

Resources for Educators

IBM Quantum

Welcome to the IBM Quantum Educators Resources Migration Guide

Dear Quantum Computing Educators,

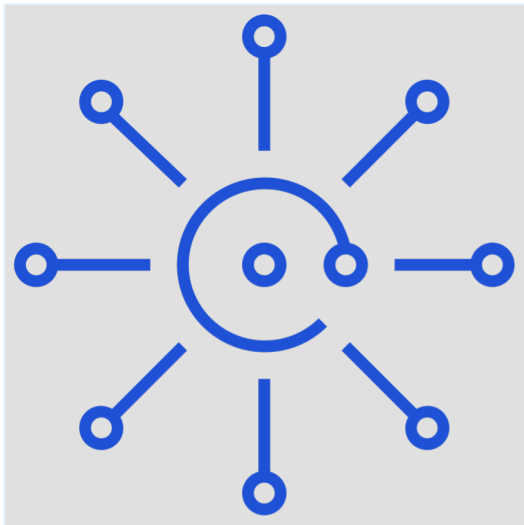
It is an exciting time for quantum computing. Quantum technology is advancing at a tremendous pace, and we are entering the new era of *quantum utility*.

Several changes have been made to the tools and resources made to educators by IBM Quantum™, enabling access to our latest technology.

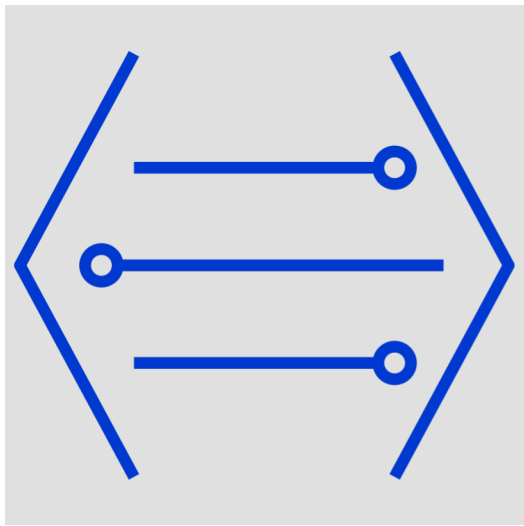
- 1) Addition of next generation quantum computers for the free public access through the Open Plan. 10min per 28days per user.
- 2) Consolidation and revision of documentation and learning resources into one location: quantum.ibm.com
- 3) Digital badges and new learning content created by IBM Quantum.

This document provides a brief orientation on how you can adapt and upgrade your courses reflect these changes.

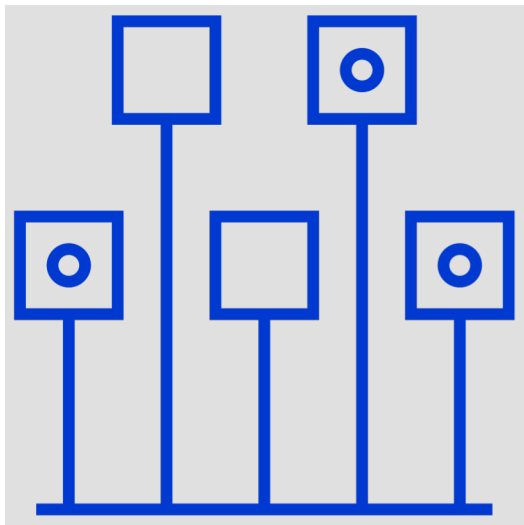
SECTIONS OVERVIEW



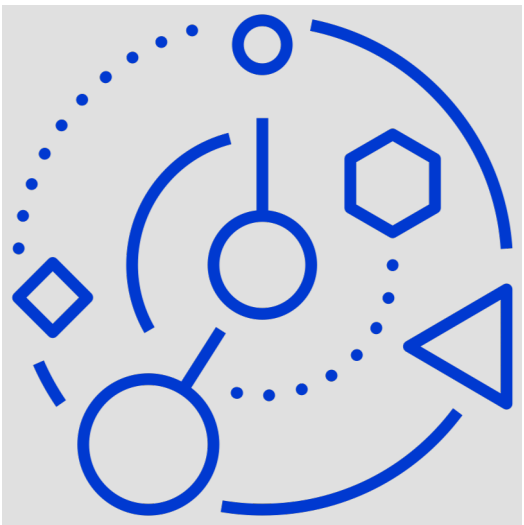
One Place for Everything –
Introducing quantum.ibm.com



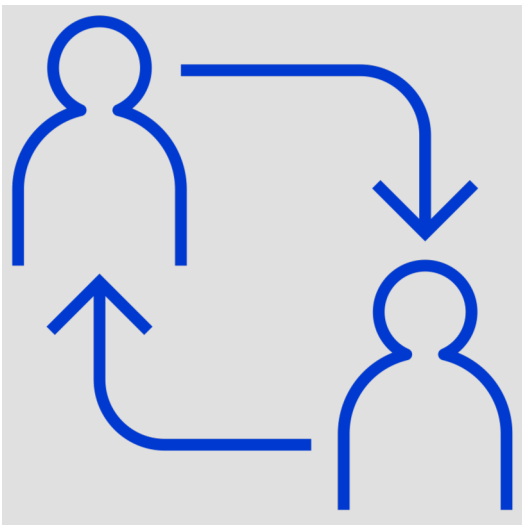
Programing Tools and Access –
What new with IBM Quantum
Composer and IBM Quantum Lab



Documentation and Learning
Consolidation –
For an easier learning experience



Learning Content –
New and existing courses and
tutorials on the new Learning
Platform



Staying in Touch –
Share your achievements and join
channels for alumni, educators, and
community



