Quantum Algorithms for Cybersecurity, Chemistry, and Optimization

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 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: Modern Cryptography and Shor's Algorithm (4-5 hrs)

In the first week of this course, you'll learn about the history and uses of modern cryptography and the RSA cryptosystem. You'll then explore the Quantum Fourier Transform and its use in Shor's algorithm to compromise RSA. The week concludes with a deep dive on prototype demonstrations of Shor's algorithm.

- Introduction (10 min)
- Modern Cryptography (15 min)
- RSA Cryptosystem, Factoring, and Shor's Algorithm (20 min)
- Deep Dive: Cryptography and Shor's Algorithm (35 min)
- ★ Case Study: Demonstrations of Shor's Algorithm (45 min)
  Suggested date to keep pace: end of Week 1
- ★ Check Your Understanding Questions* (15 min)
  Suggested date to keep pace: end of Week 1
- ★ Graded Activity (30 min)
  Suggested 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: Quantum Cryptography (4-5 hrs.)

In Week 2, you'll continue your exploration of cryptography by examining secure communication schemes enabled by quantum mechanics. You'll learn about single and entangled photons, their generation and detection, and their use in quantum key distribution. The week concludes with quantum- enabled random number generators and quantum teleportation.

- Introduction (15 min)
- Post-Quantum Cryptography (15 min)
- Quantum Makes New Cryptography - Single Photon Schemes (20 min)
- Quantum Makes New Cryptography - Entangled Photon Schemes (30 min)
- Quantum Makes New Cryptography - Random Number Generators (30 min)
- Quantum Makes New Cryptography - Quantum Repeaters (30 min)
- ✯ Check Your Understanding Questions* (20 min)
  Suggested date to keep pace: end of Week 2
- ✯ Graded Activity (20 min)
  Suggested 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: The Quantum Hamiltonian Simulation Problem and Algorithm (4-5 hrs.)

The third week of the course focuses on quantum simulation. You'll learn about Hamilton simulation, phase estimation, and their applications to quantum chemistry, including a case study on variation quantum eigensolvers.

- Introduction (15 min)
- Hamilton Simulation (25 min)
- Quantum Simulation: Chemistry (30 min)
- ✯ Case Study: VQE in Practice (30 min)
  Suggested date to keep pace: end of Week 3
- ✯ Reflect and Review Activity** (1 hr. 30 min)
  Written Submission suggested due date to keep pace: end of Week 3
  Peer Assessment suggested due date to keep pace: beginning of Week 4
- ✯ Check Your Understanding Questions* (20 min)
  Suggested date to keep pace: end of Week 3
- ✯ Graded Activity (30 min)
  Suggested date to keep pace: end of Week 3
- Key Images (2 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: Quantum Optimization (4-5 hrs)

The fourth week of the course will focus on quantum optimization. You'll start the week by learning about adiabatic quantum computing and quantum annealing. You'll then explore a specific example of a digital simulation: Grover's algorithm. Finally, you'll put into practice what you have learned in the IBM Quantum Experience practicum.

- Program Certificate (2 min)
- Introduction (5 min)
- Adiabatic Quantum Computing (45 min)
- Quantum Annealing & Polynomial-Speedup Quantum Algorithms (45 min)
- ✯ Digital Simulation: Grover's Algorithm (25 min)
  Suggested date to keep pace: end of course
- ✯ Lab Practicum: Grover's Algorithm (2 hrs)
  Suggested date to keep pace: end of course
- ✯ Check Your Understanding Questions (10 min)
  Suggested date to keep pace: end of course
- ✯ Graded Activity (20 min)
  Suggested date to keep pace: end of course
- Key Images (3 min)
- Acknowledgements (2 min)
- Exit Survey (5 min)
- ✯ Post-Assessment (10 min)
  Suggested date to keep pace: end of course

* 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
- Program certificate available on MIT xPRO dashboard for learners who completed both courses