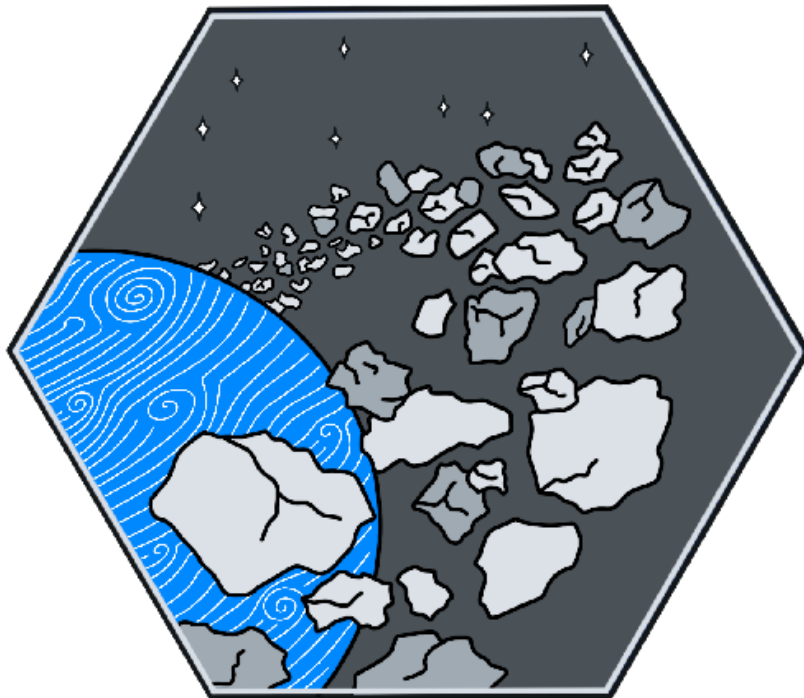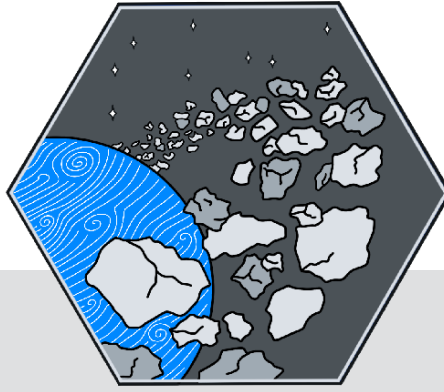# Qiskit | Quantum Explorers

A Self-Paced Quantum Learning Journey

Achievement:
EXPERT NAVIGATOR

Quantum Optimization

QUANTUM OPTIMIZATION

Achievement to unlock: Expert Navigator
You encounter an enormous asteroid field. Find the optimal path through it to keep your crew safe.

You want to explore a particular deep space region, but there's an enormous asteroid field in your way. You decide to not let that deter you; turning back is not an option. Instead, you can perform optimization to identify the optimal path through the asteroid field to keep your crew safe. Remember, one wrong move means collision.

(Share the wonders that await you to explore beyond the asteroid field in the #space-exploration channel on Discord! New planets? New cosmic phenomena waiting to be discovered? Get creative!)

Complete this module to successfully navigate through the asteroid field, and become an Expert Navigator.

In this module you will:

- Understand what optimization problems are

- Understand quadratic programs

- Use Qiskit's optimization module to code and solve some famous optimization problems

SYLLABUS

Checklist of tasks to complete and materials to learn

Warm-up Activities

LIVE EVENT: Badge Kick-off - Quantum Machine Learning

Date: October 12 [time] [video recording link] [demo notebook link]

Introduction to Optimization and Quantum Optimization

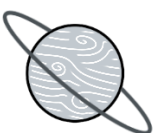**VIDEO: Introduction To Optimization: Objective Functions and Decision Variables [link]**

A short and sweet introductory video that shares basic optimization vocabulary and concepts.

VIDEO: Quantum Algorithms for Optimization [link]

Lecture by Ronald de Wolf (QuSoft, CWI and University of Amsterdam) that introduces Quantum Optimization.

VIDEO: Introduction to QAOA and Applications [link]

Lecture from QGSS 2021 by Johannes Weidenfeller explaining Variational Quantum Eigensolvers, QUBOs, MaxCut and the QAOA circuit.

SYLLABUS (CONT'D)

Main Activities

VIDEO: Introduction to Qiskit Optimization [link]

Demo of the Qiskit Optimization Application module by Atsushi Matsuo with code examples. (Starting from timestamp 02:22, ending at 30:27) [jupyter notebook for this demo].

TUTORIAL: An Introduction to Algorithms in Qiskit [link]

High-level overview and introduction to algorithms in Qiskit.

TUTORIAL: Max-Cut and Traveling Salesman Problem [link]

A jupyter notebook that demonstrates Max-Cut and Traveling Salesman problem using Qiskit Optimization module.

