

18-819F: Introduction to Quantum Computing 47-779/47-785: Quantum Integer Programming & Quantum Machine Learning

Create AWS Braket, Dwave Leap, and IBM Qiskit accounts

Access USRA RIACS Resources

Join CMU Quantum Computing

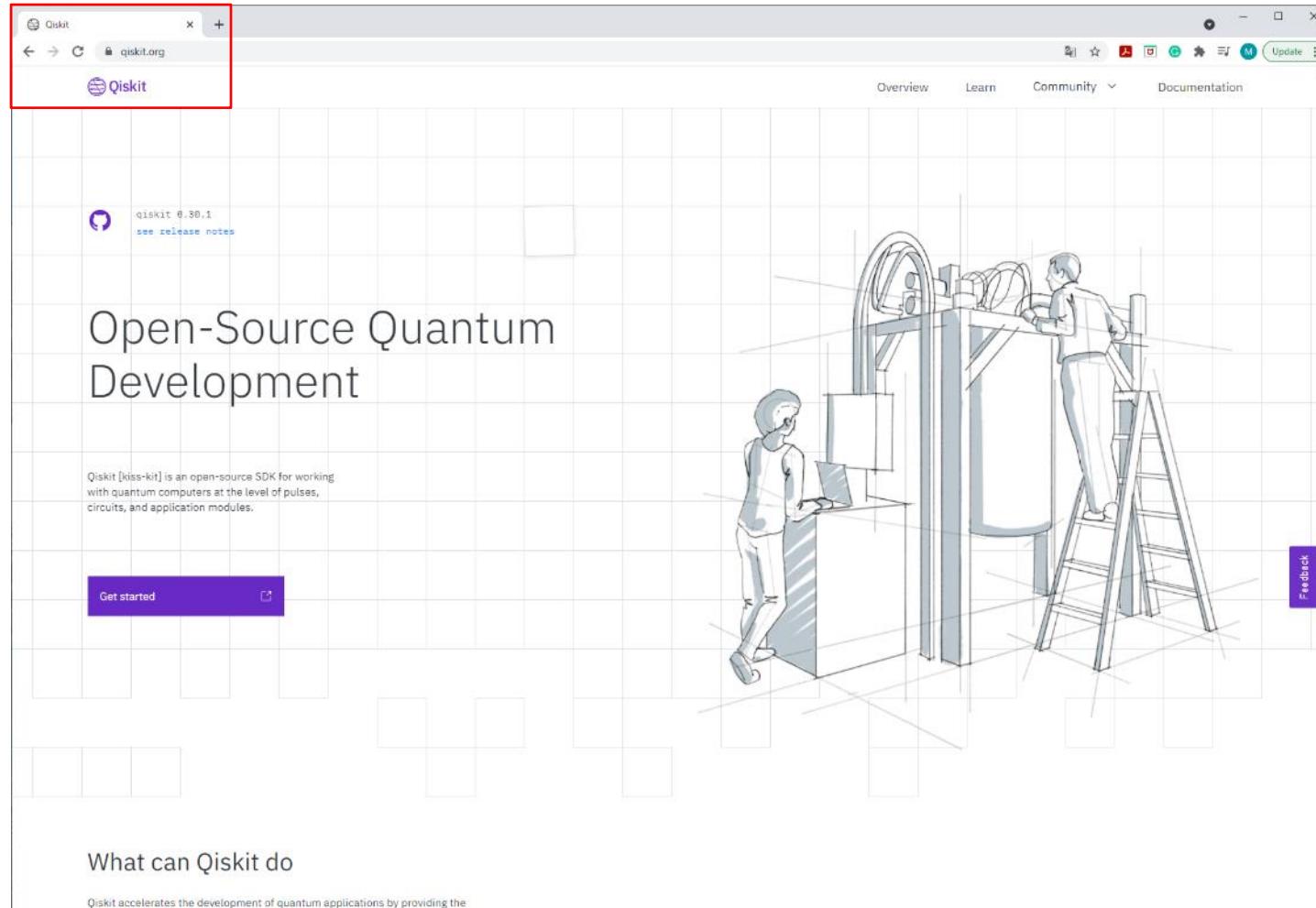
Lecture X

09.28.2022

Agenda

- Create IBM (Qiskit) account
- Create D-Wave (Leap) account
- Create AWS account
- Amazon Bracket
- Accessing USRA resources