Links and Further Reading –
Additional news and resources on
the web


One Place for Everything –
Introducing
<https://quantum.ibm.com>

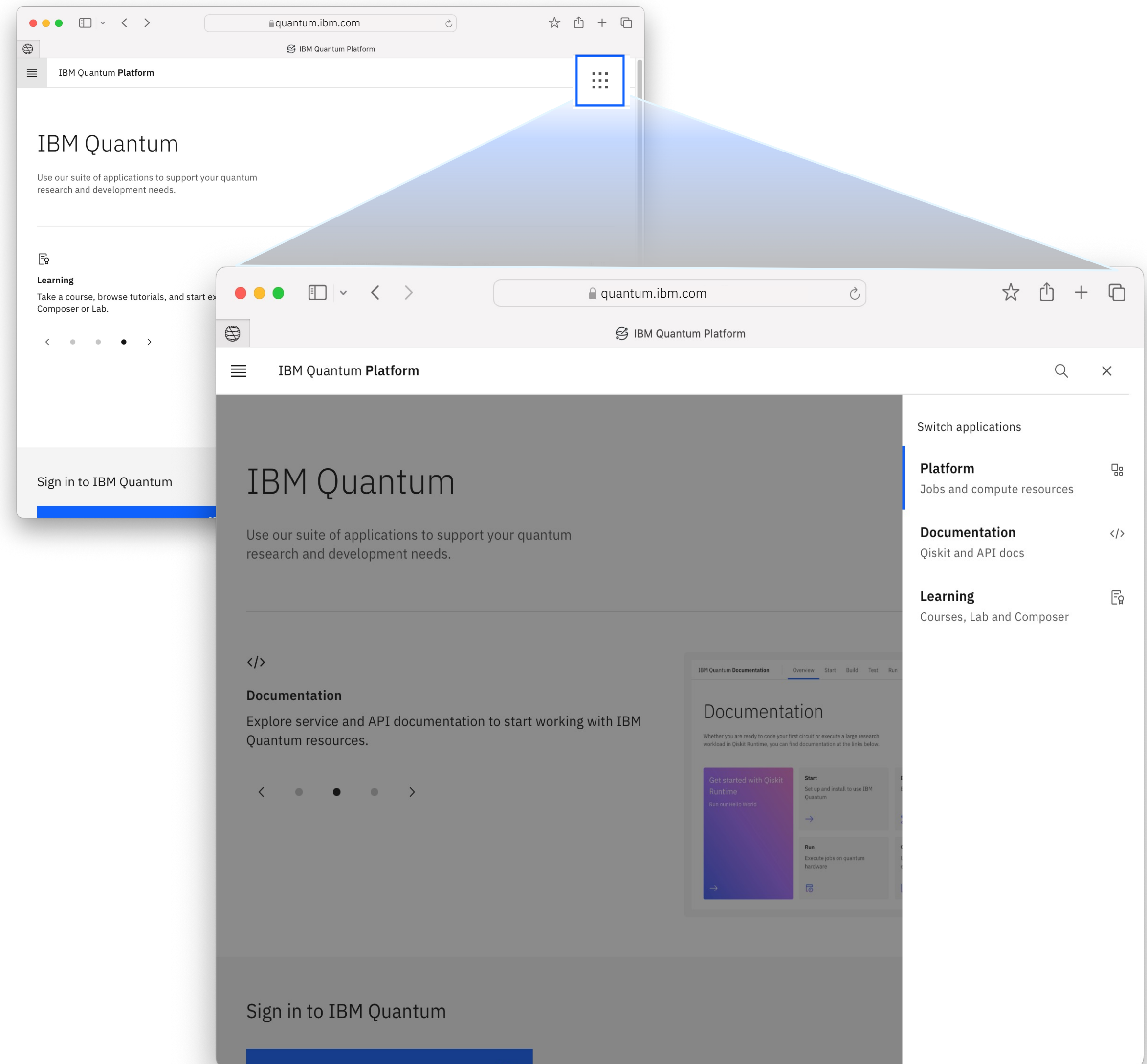


Easy access and viewing from one place

Browse and navigate to

- Platform
- Documentation
- Learning

using the “Application Switcher” icon  in the upper right-hand corner.



Easy access and viewing from one location

The IBM Quantum Platform – Compute resources

- View all compute resources and their properties
- Sign in to filter systems available on your access plan
- Find submitted jobs

quantum.ibm.com

IBM Quantum Platform

IBM Quantum PlatformDashboardCompute resourcesJobs

Compute resources

Access IBM Quantum systems and simulators via our available [access plans](#). Resources you don't have access to will be denoted by a lock.

Instance resourcesAll systemsAll simulators

CardTable

Search by system name

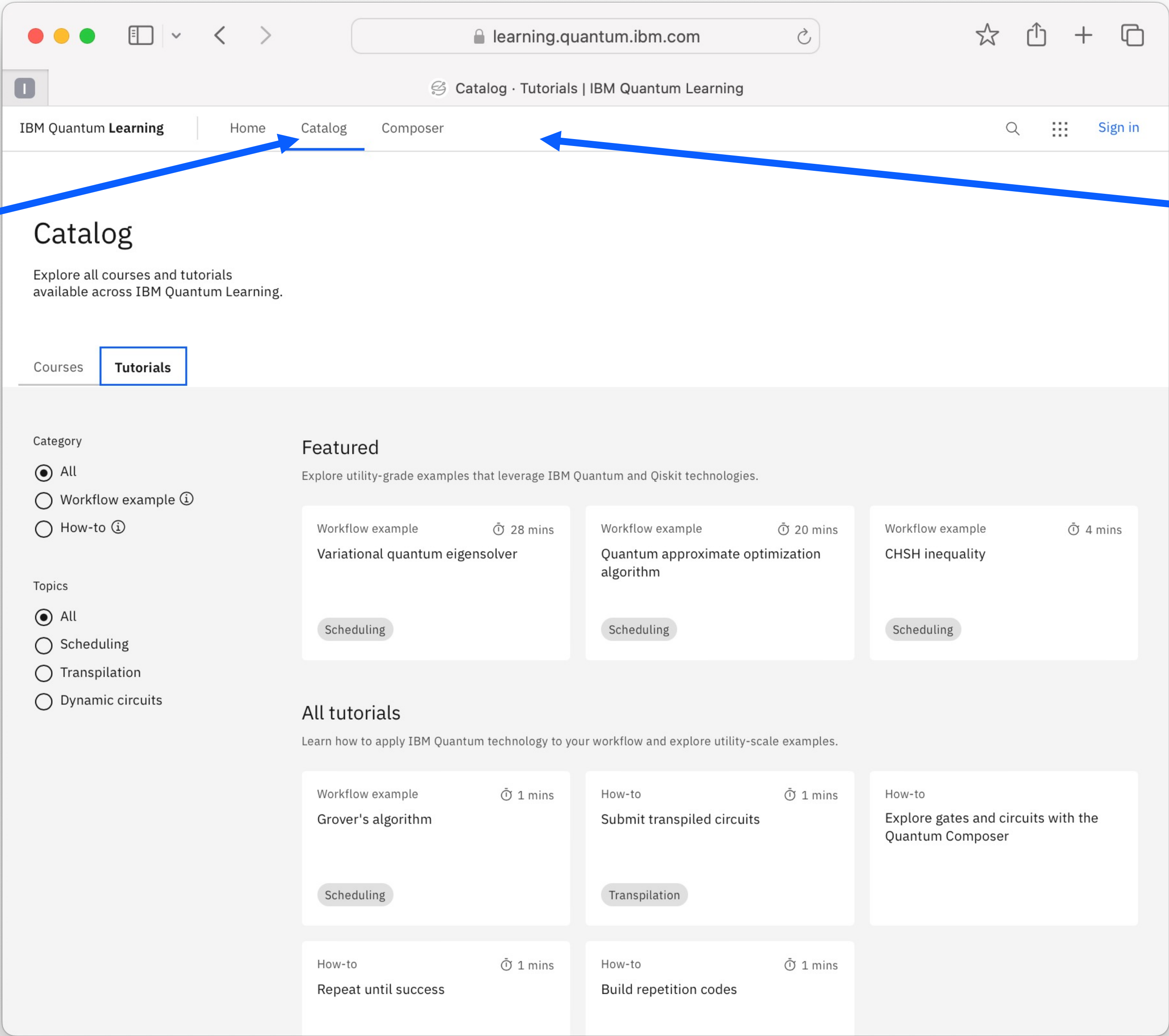
| |
|---|
| <div>ibm_torino</div> <div>System statusOnline</div> <div>Processor typeHeron r1</div> <div><div>Qubits</div>133</div> <div><div>EPLG</div>0.8%</div> <div><div>CLOPS</div>3.8K</div> <div></div> |
|---|

 ibm_sherbrooke System statusOnline Processor typeEagle r3 Qubits 127 EPLG 1.7% CLOPS 5K |

Learning Resources and Tools moved to one place

NEW CATALOG

- Use the newly added Catalog to navigate the brand new courses and tutorials.

