Quantum Information

General information

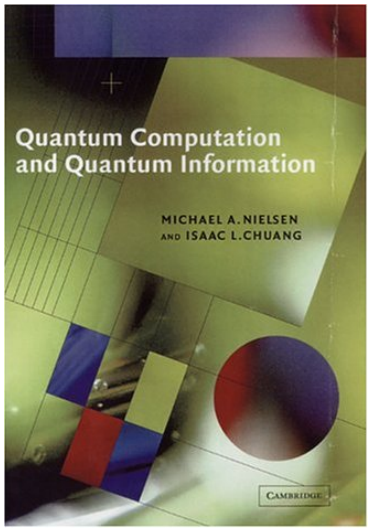
- 7.5 hp PhD/masters course, March to June 2019.
- Teachers: Stefan Kröll, Andreas Walther, Göran Johansson, Peter Samuelsson and Patrick Potts
- Homepage: http://www.atomic.physics.lu.se/education/elective-courses/fyst30-fafn40-quantum-information/.

Course content

Subjects

- Overview
- Quantum mechanical background.
- Physical realizations of quantum bits and circuits.
- Quantum circuits and universal quantum gates.
- Density matrix and quantum measurements, computer science background
- The quantum Fourier transform and Shors algorithm for prime factorization.
- Grovers search algorithm.
- Quantum operations and noise.
- Quantum error correction.

Book



Quantum Computation and Quantum Information
Nielsen and Chuang

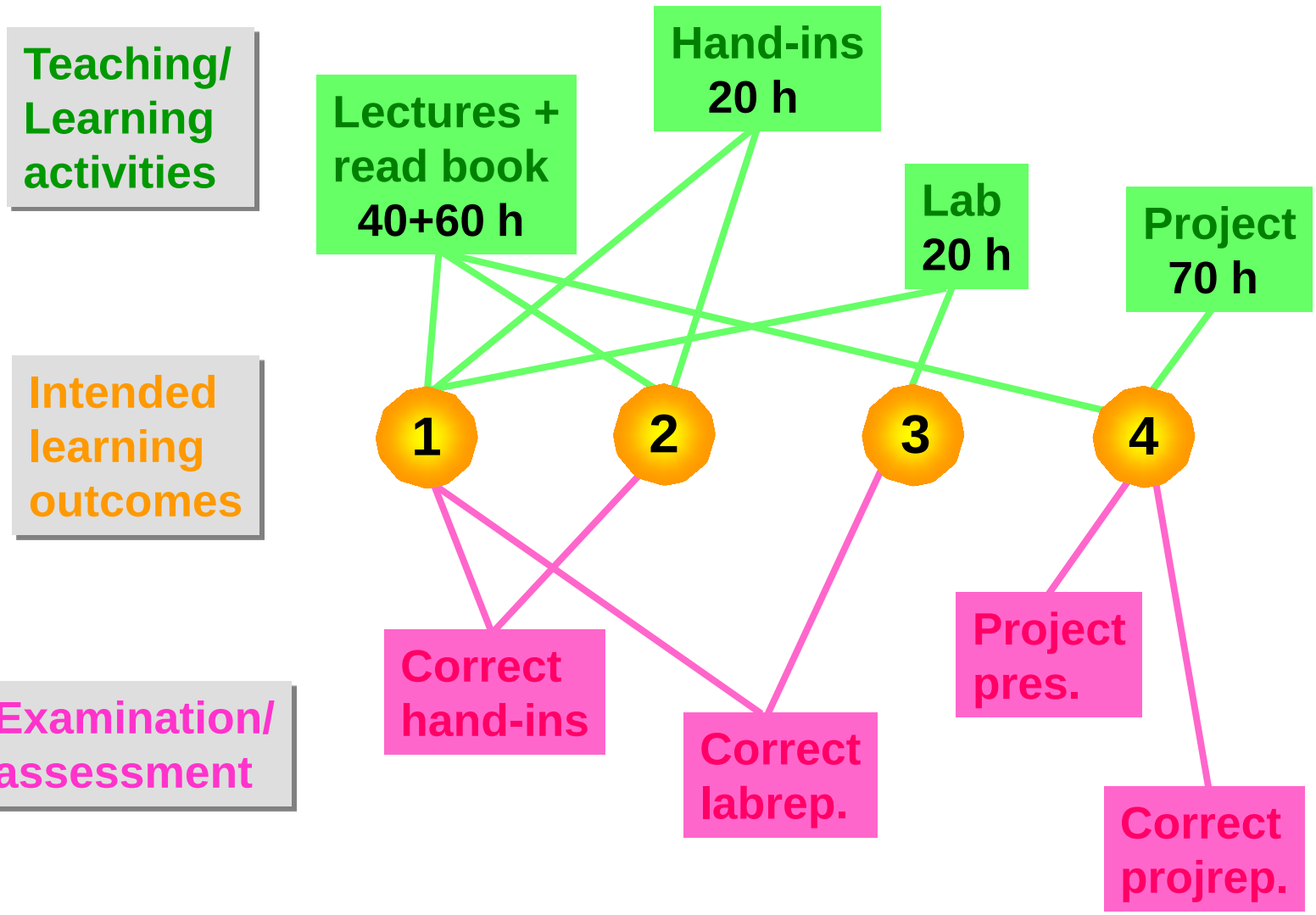
KFS Studentbokhandel
Studiecentrum
John Ericssons väg 4

