Quantum Computing for Engineers

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Course description:

This course introduces quantum computation and algorithms. It is specifically designed to be accessible to those without a physics background; instead of requiring prior knowledge of quantum mechanics, we simply define the "rules of the game" through a few basic postulates. We will explore the massive promise of quantum algorithms and define what constitutes a true practical advantage. However, we stay grounded by discussing the conceptual limitations that can stem from input/readout models, which are often the bottleneck in real-world applications. We focus on quantum algorithms that aim to solve problems of interest to engineers—covering search, optimization, and solving linear systems of equations. We introduce these algorithms using modern, unified approaches such as quantum walks, block encoding, and quantum signal processing, rather than the traditional textbook derivations found elsewhere. Finally, we evaluate whether theoretical quantum advantages withstand practical constraints and discuss the status of today's hardware and what to expect next.

The course is organized in 5 lectures hosted at Aarhus University, Civil and Architectural Engineering Department (Navitas Campus, Room 03.103) from Monday, June 1st to Friday, June 5th, 2026, from 9:00 AM to 12:00 AM. This is the lecture plan:

- Day 1: Introduction to gates, circuits, and algorithms.
- Day 2: The input/output model and introduction to software.
- Day 3: Search with quantum amplitude amplification.
- Day 4: Block Encoding and Quantum Signal Processing.
- Day 5: Applications: solving linear systems and PDEs.

Each lecture alternates between theory and practical applications, including coding; at each lecture, 1-2 exercises are assigned for self-study in the afternoon.

The event is co-organized by Associate Prof. Giuseppe Abbiati[2], Aarhus University (DK), and Associate Prof. Yashar Eftekhar Azam[3], University of New Hampshire (U.S.). The event is co-financed by the University of New Hampshire (U.S.) and Aarhus University (DK).

To enroll in the course and for any information, get in touch with Associate Prof. Giuseppe Abbiati (abbiati@cae.au.dk), Department of Civil and Architectural Engineering, Aarhus University, Denmark. We have up to 30 seats available for in-person attendance.

Short bio:

I am an associate professor at the International School for Advanced Studies (SISSA). I am a computational condensed-matter physicist interested in developing algorithms for quantum computing to tackle quantum many-body systems, as well as purely classical complex systems. Previously, I was a postdoc at ETH Zurich, a Research Staff Member at IBM Quantum,

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and an Assistant Professor at the University of Zurich, where my research was funded by an SNSF Eccellenza grant. I have worked in quantum computing since 2015, starting with analog platforms and later extending to digital quantum processors. My main research focus is understanding the origin of quantum speed-up and evaluating its practical limitations, since many textbook quantum algorithms may not provide the expected advantage once realistic constraints, such as gate times, error rates, and input–output bottlenecks, are taken into account. My interests in quantum algorithms are broad: I have developed or studied quantum approaches for sampling, optimization, chemistry, genomics, and finance.