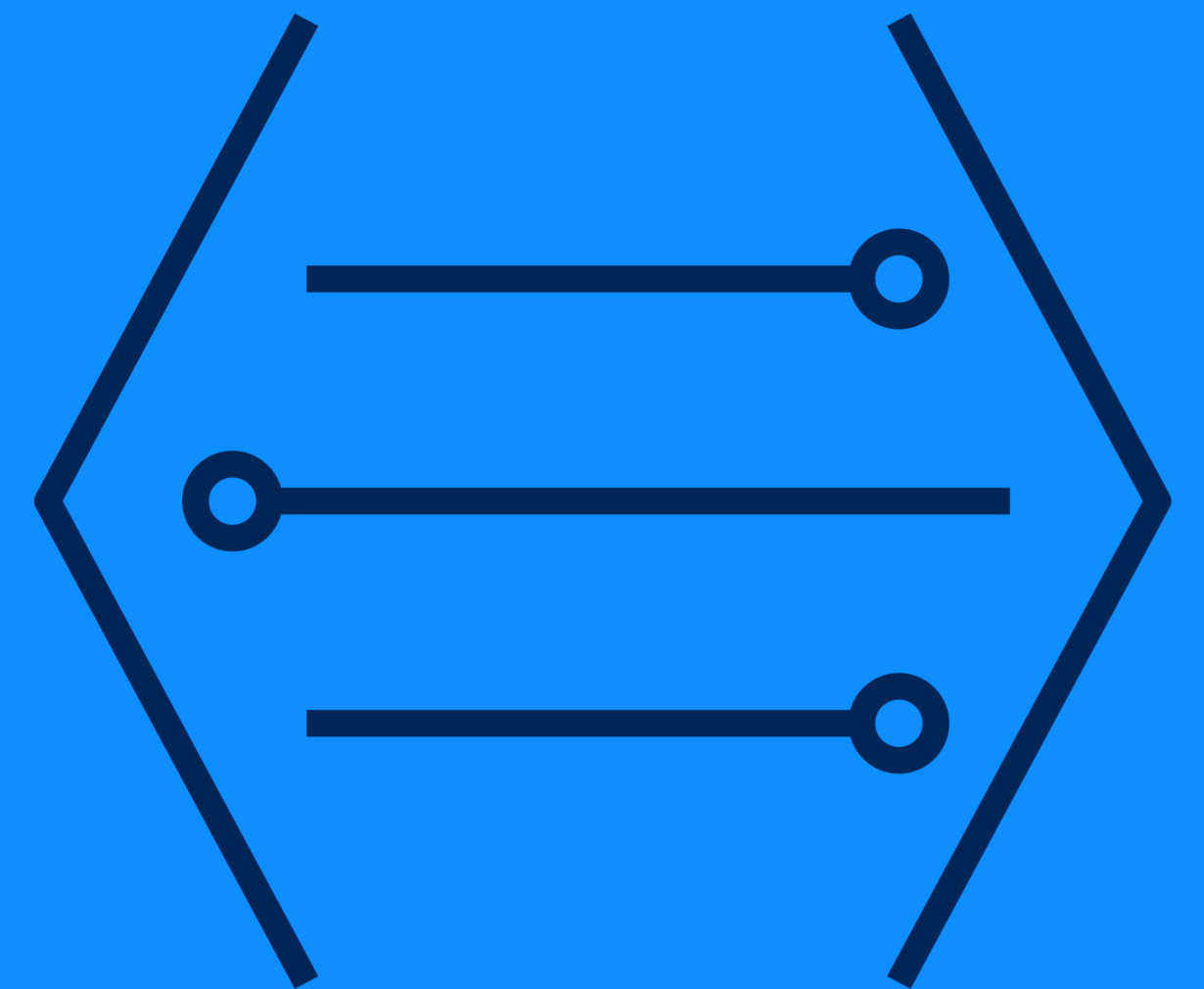


IBM QUANTUM COMPOSER MOVED

New location for learning resources:
learning.quantum.ibm.com

Programing Tools and Access

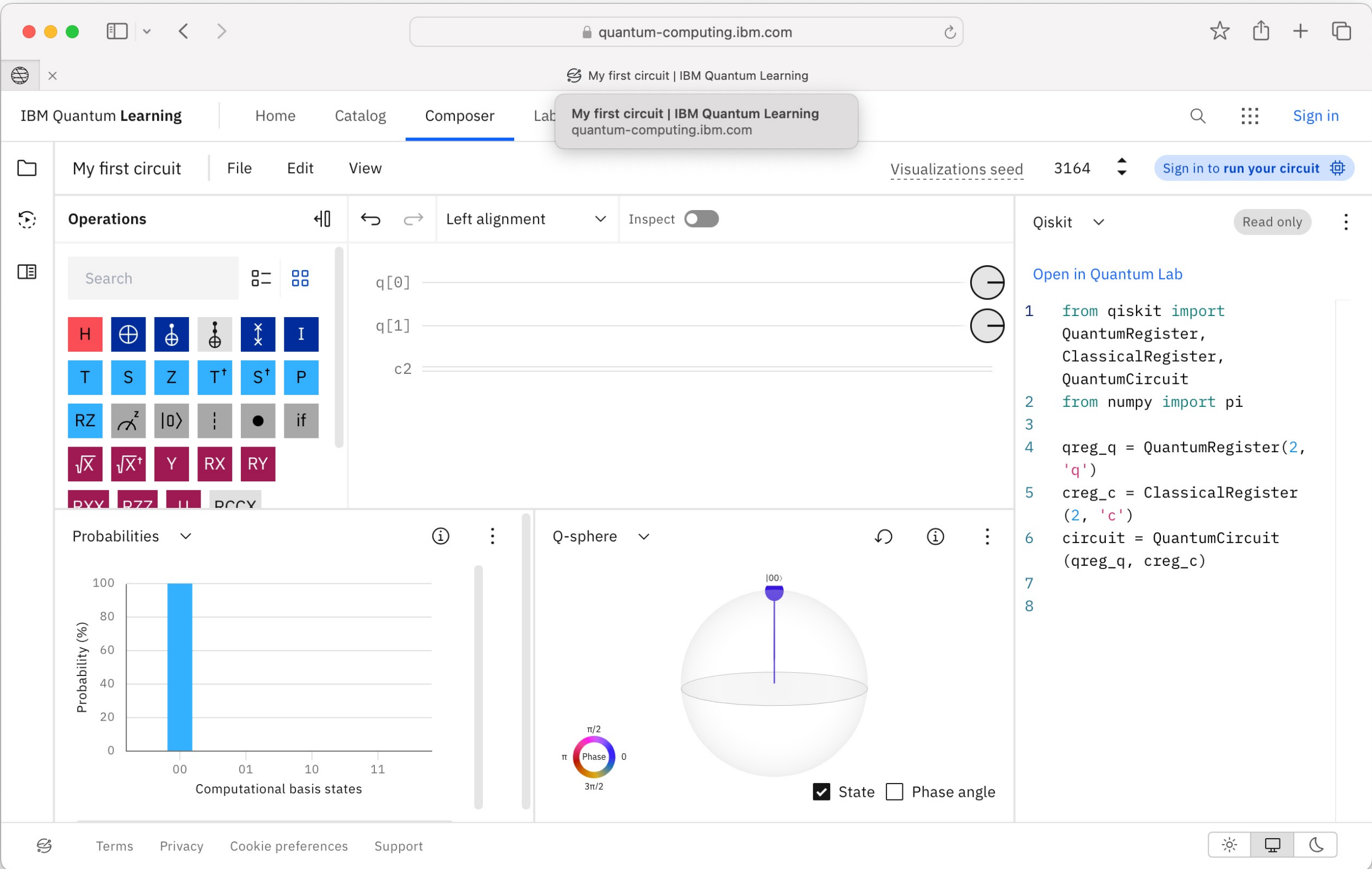
Composer and Lab continue to be available for use in your lectures, enabling a frictionless entry point for learning to program quantum computers. New features and tips are highlighted on the pages that follow.



Quantum Composer – What you know and love

The composer’s layout has been refined over the past three years to make its easy to:

- 1) Show the ideal behavior of gates
- 2) Draw graphical representations of quantum states and measurement results
- 3) Obtain Qiskit® and QASM code corresponding for circuits
- 4) Run circuits on real hardware using the open plan provider (requires sign-in)



Quantum Composer – How to use it in your course

LIVE DRAWING OF IDEAL CIRCUITS:
You can project your screen to introduce and illustrate ideal introductory concepts

STUDENT LOGIN: Invite students to create a free account to be able to do exercises that use real machines.

