Quantum Computing and its Applications

Information about the homework, Spring 2025

Last update: February 10, 2025

General questions

What is the purpose of homework?

To delve into a quantum computing/communication topic of your choice

How many people can do the homework?

The homework can be done individually or in groups (2-3-4 people).

What can be used for the homework?

Anything can be used (including artificial intelligence). However, be careful with AI and please state exactly if you used AI (except for correcting / improving your text).

What is the deadline?

The deadline for homework is May 4 at midnight

What is this " Submit for first round review (optional, until March)" deadline?

The homework is in two parts. Anyone who submits the first part of the homework by midnight on March 20 will be reviewed and given feedback on how to maximize the accuracy of the first part. The corrected first part and the second part must be submitted by the final deadline, and only then will we mark the homework (both the first part and the second part).

How will the homework be corrected?

The homework will be marked, the scoring criteria can be found in the assignment.

Tasks in Spring 2025

1, Back to the future 30

We are 30 years in the future, in 2055. There already exists a working universal quantum computer that can run every quantum algorithm known today. The task is to choose one or more quantum algorithms and show how/why they are used in everyday life or in business or in a special place.

To be submitted:

- A paper at least 5 pages long (for individual work), for team work at least 4 * (number of teams) pages, e.g. 8 pages for a team of 2, 16 pages for a team of 4. The maximum length of the document is 30 pages (regardless of the number of participants) [The length of the document is understood in font size 11, the title page - if it is on a separate page - is not included, but the bibliography is included.]

OR

- A video of at least 3 minutes and up to 10 minutes in length.

Scoring (30 points in total)

- choose and identify at least 5 references from the literature on which you base your work (5p)
- briefly introduce the topic and explain its importance (5p)
- choose 4 criteria to describe in detail the advantages/challenges/disadvantages of the topic (4 criteria chosen: 4 points, description along the criteria: 8 points, total 12 points)
- briefly summarize the results/learnings of your work (3p)
- format/quality of the document/video produced (5p)

Submit for first round review (optional, until March)

- Choose and identify at least 5 literature works on the topic
- briefly introduce the topic and explain its importance
- choose 4 criteria to describe in detail the advantages/challenges/disadvantages of the topic (only 4 criteria to be chosen)

2, Back to the future 2100

We are 75 years in the future, in 2100. Imagine where the quantum mechanics principle of a given quantum phenomenon/algorithm could develop to, what technology it would make available, what tools it would give people.

To be submitted:

- a recorded presentation [PPT slide show + audio recording], at least 3 minutes long, maximum 10 minutes long.

OR

- a video at least 3 minutes long and up to 10 minutes long.

Scoring (30 points in total)

- choose and identify at least 5 references from the literature on which you base your work (5p)
- briefly introduce the topic and explain its importance (5p)
- choose 4 criteria to describe in detail the advantages/challenges/disadvantages of the topic (4 criteria chosen: 4 points, description along the criteria: 8 points, total 12 points)
- briefly summarize the results/learnings of your work (3p)
- format/quality of the document/video produced (5p)

Submit for first round review (optional, until March)

- choose and identify at least 5 literature works on the topic
- briefly introduce the topic and explain its importance
- choose 4 criteria to describe in detail the advantages/challenges/disadvantages of the topic (only 4 criteria to be chosen)

3, Quantum computing basics –Bloch's sphere simulator

The task is the development of a Bloch's sphere simulator in a programming environment of your choice.

To be submitted (all must be submitted)

- the code of the simulator
- the executable simulator
- and an associated document of at least 10 pages

Scoring (30 points in total)

- present existing Bloch sphere simulators, evaluate their advantages and disadvantages (5 points)
- provide a specification (5 points)
- build the simulator with tools of your choice (15 points)
- main evaluation criteria: correctness of operation, implementation (capabilities (e.g.: representation of arbitrary states, implementation of simple quantum gates), usability/user interface
- documentation of the completed program (5 points)

Submit for first round review (optional, until March)

- present existing Bloch sphere simulators, evaluate their advantages and disadvantages (5 points)
- provide a specification (5 points)
- name of the development environment chosen

4, Quantum computing and artificial intelligence

The task is to write a program for a quantum computer [IBM's quantum computer is preferred, but other quantum computers can be used] that supports the cooperation between quantum computers and artificial intelligence.

Demonstrate how the program works either in a document or in a video.

To be submitted:

- a document containing the literature search and the specification (at least 5 pages)
- the code produced
- document demonstrating how the program runs (minimum 5 pages) OR video demonstrating how the program runs (minimum 1 minute, maximum 5 minutes)

Submit for first round review (optional, until March)

- the document containing the literature and the specification

Scoring (30 points in total)

- choose and identify at least 5 literature references for the topic (5p)
- choose a platform for development (2p)
- prepare a specification (7p)
- prepare the program (6p)
- produce documentation (5p)
- format/quality of the document/video/program produced (5p)

5, Quantum computer and supercomputer

The task is to write a program for a quantum computer [IBM's quantum computer is preferred, but other quantum computers may be used] that supports the interoperability of quantum computers and supercomputers.

Demonstrate how the program works either in a document or in a video.

To be submitted:

- a document containing the literature search and the specification (at least 5 pages)
- the code produced
- a document demonstrating how to run the program (minimum 5 pages) OR a video demonstrating how to run the program (minimum 1 minute, maximum 5 minutes)

Submit for first round review (optional, until March)

- the document containing the literature and the specification

Scoring (30 points in total)

- choose and identify at least 5 literature references for the topic (5p)
- choose a platform for development (2p)
- prepare a specification (7p)
- prepare the program (6p)
- produce documentation (5p)
- format/quality of the document/video/program produced (5p)