Format: Closed book exam
Allowed aids: Calculator from the DACS list of allowed calculators and the given formula sheet of basic quantum operators
Instructions to students:

- The exam consists of 5 questions on 12 pages.
- Fill in your name and student ID number on the cover page and tick the corresponding numerals of your student number in the table (top right cover page).
- Answer every question in the reserved space below the question. **Do not write outside the reserved space or on the back of pages, this will not be scanned and will NOT be graded!** As a last resort if you run out of space, use the extra answer space at the end of the exam.
- *In no circumstance write on the QR code at the bottom of the page!*
- Ensure that you properly motivate your answers.
- Only use black or dark blue pens, and write in a readable way. Do not use pencils.
- Answers that cannot be read easily cannot be graded and may therefore lower your grade.
- If you think a question is ambiguous, or even erroneous, and you cannot ask during the exam to clarify this, explain this in detail in the space reserved for the answer to the question.
- If you have not registered for the exam, your answers will not be graded, and thus handled as invalid.
- You are not allowed to have a communication device within your reach, nor to wear or use a watch.
- You have to return all pages of the exam. You are not allowed to take any sheets, even blank, home.
- Success!

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Exercise 1

10p **1a** Is there an experiment (measurement) where you can distinguish with absolute certainty whether the qbit is in the state (1) or (2)?
State (1): $|0>$
State (2): $\frac{3}{5}|0> + \frac{4}{5}|1>$
Justify your answer.

10p **1b** Considering state (2) what are the probabilities that we will measure |+> or |-> if we measure in the |+>, |-> basis?

Exercise 2

20p **2** Explain why the classical copy of a quantum state is not possible (no-cloning theorem).

Exercise 3

20p **3** Using shared EPR-pairs, Alice and Bob can communicate with each other instantaneously (so faster than light). Is this true or false? Justify your answer.

Exercise 4

10p **4a** Which quantum state do we get if we apply (H ⊗ I)CNOT to
$\sqrt{\frac{1}{3}}|00> + \sqrt{\frac{2}{3}}|11>$?
Here I is the 1-qubit identity operation, H is the one-qubit Hadamard, and CNOT is the 2-qubit controlled-not operation with the first (=leftmost) qubit being the control.

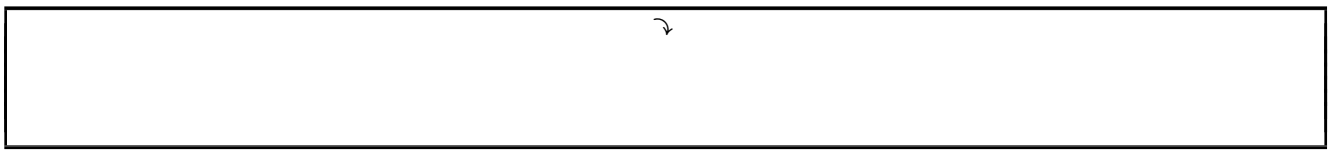
10p **4b** What is the probability of seeing |11> if we measure the resulting state in the computational basis?

Exercise 5

20p **5** Show that unitaries cannot “delete” information: there is no one-qubit unitary U that maps $|\varphi\rangle \rightarrow |0\rangle$ for every one-qubit state $|\varphi\rangle$.

Additional space

6



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