Create IBM (Qiskit) account



1- Go to www.qiskit.org

Create IBM (Qiskit) account

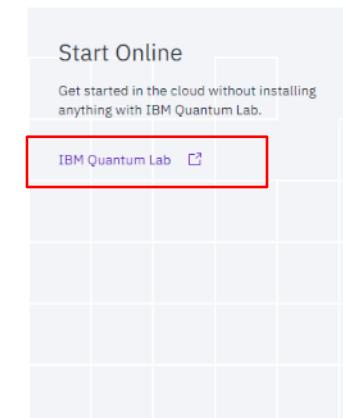
Quick Start

When you are looking to start Qiskit, you have two options. You can start Qiskit locally, which is much more secure and private, or you get started with Jupyter Notebooks hosted in IBM Quantum Lab.

Start locally

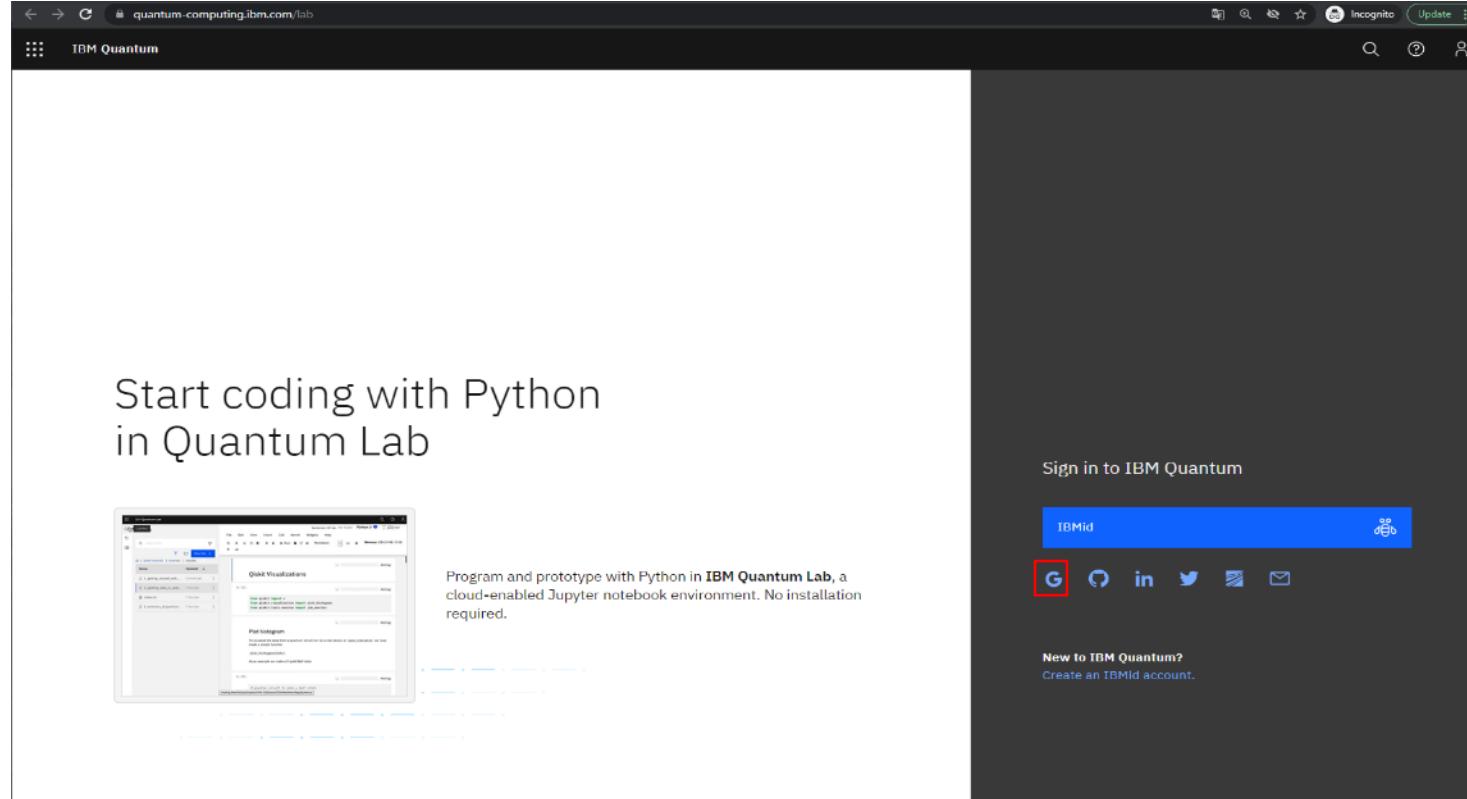
To install Qiskit locally, you will need [Python 3.6+](#). Although it is not required, we recommend using a [virtual environment with Anaconda](#).

