

# UE Quantum Algorithm



Level  
Baccalaureate  
+5



ECTS  
3 credits



Component  
UFR PhITEM  
(physique,  
ingénierie, terre,  
environnement,  
mécanique)



Semester  
Automne

- > **Teaching language(s):** English
- > **Open to exchange students:** Yes
- > **Code d'export Apogée:** PAX9QIAD

## Presentation

### Description

Teacher : Benoit Vermersch (UGA)

#### Objectives :

While the mathematical basis of quantum computing, the programming model, and most quantum algorithms have been published decades ago (starting in the 1990s), they have been of interest only to a small dedicated community. Time has come to make quantum algorithms and their implementations accessible to a broader audience aiming to explain the principles of quantum programming, which are quite different from those of classical programming. During these lessons and tutorials, you will learn Quantum Algorithms.

#### Program :

##### Lecture 1: *From classical computers to quantum computers*

- Classical computers in the circuit representation: Bits, gates, universality, computational complexity
- Motivations to build a quantum computer: Quantum parallelism and quantum speedup
- Introduction of quantum computing in the quantum circuit model
- Universal set of quantum gates – connection to entanglement
- The measurement

##### Lecture 2: *Quantum Algorithms*

- Warm-up: Deutsch's problem
- Data search: Grover's algorithm
- Factorization: Shor's algorithm

**Lecture 3: Quantum Error correction**

- The role of decoherence in a quantum circuit
- Introduction to repetition codes
- Stabilizer formalism.
- Quantum threshold theorem and fault-tolerant quantum computing. The example of surface codes

**Lecture 4: Quantum optimization I: Quantum annealing**

- Warm-up: Quantum adiabatic theorem
- Quantum annealing
- Fundamental limitations of quantum annealing

**Lecture 5 : Quantum optimization II: hybrid classical quantum Quantum annealing**

- Quantum approximation optimization algorithm (QAOA)
- Analog/Digital quantum Simulation.
- Solving quantum chemistry problems
- variational quantum eigensolver (VQE)

**Lecture 6 : Bonus lecture**

- Implementing a quantum oracle for Grover's algorithm
- Google's quantum supremacy and toric code experiments

Useful references: J. Preskill's notes on quantum information: <http://theory.caltech.edu/~preskill/ph229/> Quantum computation and quantum information, M. Nielsen, I. Chuang, Cambridge Press

Prerequisite: Quantum mechanics M1

---

## Course parts

UE Quantum Algorithm - CMTD

Teaching Unit (UE)

24h

**Period** : Semester 9

## Useful info

---

## Campus

> Grenoble - University campus