MIT xPRO

Introduction to Quantum Computing

Note: All graded assignments are due the last day of the course. Items preceded by a star (✯) are graded.

Welcome to the Course (35 min)

Take a Pre-Assessment to get a baseline of your understanding of the course material. Become familiar with the platform and course design.

- Entrance Survey (5 min)
- ✯ Pre-Assessment (10 min)
  Suggested date to keep pace: end of course
- Welcome (2 min)
- Course Discussion Forum (5 min)
- Course Webinar (5 min)
- Who's in the Course? (2 min)
- Who's Teaching the Course? (3 min)
- LinkedIn Community (3 min)

WEEK 1: Introduction to Quantum Computing (4 hrs)

The first part of Week 1 is a historical introduction to classical and quantum computing. In the second part, you will learn and practice some of the basic concepts of quantum computing, including a section on mathematical tools necessary for the following weeks. In the third and final part of this week, you will be introduced to quantum algorithms and quantum computing approaches.

- Introduction & Types of Computing (25 min)
- History of Classical Electronic Computing and Quantum Computing (15 min)
- How Is a Quantum Computer Different? (45 min)
- Quantum Gates (35 min)
- Universal Quantum Algorithms (10 min)
- Quantum Simulation, Emulation, and Annealing (15 min)
- ✯ Check Your Understanding Questions* (30 min)
  Suggested due date to keep pace: final day of Week 1
- ✯ Graded Activity (30 min)
  Suggested due date to keep pace: final day of Week 1
- Key Images (3 min)

* Check Your Understanding questions are spread throughout each week and are due at the end of the course.

WEEK 2: Leading Qubit Modalities (4-5 hrs.)

In Week 2, you will learn the requirements for the physical realization of a quantum computer and for achieving quantum communication.

Next, you will learn about one of the most significant obstacles in quantum computing – decoherence, or the loss of information. Then you will learn and compare the most current qubit modalities. Finally, in the case studies, you will gain more experience in the two leading modalities: Trapped ions and superconductor qubits. Here, you will not only learn more about the theory, but you will also hear scientists describe and show their laboratories.

- What Makes a Good Qubit Modality? (15 min)
- Qubit Robustness (25 min)
- Qubit Modalities (35 min)
- ✯ Case Study: Trapped-Ion Quantum Computers (40 min)
  Suggested due date to keep pace: final day of Week 2
- ✯ Case Study: Superconducting Qubit Quantum Computers (45 min)
  Suggested due date to keep pace: final day of Week 2
- ✯ Check Your Understanding Questions* (30 min)
  Suggested due date to keep pace: final day of Week 2
- ✯ Graded Activity (30 min)
  Suggested due date to keep pace: final day of Week 2
- Key Images (3 min)

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Live Event This Week
Course Webinar with Course Instructor
More information in Welcome to the Course > Course Webinar section

WEEK 3: Applications of Quantum Information (4-5 hrs.)

In the first part of this week, you will learn about quantum algorithms and the computational power of quantum computers, also called quantum advantage and quantum speed-up. In the second part, you will learn about the fundamentals of quantum communication and current communication protocols, including quantum key distribution. In the third part of this week, you will go through a case study presenting industry perspectives of quantum computation, including IBM, Google, Microsoft, QCI, IonQ, Rigetti, and D-Wave.

Finally, in this week's Deep Dive, you will learn in more detail about computational complexity.

- Quantum Algorithms and Their Potential Speed-Up (30 min)
- Quantum Communication (35 min)
- ✯ Case Study: Industry Perspectives (30 min)
  Suggested due date to keep pace: final day of Week 3
- Deep Dive: Introduction to Computational Complexity (35 min)
- ✯ Reflection and Review Activity (1.5 hrs)
  Written Submission suggested due date to keep pace: final day of Week 3**
  Peer review suggested due date to keep pace: start of Week 4**
- ✯ Check Your Understanding Questions* (30 min)
  Suggested due date to keep pace: final day of Week 3

- ✭ Graded Activity (30 min)
  Suggested due date to keep pace: final day of Week 3
- Key Images (3 min)

* Check Your Understanding questions are spread throughout each week and are due at the end of the course.
** Suggested date for the reflection submission and discussion forum posting is the end of Week 3. The suggested date for the peer reviews is beginning of Week 4. This will allow participants to stay on track with workload before Week 4's IBMQ experience activity.

WEEK 4: A Simple Quantum Algorithm in Practice (4-5 hrs)

In the first part of Week 4, you will learn about the classical and quantum circuit models and compare them at a high level. Then, you will learn about the Deutsch-Josza Algorithm, with examples for one and two qubit systems. Next, you will learn about quantum software and programming tools for quantum computers.

Specifically, you will be introduced to OpenQASM and its GUI interface composer. Finally, you will participate in the IBM Quantum Experience or IBM QE. Here, you will practice what you learned about OpenQASM, and use it to implement the Deutsch-Josza Algorithm in a real quantum computer.

- Circuit Models (10 min)
- The Deutsch-Jozsa Quantum Algorithm (10 min)
- Quantum Software (15 min)
- ✭ IBM QE: QASM (40 min)
  Suggested due date to keep pace: end of course
- ✭ Lab Practicum: IBM QE: Deutsch-Jozsa Algorithm (2 hrs)
  Suggested due date to keep pace: end of course
- ✭ Check Your Understanding Questions* (30 min)
  Suggested due date to keep pace: end of course
- ✭ Graded Activity (30 min)
  Suggested due date to keep pace: end of course
- Key Images (3 min)
- Exit Survey (10 min)
- ✭ Post Assessment (10 min)
  Suggested due date to keep pace: end of course

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After the Course Ends…

Download your course certificate. Continue to access the course materials.

Last day of the course

- Course ends at 23:30 UTC
- Discussion forums lock at 23:30 UTC

Four days after the course ends

- Course certificate available on MIT xPRO dashboard