Intended Learning Outcomes

After completed course the student should be able to:

1. explain central QI-concepts such as quantum bits, entanglement, algorithms, error correction, teleportation, density matrices etc.
2. solve simpler exercises related to the central QI-concepts.
3. under supervision perform a basic QI-experiment and to present the result in a written report.
4. independently or in pairs perform a detailed study of and critically assess a specific QI-subject and to present the result in a written report as well as in a shorter oral presentation.

Course plan


Teaching/ Learning activities
Intended learning outcomes
Examination/ assessment
Lectures + read book 40+60 h
Hand-ins 20 h
Lab 20 h
Project 70 h
1
2
3
4
Correct hand-ins
Correct labrep.
Project pres.
Correct projrep.

Lectures

Chapters and lecturers

Ch. 1 Introduction (S.K.)
Ch. 2 Quantum mechanics, intro (P.S.)
Ch. 3 Computer science, intro (P.S.)
Ch. 4 Quantum circuits (S.K.)
Ch. 5 Quantum fourier transform (G.J.)
Ch. 6 Quantum search algorithm (G.J.)
Ch. 7 Physical realizations (A.W.)
Ch. 8 Quantum noise and operations (P.P.)
Ch. 9 Distance measures (P.S.)
Ch. 10 Quantum error correction (A.W.)
Ch. 11 Entropy and information (P.S.)
Ch. 12 Quantum information theory (P.S.)

Stefan Kröll (S.K.), Andreas Walther (A.W), *Peter Samuelsson* (P.S.), *Göran Johansson* (G.J.).

Hand-in assignements (see homepage, examination)

1) Ch. 7

Hand-in 1
To be handed in at the latest Wednesday 17/4.

2) Ch. 2-4

Hand-in 2
To be handed in at the latest Friday 10/5.

4) Ch. 5,8

Hand-in 3
To be handed in at the latest Friday 24/5.

Laboratory work

Rare earth ion quantum bit

- The laboratory work involves exercising control over atoms by laser light, preparing them in specific atomic states including superposition states.
- In addition to carrying out the actual lab this part of the course also includes a preparatory exercise a written report and (for those who have not already seen it) a Safety movie.
- Time: 8/5-10/5.

Project work

Information

- One subject.
- Work single or in pairs.
- Discussions with supervisor.
- Choose project: At the latest Wed April 17th.
- Written report: hand in deadline May 23rd
- Oral presentation for course colleagues: 20 min. + questions, either May 29th or June 3rd

Subjects

1) Quantum Simulators (A.W.)
2) Free space quantum communication (A.W.)
3) Quantum computation with spins in Quantum dots (P.S.)
4) Bell inequalities. (P.S.)
5) Entanglement (P.S)
6) Quantum computation with rare earth ion doped crystals. (S.K.)
7) Quantum repeaters. (S.K.)
8) Quantum memories (S.K.)
9) Quantum computing with super conducting qubits (Ville Maisi)
10) Majorana qubits (Martin Leijnse)
11) Beam up my quantum state, Scotty! (P.S)