COURSE INTRODUCTION

02195 – QUANTUM ALGORITHMS AND MACHINE LEARNING

Welcome to the Quantum Algorithms and Machine Learning course! In this course, you will be given a lot of freedom and you can to a fair extent learn at your own pace. There are also support activities through which you can get more individual help from the course staff. The following targeted support activities will be offered:

- Databar exercises and consultations.
- Relevant use of DTU Learn facilities.
- One-on-one feedback meetings

In return, you are asked to take responsibility of your own learning. The course staff will try to help you learn but in the end the responsibility is yours. In this process, the learning objectives are very important. They, not the literature, define the course and they explain what is expected of you!

There will not be any activities aiming at specifically repeating the material. We expect you to read assigned material and come prepared able and willing to discuss in groups but also in all of the class. Activities will rather focus on helping you understand difficult concepts or will focus on matter not fully discussed in the material.

The assessment is based on a four hour written exam. No other activity counts toward your grade.

We, in the course staff, value your feedback and suggestions. All your feedback and questions are important to us. Most, if not all, learning activities will be based on your input so that they will focus on the concepts that you find difficult. This means that the topics for learning activities may change with short notice. It also means that you have a responsibility to provide feedback. Finally, throughout the course, we will constantly evaluate the activities and we kindly ask for your participation in those evaluations.

Remember to often browse the DTU Learn file sharing area. There you will find all available course information. Do not expect the course staff to inform you about the contents of the documents. Please, do not hesitate to ask if something is confusing to you.

COURSE LAYOUT

There is one four hour course module per week. The time in the modules will be split between a number of different learning activities including databar consultations. Expect an average of two hours of databar consultations per module.

The module is scheduled on Monday afternoons between 13.00-17.00. The activities start at 13.00. The calendar on DTU Learn will hold up-to-date information.

We will be in 308/A11.

The exact place, and time of the written exam is not known when this text was written. It will likely be on May 16th. The exam is a four (4) hour written exam. The exam problems will be available in English but you are allowed to answer in Danish as well as English. Written aids are permitted at the exam.

READING LIST

The following list of literature is used:

- Thomas Wong, Introduction to Classical and Quantum Computing, https://www.thomaswong.net/introduction-to-classical-and-quantum-computing-1e4p.pdf, chapters 1-4, 6, and 7 – 7.5.
- Cormen, Leiserson, Rivest and Stein, "Introduction to Algorithms", edition four if possible, http://mitpress.mit.edu/9780262046305/introduction-to-algorithms/. The book is available via the DTU Library. Ch 1, 2, 3.1, ch 4 introduction do not continue into 4.1, 5 – 5.3, 34, and 35.
- Ronald de Wolf's notes: http://homepages.cwi.nl/~rdewolf/qcnotes.pdf, ch 4, 5, 7, 8, 9.
- Brassard, G., Høyer, P., & Tapp, A. (1997). Quantum Algorithm for the Collision Problem. ENCYCLOPEDIA OF ALGORITHMS. https://arxiv.org/pdf/quant-ph/9705002.pdf
- Chailloux, A., Naya-Plasencia, M., Schrottenloher, A. (2017). An Efficient Quantum Collision Search Algorithm and Implications on Symmetric Cryptography. In: Takagi, T., Peyrin, T. (eds) Advances in Cryptology – ASIACRYPT 2017. ASIACRYPT 2017. Lecture Notes in Computer Science(), vol 10625. Springer, Cham. https://doi.org/10.1007/978-3-319-70697-9_8 . https://eprint.iacr.org/2017/847.pdf

ROUGH COURSE SCHEDULE

The following table outlines the semester schedule. Expect changes to this schedule as we will attempt to adapt to how quickly you learn.

Week	**Topics**	**Primary reading material, NB: The material is to be read before Monday each week!**
1	Introduction meeting	Wong, ch 1-4, and 6
2	Review and refresh of fundamental Quantum computing concepts	Wong, ch 1-4, and 6
3	Algorithmic theory	Cormen, ch 1, 2, 3.1, ch 4 introduction do not continue into

		4.1, 5 – 5.3, 34, and 35
4	Quantum complexity theory	Wong, ch 1.5, 1.8.3, 4.6, 4.7.1, 4.7.2, 6.2-6.5 (but not 6.2.3), and 7 - 7.5
5	Phase estimation	de Wolf, ch 4
6	Shor's factoring algorithm	de Wolf, ch 5
7	Grover's algorithm and Quantum walks	de Wolf, ch 9
8	Hamiltonian simulation	de Wolf, ch 7, 8
9	QRAM; Cryptography in the context of Quantum computing	Brassard; Chailloux
	Easter break	
10	Quantum Machine Learning and NISQ	TBA
11	Algorithms for HPC – QC integration	TBA
12	HPC - QC hybrid algorithms	TBA
13	Test exam; You can try a fictive written exam and we will go over the solutions together.	

DATABAR EXERCISES

GENERAL COMMENTS

Every week you will be given small exercises to carry out on your own in the databar. You will also receive preparation exercises to solve before class. The scope and nature of exercises will vary each week. You will in general be asked to prepare by reading source material.

Exercises are generally available at the end of Thursdays the week before the respective databar activity.

FEEDBACK MEETINGS

You can ask for a maximum of two feedback meetings during the course. During the feedback meeting you get feedback on anything you have produced during the course. This could for example be programs written during databars or answers to preparation or reflection questions. During the meeting you sit down with the course staff for a 30 minutes meeting and go over all your material.

The material you want feedback on needs to be submitted at least one week before the meeting and must adhere to DTUs rules on plagiarism.

You ask for a feedback meeting via email and it might not be possible for you to select a meeting slot.

COURSE STAFF POLICY

BACKGROUND

The members of the course staff has set up some rules that they will follow throughout the course. This documents inform you about the rules so that you know what level of service you can expect.

POLICY RULES

The course staff promises to:

- Always behave respectfully and correctly.
- Always make every possible effort to show up for activities on time and stay for the entire length.
- Provide accurate and up to date information about the course on DTU Learn.
- In the databar, provide at least five (5) minutes of consultation time per student before circulating to another student. Once the five minutes have expired, the course staff member may circulate to another student.
- Take all constructive input from students seriously.
- Make all possible efforts towards answering questions. For exceptions see below. However due to the open nature of some of the problems studied, it might not be possible to answer. The course staff will in that case clarify that and if possible provide guidance into attacking the problem.

The course staff will not solve any graded problem for any students neither as a whole nor in parts. The course staff may decide not to answer questions that are too leading but will in that case clearly say so. The course staff may decide to not answer questions but instead give suggestion or guidelines as to solve the problem. This may include paraphrasing the question in a way that is easier or more obvious to solve or help students formulate new questions.

The course staff may decide to politely defer questions to an off-line activity if the questions are deemed to be out of scope of the course or off topic.