FAIR-SHARE QUEUE: Algorithm to give everyone a fair chance to submit jobs. On days of high demand, wait time may vary.

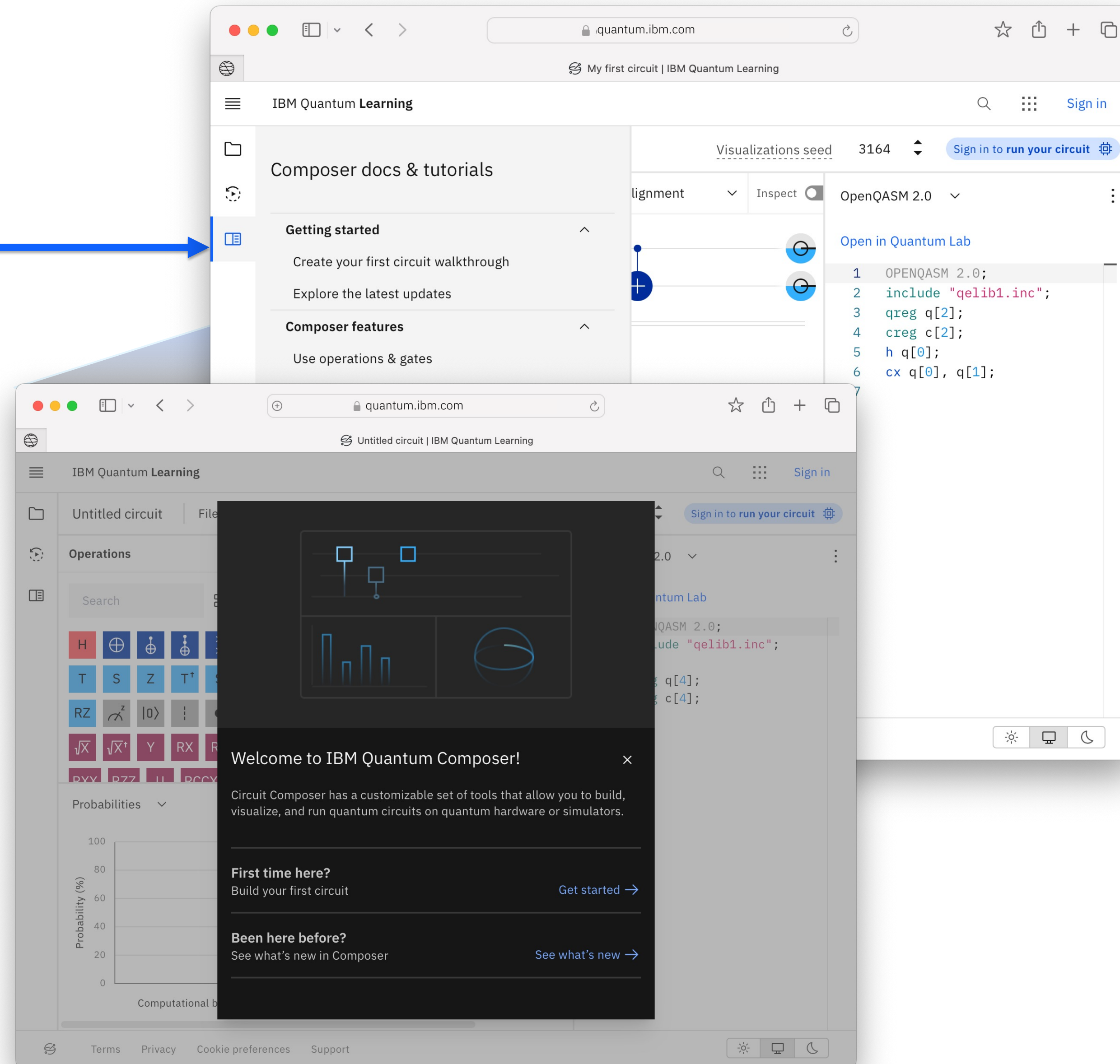
- TIPS:
- Assign work on real machines as homework.
 - Pre-run jobs to avoid delays in live lectures.
 - Download Qiskit and simulators for offline use.
 - Use noisy simulators for introductory courses and small qubit count exercises.

Quantum Composer – What is new?

New tutorials and features.

Navigate to a QuickStart guide and explore new features in the sidebar.

1. New way to use operations and gates
2. ISA transpilation added
[announcement link](#), [documentation link](#)
3. Improved editing and contextual information
4. In-line phase disk
5. Expand gates and show layers
6. Edit registers
7. New themes and options for circuit drawing and image creation



Quantum Lab & Simulators – Replacement Guide

Retirement of cloud simulators and IBM Quantum Lab to focus on utility-scale computing.

[Product Announcement](#) May 2024.

Opt-in to the product announcements setting in your [account profile](#) to stay informed of important updates like these..

Cloud simulators

In line with our focus on [utility-scale](#) quantum computing, we're retiring our cloud simulators on 15 May 2024. We invite you to start using the [Qiskit Runtime local testing mode](#) (with qiskit-ibm-runtime 0.22.0 or later), which makes it possible to perform development and testing locally prior to submitting your workloads to our >100-qubit systems.

This change emphasizes a shift toward quantum hardware capabilities, since the benefits of quantum hardware have surpassed the utility of simulators in helping determine which applications have the greatest potential for advantage.

- Guide: [Migrate from cloud simulators to local simulators](#)
- [Noisy simulation with Qiskit Aer primitives](#)
- [Getting started with Qiskit Aer](#)

IBM Quantum Lab

IBM Quantum Lab will be retired on 15 May 2024 to increase our focus on utility-era tooling.

You can execute jobs locally with [Qiskit](#), or you can set up your own cloud-based environment. For an independent review of alternatives to host jupyter notebooks see for example the article [linked here](#).

Download your Lab files in bulk from the [Lab platform\(opens in a new tab\)](#). Bulk file downloads will remain available until 15 November 2024.

Qiskit

1.0

Now with increased performance, stability, and reliability.

- 55% decrease in memory usage
- 16x faster binding and transpiling
- 23% fewer 2Q gates
- Up to 5x faster with [batch](#) parallelism
- Qiskit Patterns ([link to blog](#))

Read more in the [Qiskit 1.0 Announcement](#) and the [blog](#) and new transpilation architecture.

