Requirements for Large-Scale Universal Quantum Computation

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

WELCOME TO THE COURSE (30 min)

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

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

WEEK 1: What Strategies Exist for Mitigating and Correcting Errors in Quantum Computers? (4 hrs)

In the first week of this course, you'll learn about strategies for detecting and correcting errors in quantum systems. You'll also learn several simple examples of quantum error correction codes.

- Introduction (5 min)
- Introduction to Classical and Quantum Error Correcting Codes (45 min)
- Introduction to Computational Capacity (25 min)
- ★ Check Your Understanding Questions* (30 min)
  Suggested due date to keep pace: end of Week 1
- ★ Graded Activity (30 min)
  Suggested due date to keep pace: end 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: How Can Reliable Classical and Quantum Machines be Built from Unreliable Components? (4-5 hrs.)

In Week 2, you'll learn how reliable classical and quantum machines can be built from unreliable components. You will explore the threshold theorem and principles of fault tolerance in both classical and quantum circuits.

- Introduction (5 min)
- Threshold Theorem for Fault-Tolerant Computation (45 min)
- Principles of Fault Tolerance (35 min)
- Threshold for Reliable Quantum Computation (45 min)
- ✯ Check Your Understanding Questions* (30 min)
  Suggested due date to keep pace: end of Week 2
- ✯ Graded Activity (30 min)
  Suggested due date to keep pace: end of Week 2
- Key Images (3 min)

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

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

WEEK 3: Quantum Error Mitigation and Error Correction in Practice (4-5 hrs.)

The third week of the course focuses on the quantum error mitigation and quantum error correction in practice. You will learn about composite pulses and dynamical decoupling pulse sequences. You will also explore the principles and challenges of implementing the surface code in practice.

- Introduction (5 min)
- Quantum Computation vs Analog Computation (10 min)
- Dynamical Error Suppression (40 min)
- ✯ Case Study: Reaching for Fault-Tolerant Quantum Computation with Superconducting Qubits (45 min)
  Suggested due date to keep pace: end of Week 3
- ✯ Reflect and Review Activity** (2 hrs)
  Written Reflection and Shared Post suggested due date to keep pace: end of Week 3
  Peer Reviews suggested due date to keep pace: start of Week 4
- ✯ Check Your Understanding Questions* (30 min)
  Suggested due date to keep pace: end of Week 3
- ✯ Graded Activity (30 min)
  Suggested due date to keep pace: end 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 the start of Week 4. This will allow participants to stay on track with workload before Week 4's IBMQ experience activity.

WEEK 4: Computational Complexity and Quantum Supremacy (4-5 hrs)

The fourth week of the course will focus on topics computational complexity, and you will explore the concept of quantum advantage, often referred to as quantum supremacy. Finally, you'll put into practice what you have learned in the IBM Quantum Experience practicum.

- Program Certificate (2 min)
- Introduction (5 min)
- Classical Complexity Theory (30 min)
- Standard Classical Computational Complexity Classes (20 min)
- Quantum Computational Complexity Classes (30 min)
- ✯ Case Study: How to Think about Quantum Supremacy (40 min)
  Suggested due date to keep pace: end of Week 4
- ✯ Lab Practicum: Mitigating Errors in a Superconducting Qubit System with Composite Pulses (2 hrs)
  Due date: end of course
- Discussion Preparing for Quantum Computers (10 min)
- ✯ Check Your Understanding* (30 min)
  Suggested due date to keep pace: end of Week 4
- ✯ Graded Activity (30 min)
  Suggested due date to keep pace: end of Week 4
- Key Images (3 min)
- Acknowledgements (2 min)
- Exit Survey (10 min)
  Suggested due date to keep pace: end of Week 4
- ✯ Post-Assessment (15 min)
  Suggested due date to keep pace: end of Week 4

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

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