The screenshot shows the Qiskit Install page. It has four main sections: 1. Qiskit Install: A button for "Stable (recommended)" is highlighted with a purple border. 2. Operating System: Buttons for "Linux", "Mac" (highlighted with a purple border), and "Windows". 3. Terminal: A code input field containing "pip install qiskit" with a "copy" button to its right. 4. A large red box highlights the "IBM Quantum Lab" link under the "Start Online" heading.



2- Scroll down to Start Online and click where it says “IBM Quantum Lab”.

Create IBM (Qiskit) account



3- If you want to log with your cmu account, click Google's symbol

Create IBM (Qiskit) account

Acceder con Google

Acceder

Ir a [ibm.com](#)

Correo electrónico o teléfono

[¿Olvidaste el correo electrónico?](#)

Para continuar, Google compartirá tu nombre, dirección de correo electrónico, preferencia de idioma y foto de perfil con ibm.com. Antes de usar ibm.com, revisa su [política de privacidad](#) y [condiciones del servicio](#).

[Crear cuenta](#) [Siguiente](#)

Web Login

AndrewID

Password

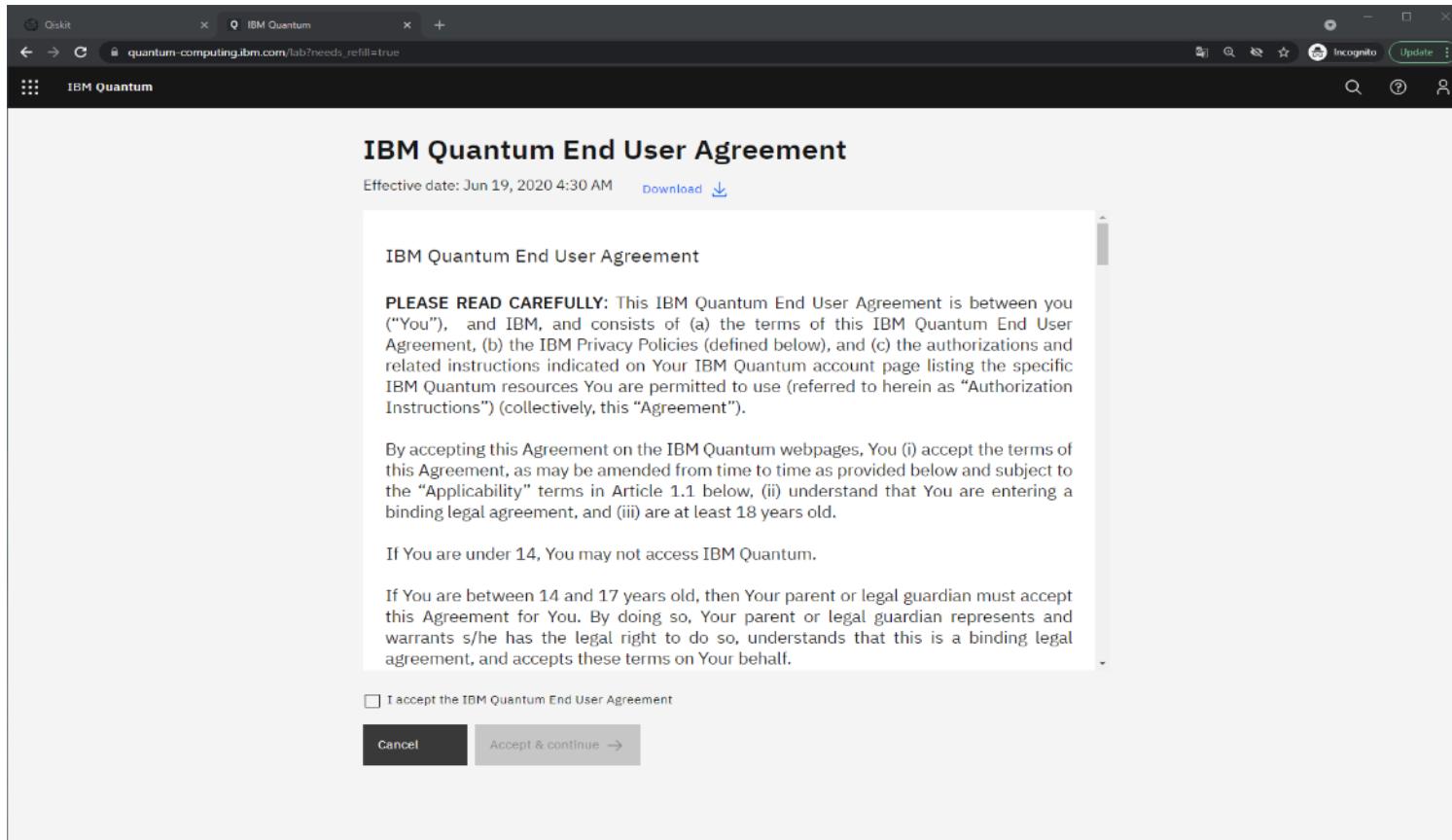