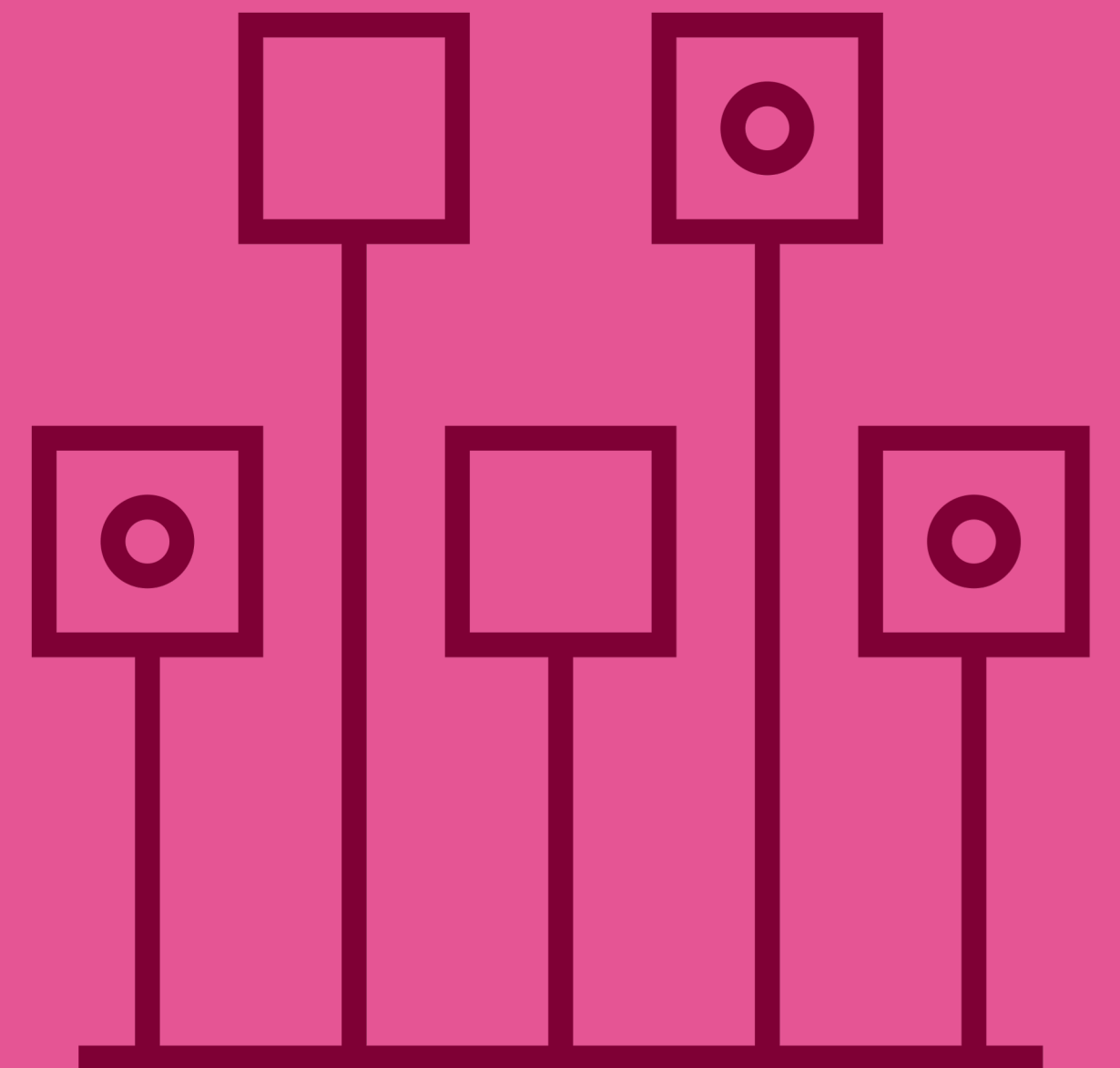
Documentation and Learning Consolidation

On November 29, 2023 Qiskit Documentation and Learning will only be live on IBM Quantum.

Learn more about these important changes [here](#)

Community-built content, such as the Qiskit Textbook, will be available via GitHub. It will not be maintained, instead we are focusing efforts on generating new content and learning tools for the new unified platform on learning.quantum.ibm.com

We will be creating new live learning content in phases into the new platform.



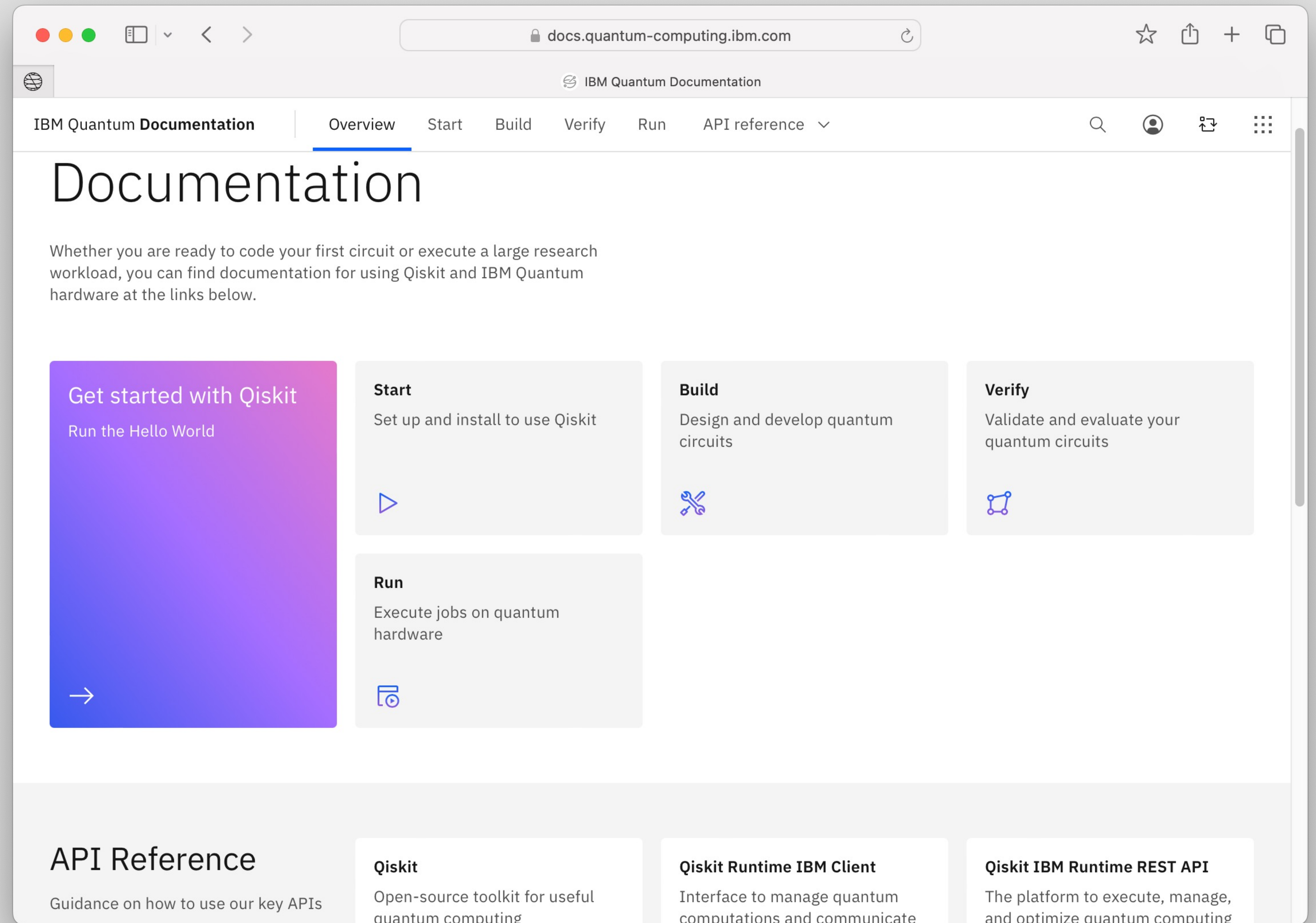
Documentation Consolidation

New documentation pages consolidate the IBM Quantum documentation and Qiskit.org documentation into one location to improve navigation and maintenance.