TUTORIAL: Quadratic Programs [link]

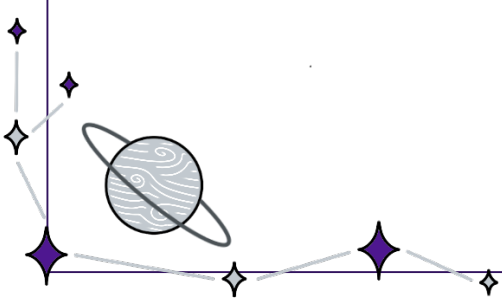Introduces the QuadraticProgram class and how to build optimization problems using Qiskit's optimization module.

QISKIT COURSE: Solving Combinatorial Optimization Problems using QAOA [link]

Introduces combinatorial optimization problems, explains approximate optimization algorithms, and how QAOA works.

VIDEO: The Variational Quantum Eigensolver [link]

Demo of chemistry simulation using VQE for optimization problems. Featuring Jin-Sung Kim from Coding with Qiskit S2E4.

SYLLABUS (CONT'D)

Main Activities (Cont'd)

VIDEO: Circuits for Optimization Problems [link]

Circuit Sessions for optimization problems by Stefan Woerner.

VIDEO: Tutorial on Combinatorial Optimization on Quantum Computers [link]

Video by Ruslan Shaydulin [jupyter notebook for this tutorial]

LAB: Fall Challenge 2022 Lab 3 - Optimization [link]

Learn more about the travelling salesman problem and some fundamental concepts in Quantum Optimization. Complete up to Exercise 2. [Solutions]

ADVANCED SYLLABUS

Optional advanced additional materials

QISKIT COURSE: Solving Satisfiability Problems using Grover's Algorithm [link]

In depth tutorial on solving satisfiability problems using Grover's Algorithm

VIDEO: Approximate Solutions of Combinatorial Problems via Quantum Relaxations [link]

Video showcasing a research collaboration between IBM Quantum and the Boeing Company featuring a quantum relaxation in the context of an optimization problem and a use case in aerospace engineering by Bryce Fuller in the Qiskit Seminar Series.

LAB: Fall Challenge 2022 Lab 3 - Optimization [link]

Practise using Qiskit Primitives to solve a challenging optimization problem. Start from just after Exercise 2, which you completed in main activities. [Solutions]

RESOURCES

Supplementary Materials

■ **VIDEO: Combinatorial Optimization Lecture Series [link]**

A great video series that walks you through combinatorial optimization by Prof. Constantine Caramanis at University of Texas Austin.

■ **COURSE: Optimization Crash Course [link]**

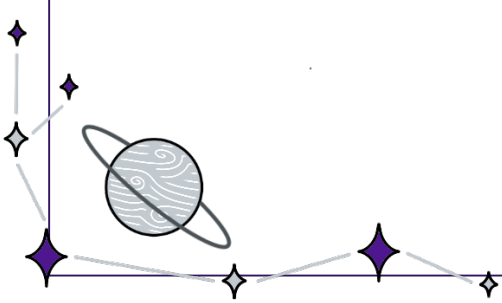A boot-camp lecture series of geometric methods and sampling involving optimization.

■ **LAB: Fall Challenge 2021 Lab 1 - Portfolio Optimization [link]**

This lab has some fantastic explanations on QUBO problems, QAOA, and VQE. [Solutions]

■ **LAB: Fall Challenge 2021 Lab 4 - Optimization [link]**

This lab walks you through some of the application classes available in Qiskit Optimization and additionally explains concepts like QAOA. [Solutions]

UNLOCK YOUR BADGE

QUIZ

Ready to test your knowledge and unlock your achievement?
Return to the Quantum Explorers portal.

Quantum Explorers Portal

PASSED?

Congratulations!

Download your badge image using the password
revealed on passing the quiz.

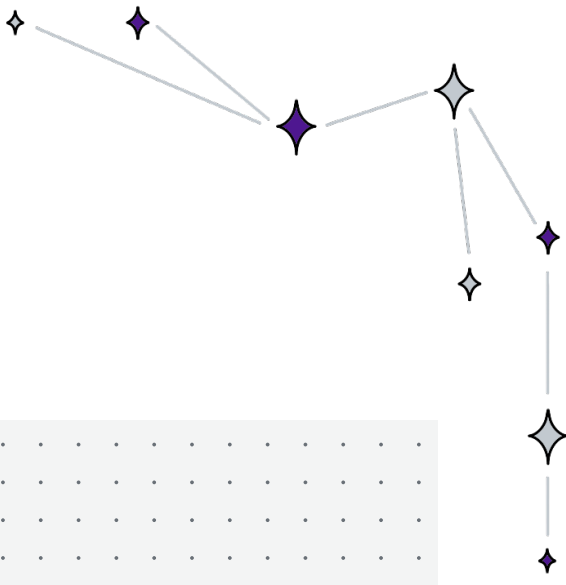Then share your achievement in the #level-up channel
on Discord.

Badge Download

Keep an eye on the #announcements channel for details about the
next modules and Badge achievements.

NOTES