Warning: The URL for this page should begin with <https://login.cmu.edu>. If it does not, do not fill in any information, and report this site to it-help@cmu.edu.

[About](#) | [Change Password](#) | [Forgot Password?](#)

4- Log with your credentials

Create IBM (Qiskit) account



5- Read the End User Agreement

Create IBM (Qiskit) account

Last step! Before you get started,
Tell us a little more about yourself

First name *

Last name *

Your institution *

Carnegie Mellon University

What is your familiarity with quantum?

Select an option

What would you like to use IBM Quantum for?

Stay up to date with the latest news and updates by receiving:

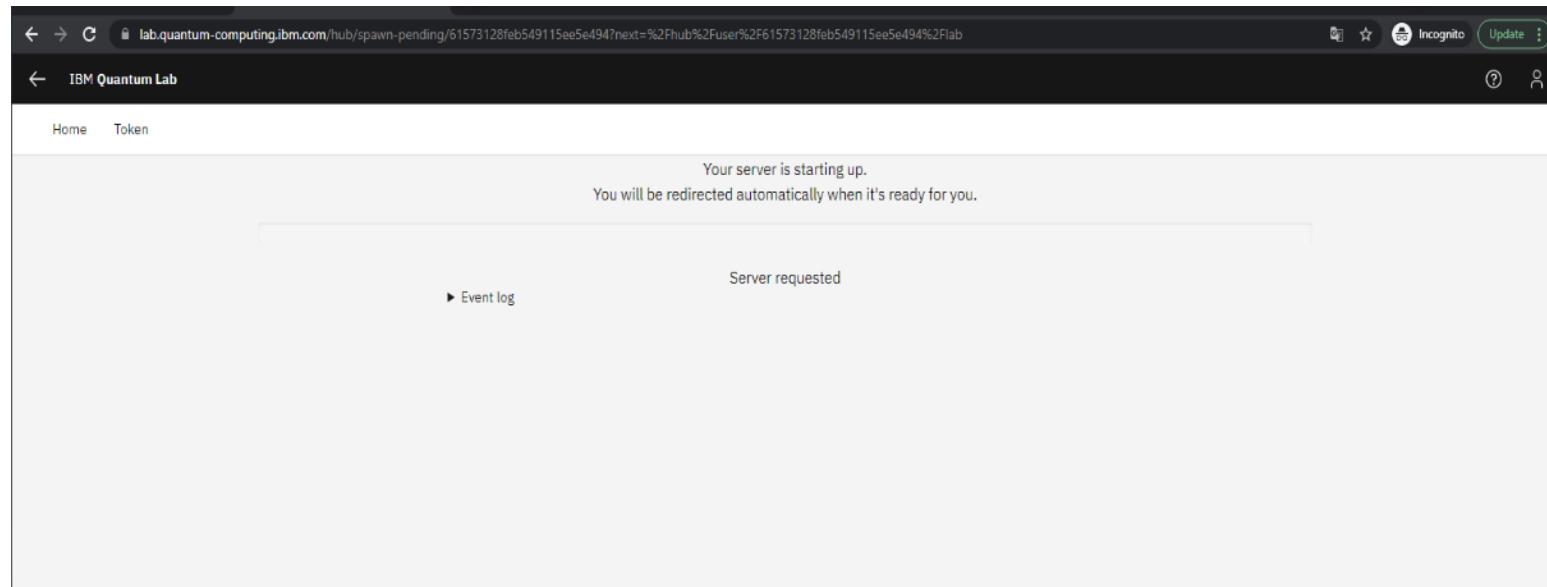
Product updates and announcements
 IBM Quantum newsletter
 Tips about using our tools
 Requests for feedback to help improve our tools

Cancel Continue →

This screenshot shows the final step of creating an IBM Quantum account. It asks for personal information (first and last name), the user's institution (set to Carnegie Mellon University), and their familiarity with quantum computing. It also asks what the user plans to use IBM Quantum for and provides options to receive news and updates. At the bottom, there are 'Cancel' and 'Continue' buttons.