Get started with Qiskit, in 4 steps:

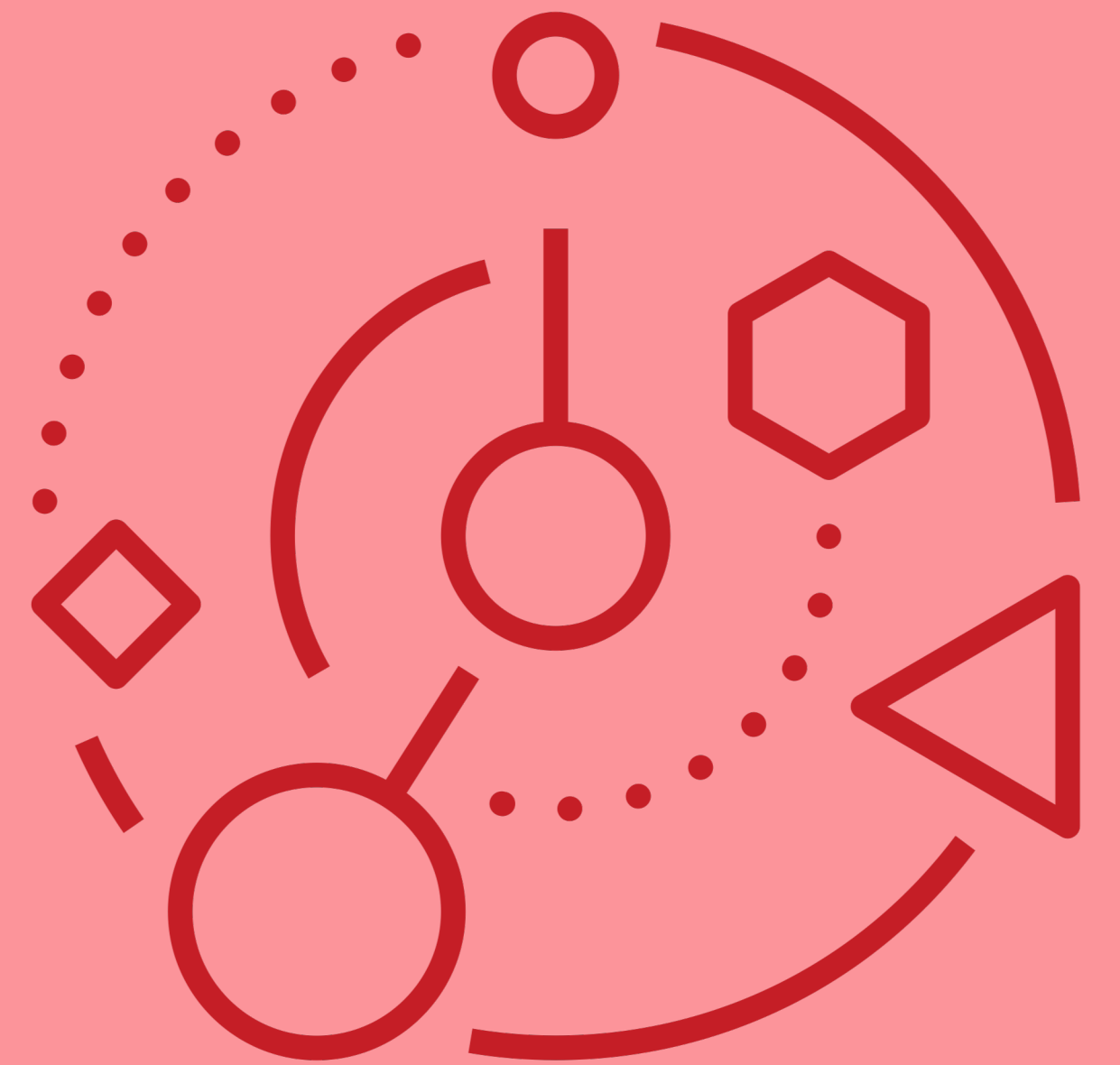
- (1) Start,
- (2) Build,
- (3) Verify,
- (4) Run.

Includes a complete API reference documentation for Qiskit, Qiskit Runtime and IBM providers



Learning Content –

New and existing courses
and tutorials on the new
Learning Platform



Courses

Currently available

- Basics of quantum information
- Fundamentals of quantum algorithms
- Variational algorithm design
- Practical introduction to quantum-safe cryptography

Coming in 2024

- The general formulation of quantum information
- Quantum computing in the presence of noise
- Quantum computing in practice
- Heterogeneous quantum computing

IBM Quantum Learning

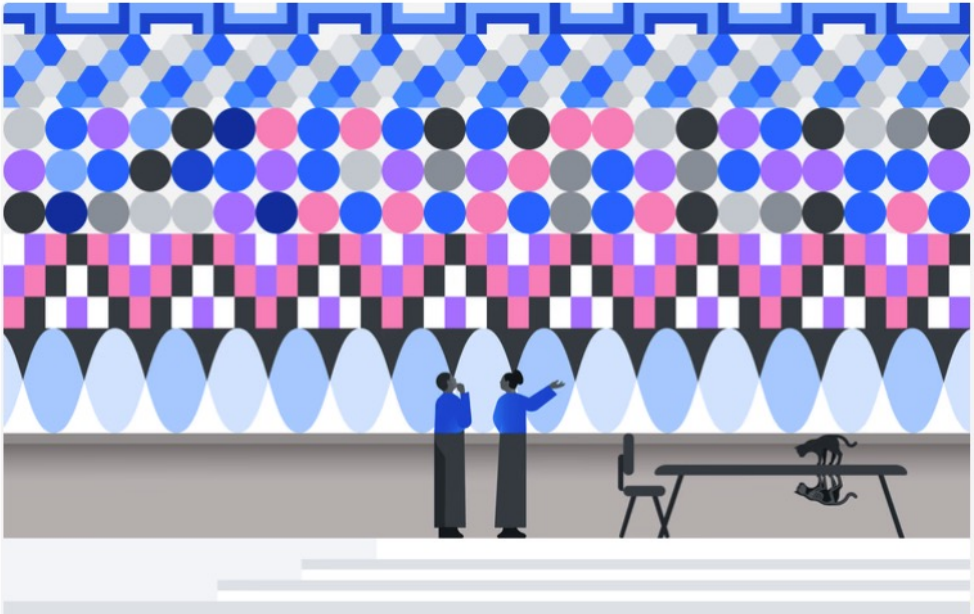
HomeCatalogComposerLab

Q⋮Sign in

IBM Quantum Learning

Learn the basics of quantum computing, and how to use IBM Quantum services and systems to solve real-world problems.

Explore the latest course



Fundamentals of quantum algorithms

New

Use quantum computers to solve problems more efficiently, including problems with real-world relevance such as searching and factoring.

Lessons

4

Your progress

N/A

Start course →

Courses

Learn about key concepts, algorithms, and their applications

[View all](#)

Basics of quantum information

A detailed course covering mathematical aspects of quantum computing, comparable to an advanced undergraduate or introductory...

Lessons

4

Start course →

Variational algorithm design

Today's hardware is delicate and error-prone. This course covers variational algorithms, which play to the strengths of these machines.

Lessons

7

Start course →

Practical introduction to quantum-safe cryptography

New

An introduction to quantum-safe cryptography, and how quantum computing poses a risk to existing cryptography.

Lessons

7

Start course →

Tutorials

Explore utility-grade algorithms and applications with Qiskit Runtime

[View all](#)

Tutorial

Demonstrate the violation of the CHSH inequality with the Estimator primitive

→

Tutorial

Variational Quantum Eigensolver using Estimator primitive and sessions

→

Tutorial

Quantum Approximate Optimization Algorithm using Qiskit Runtime primitives and sessions

→

Tutorial

Grover's algorithm using the Sampler primitive

→

Tutorial

Working with the Qiskit Runtime Sampler primitive

→

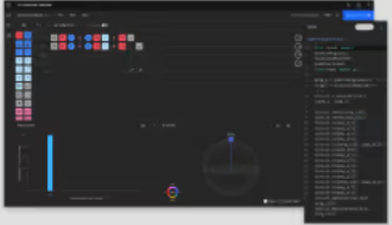
Tutorial

Error suppression and error mitigation with Qiskit Runtime

→

Tools

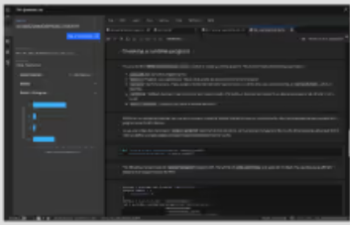
Start experimenting in one of our quantum programming environments



Quantum Composer

Build, simulate, and run quantum circuits with a drag-and-drop interface

→



Quantum Lab

Develop quantum programs in a custom JupyterLab environment

→

Understanding Quantum Information & Computation

Explains the theory of quantum information and computation at a detailed mathematical level.

