

QX01 – Introduction to quantum information and associated technologies

Open to undergraduate students as well as graduate students with basics in mathematics, computer science, and physics.

Introduction :

Quantum technologies have developed for several years already within the field of what was initially called quantum information. For the past 3-4 years, it has been referred to as quantum technologies because potential applications are currently being developed and so it is now not only about theoretical concepts or about proving experiential principles. Major companies such as Google, Microsoft, Intel, IBM and more recently ATOS have shown a real interest in these new innovative technologies. Besides, there has been an exponential number of start-ups on these topics, the adoption of a European flagship project, and of a bill has been approved by the American Congress on this question. More recently, in January 2021, France has announced its 5-year, 1.8-billion euro quantum plan.

On top of these significant milestones, it is important to understand that these technologies lie essentially on properties and laws from quantum physics that are by no means predictive and therefore require short, mid and long term investment on research and training. UTT wants to be a leader on both these aspects in partnership with academics and industrialists such as ATOS and IBM, but also with government agencies such as the French DGA and DGSE.

Objectives :

This course gives the essential basics to understand the forthcoming new technologies in communications, calculus, or sensors. Industrialists will also contribute from time to time.

Contents :

As mentioned above, quantum technologies involve knowing about quantum physics. Then, these technologies are based on some completely non-predictive physics principles such as quantum super position, quantum entanglement, or even non-cloning. Current engineering students at Universities worldwide do not all have the necessary background to understand these technologies and so we deem it essential to provide them early in their curriculum with academic training on these technologies as they are likely to be faced with them in their career.

This course includes lectures, tutorials, and practical work. The instruction language is English.

- Lectures will be broadcasted live on Tuesdays from 10:00 am to 12:00 pm French time. Lectures will also be recorded and therefore available for replays ;
- Tutorials will be broadcasted live on Tuesdays from 2:00 pm to 4:00 pm French time. They will also be recorded and available for replays.
- Practical work will be delivered live on Tuesdays from 5:00 pm to 8:00 pm French time and available for replays.

Estimated workload to follow this course is 170 hours and is distributed as follows :

- 28 hours of lectures
- 28 hours of tutorials
- 9 hours of practical work
- 85 hours of personal work
- 20 hours of project (article writing)

Required personal equipment :

- Personal laptop or tablet computer;
- Reliable Internet connection ;
- Audio headset with integrated microphone;
- Webcam.

Assessment:

Formative and summative assessment will take place all along the duration of the course and students will have to write a research article to be submitted in June 2022. Different types of additional resources will be made available to students and synchronous or asynchronous sessions will be planned to support students learning.

Provisional program:

Lecture 1: Introduction to quantum information & technologies

Lecture 2: Classical information & computation

Lecture 3 : The qubit

Lecture 4: Quantum sensors : Quantum magnetometry

Lecture 5: Multiple Qubit and entanglement

Lecture 6: Quantum cryptography

Lecture 7: Measurements and operators

Lecture 8: Quantum gates

Lecture 9: Quantum algorithm + quantum parallelism

Lecture 10: Shor's algorithm

Lecture 11: Quantum Error Correction

Lecture 12: Introduction to Quantum Learning Machine

Lecture 13: Quantum technologies 1

Lecture 14: Quantum technologies 2

Related links and information:

UTT's Youtube channel : <https://www.youtube.com/user/ChaineUTT>

UTT's research : <https://recherche.utt.fr/>

UTT's Pr Christophe Couteau's webpage: <https://recherche.utt.fr/light-nanomaterials-nanotechnologies-l2n/members/christophe-couteau>

UTT's Graduate school : <https://nano-phot.utt.fr/>

For any question, please contact us at quantum@utt.fr.