Consists of four units, Unit 1 and 2 are available units 3 and 4 are coming later in 2024:

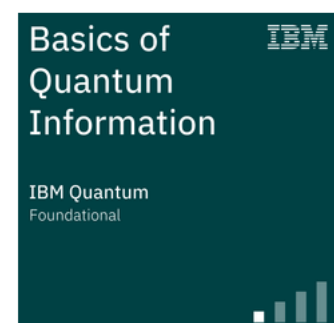
1. [Basics of quantum information](#)
2. [Fundamentals of quantum algorithms](#)
3. [The general formulation of quantum information](#)
4. Quantum computing in the presence of noise

Each unit consists of 4 lessons (video and text).

Problem sets, labs, and unit summative exams.

Badge 1 available, more under construction

Awarded badge



IBM Quantum Learning | Home | Catalog | Composer | Lab

Course overview / Fundamentals of quantum algorithms

- Phase-estimation and factoring
 - Introduction
 - Phase estimation problem
 - Spectral theorem
 - Problem statement
 - Phase estimation procedure
 - Warm-up: approximating phases with low precision
 - Quantum Fourier transform**
 - General procedure and analysis
 - Shor's algorithm
 - Order finding

32-dimensional quantum Fourier transform

The diagram shows a quantum circuit with 5 horizontal lines representing qubits. The top line is labeled 'a' and the bottom line is labeled 'b'. The qubits are labeled x₀, x₁, x₂, x₃ on the left and y₀, y₁, y₂, y₃ on the right. A large blue box labeled 'QFT₁₆' is on the left, spanning qubits x₀ through x₃. On the top line, there are four phase shift gates with values π/16, π/8, π/4, and π/2. A Hadamard gate 'H' is on the top line after the phase shifts. There are also control points (dots) on the other qubit lines for the phase shifts. The circuit ends with measurement symbols (circles with 'x') on all four qubit lines.

Analysis

The key formula we need to verify that the circuit just described implements the 2^m -dimensional quantum Fourier transform is this one:

$$(-1)^{ab} \omega_{2^{m-1}}^{xy} \omega_{2^m}^{ay} = \omega_{2^m}^{(2x+a)(2^{m-1}b+y)}.$$

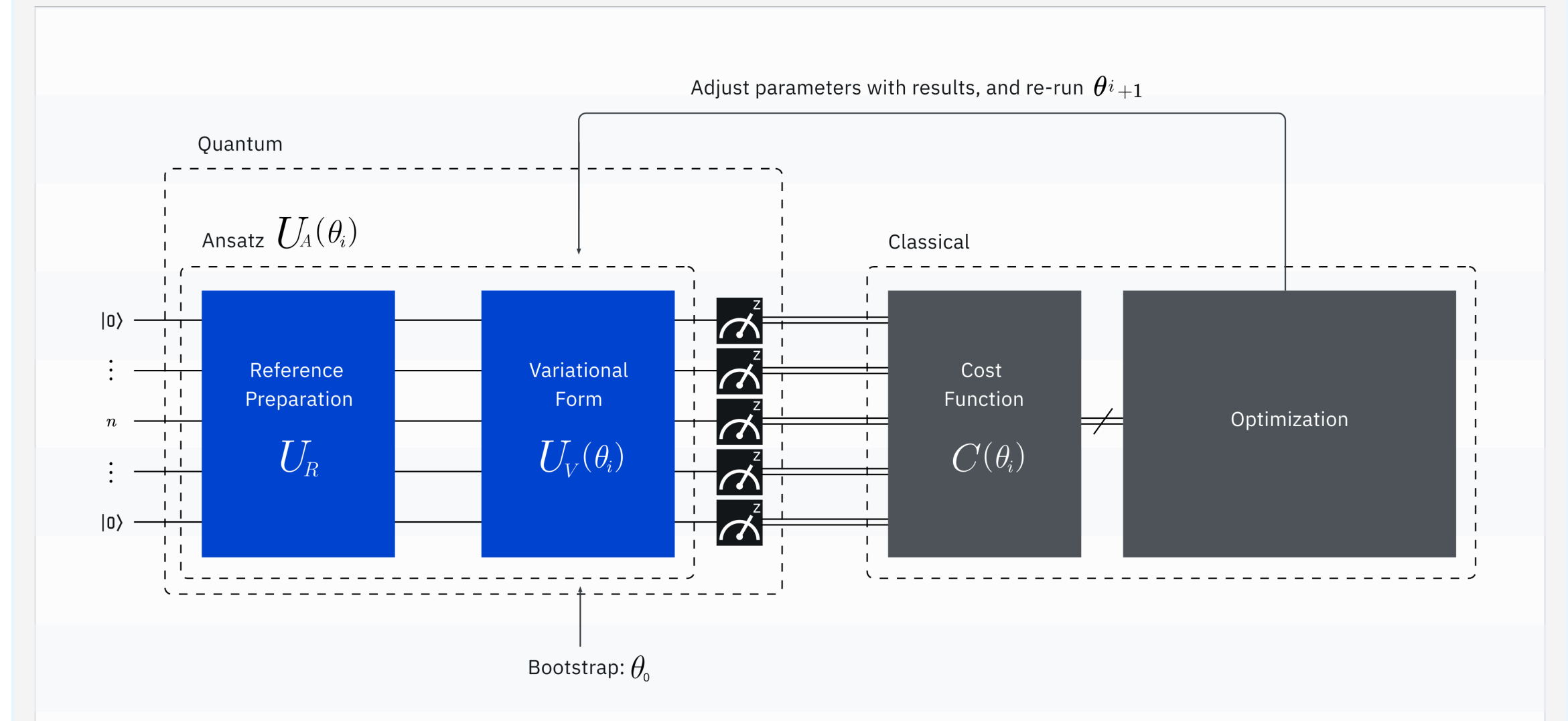
Learn how to design hybrid algorithms for today's quantum systems.

Variational Algorithm Design introduces a class of near-term, hybrid-quantum-classical algorithms applicable for a variety of use cases across chemistry, optimization, machine learning, etc.

This course explores each step in the algorithm workflow, tradeoffs associated with each step, and how to use Qiskit Runtime primitives to optimize for speed and accuracy.

Read more [here](#)

Awarded badge



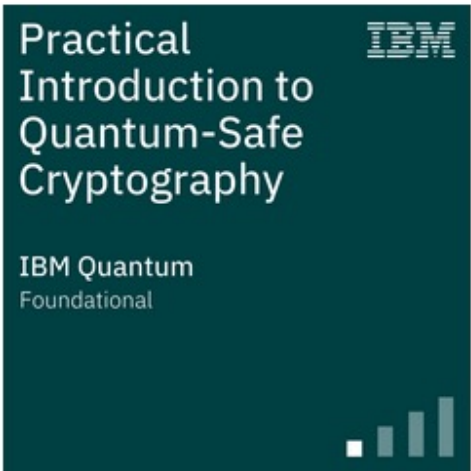
Understand how to make the world quantum-safe.

Practical Introduction to Quantum-Safe Cryptography reviews today’s cryptography that secures our online banking applications, healthcare records, e-commerce transactions, and electronic messaging systems.

Review how quantum poses risks to popular encryption standards and explore the latest algorithms to secure data.

Read more [here](#)

Awarded badge



IBM Quantum **Learning**

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Practical introduction to quantum-safe cryptography

Review the basics of cryptography, and understand the challenges posed by new quantum algorithms, as well as how to mitigate the impact of that challenge through use of new quantum-safe encryption algorithms.

Start from beginning →

Lessons (0/7 complete)Expand all lessons

| | |
|--------------------------------|---|
| ○ Introduction to this course | ▼ |
| ○ Cryptographic hash functions | ▼ |
| ○ Symmetric key cryptography | ▼ |
| ○ Asymmetric key cryptography | ▼ |
| ○ Quantum-safe cryptography | ▼ |
| ○ What's next? | ▼ |

Helpful materials

The following may be useful to you when reading through the course:

Pre-reading

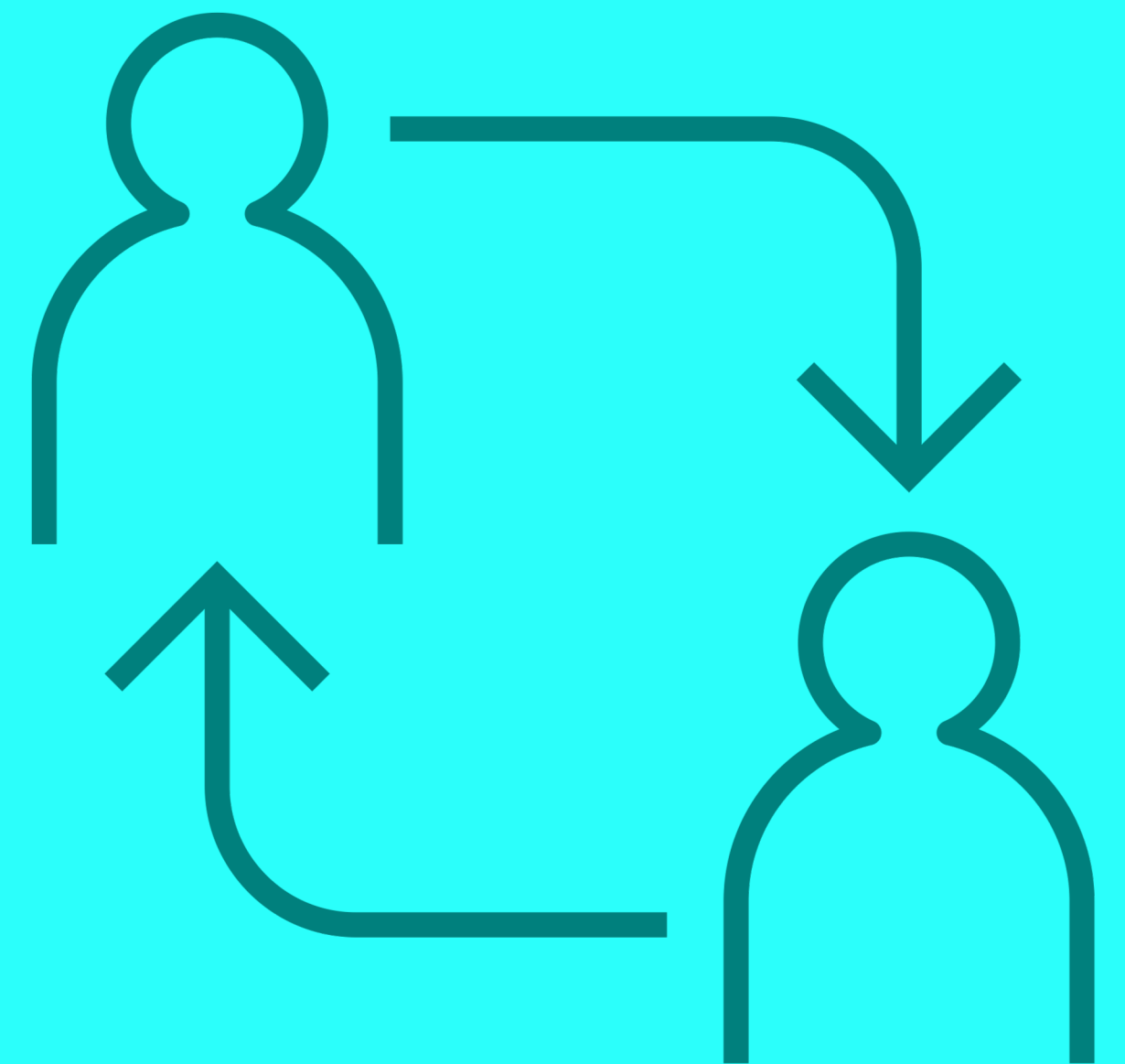
This course contains a lot of detail on cryptography, and numerous maths examples which may use terminology and symbols you are not familiar with.

[This Presentation](#) offers:

- A primer on cryptography
- An introduction to some of the maths concepts used in this course

Staying in Touch

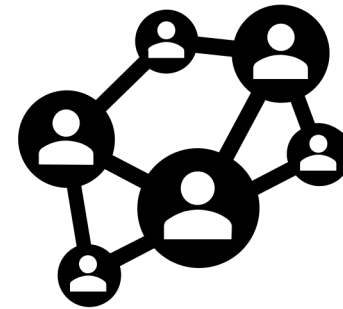
Share your achievements and join channels for alumni, educators and community



Staying in Touch



Share your achievements enabled by these resources
<https://quantum-computing.ibm.com/credits-program/achievements>



Explore the Qiskit partners, advocate ecosystem. Learn about community events.
<https://qiskit.org>



Contact email:
quantum.programs@ibm.com

Links

Further resources with news and information



Resources: Self-learning

Quantum Tools & Hardware

[IBM Quantum Platform](#)

[IBM Quantum Composer](#)

[IBM Quantum Lab](#)

[OpenQASM](#)

[IBM Cloud](#) – (for pay-as-you go option)

Learning

[IBM Quantum Learning](#)

[IBM Quantum Website](#)

Documentation & Certifications

[Documentation](#)

[IBM Quantum page for Qiskit Developers](#)

[Developer Certificate Syllabus](#)

[Developer Certificate Details](#)

YouTube Channels

[IBM Research on YouTube Quantum Computing Playlist](#)

[Qiskit YouTube Channel](#)

Resources: Web, Social Media and Blogs

Articles on new Advancements

[IBM Quantum Blog](#)

[IBM Research Blog](#)

[IBM Research Europe](#)

[Database of Publications
by IBM Quantum Network
members](#)

Key Information about IBM Quantum

[IBM Quantum Website](#)

[IBM Quantum Summit
2023 \(Webpage\)](#)

[IBM Quantum Summit
Keynote 2023 \(Video\)](#)

[IBM Quantum Summit Full
Playlist \(Videos\)](#)

Announcements on Social Media

[Jay Gambetta](#)

[IBM Research](#)

[IBM Quantum LinkedIn](#)

[Qiskit](#)

Community & Help

[Qiskit on Slack](#)

#qiskit-101
#qiskit-dev
#ibm-quantum-systems
#ibm-quantum-platform
...and many more

[Qiskit on GitHub](#)

[Quantum computing on
Stack Exchange](#)

[Stack Overflow – Qiskit tag](#)

Application use cases

The tools of utility

IBM Quantum is not in this alone. Working groups bring together the best industry pioneers and scientists in their field to accelerate our path to achieving Quantum Advantage by 2025 across several domain areas:

Optimization

Quantum Optimization: Potential, Challenges, and the Path Forward:

<https://arxiv.org/abs/2312.02279>

High energy physics

Quantum Computing for High-Energy Physics: State of the Art and Challenges. Summary of the QC4HEP Working Group

[arXiv:2307.03236](https://arxiv.org/abs/2307.03236)

Materials and HPC

Quantum-centric Supercomputing for Materials Science: A Perspective on Challenges and Future Directions

<https://arxiv.org/abs/2312.09733>

Healthcare and life sciences

Towards quantum-enabled cell-centric therapeutics

[arXiv:2307.05734](https://arxiv.org/abs/2307.05734)