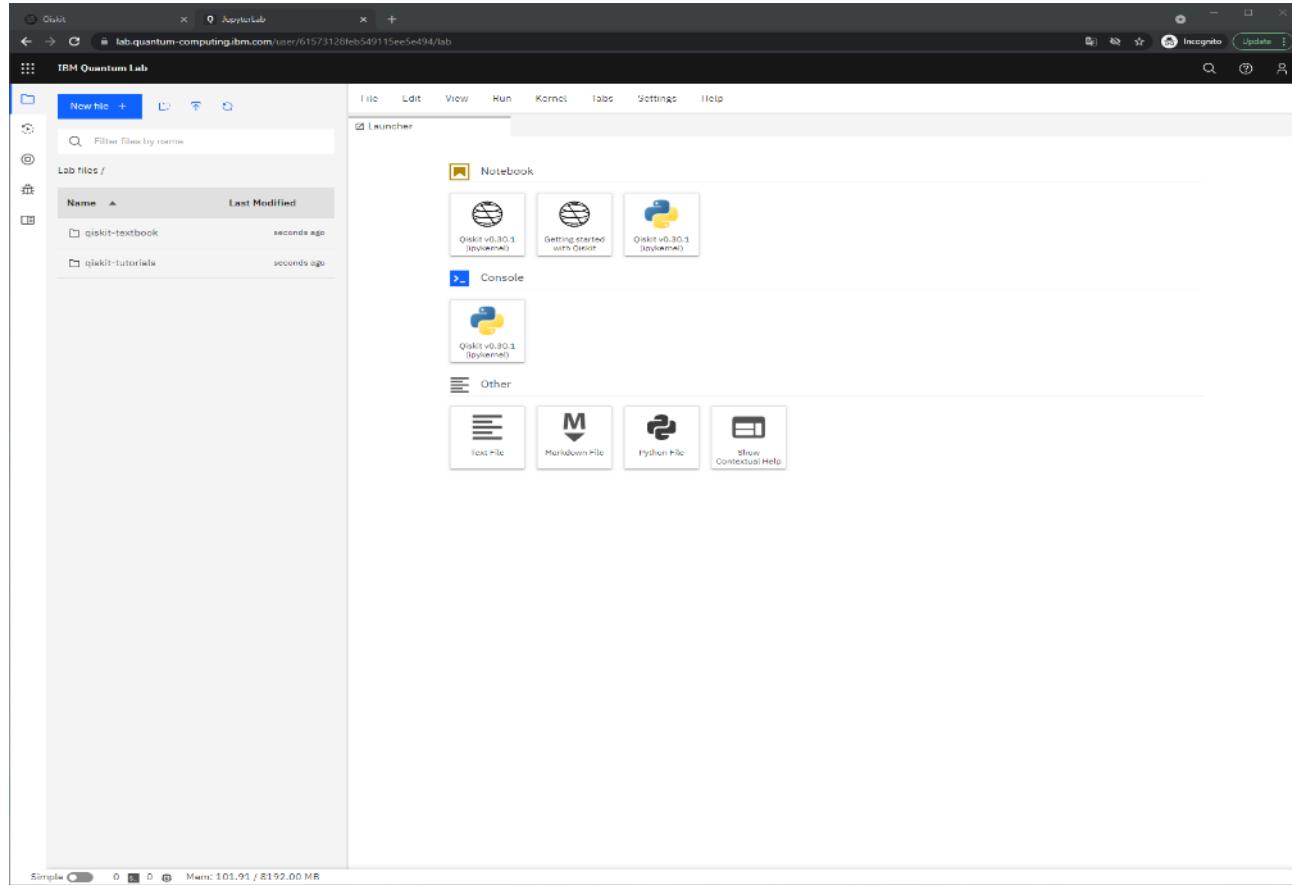
6- Complete the last step

Create IBM (Qiskit) account



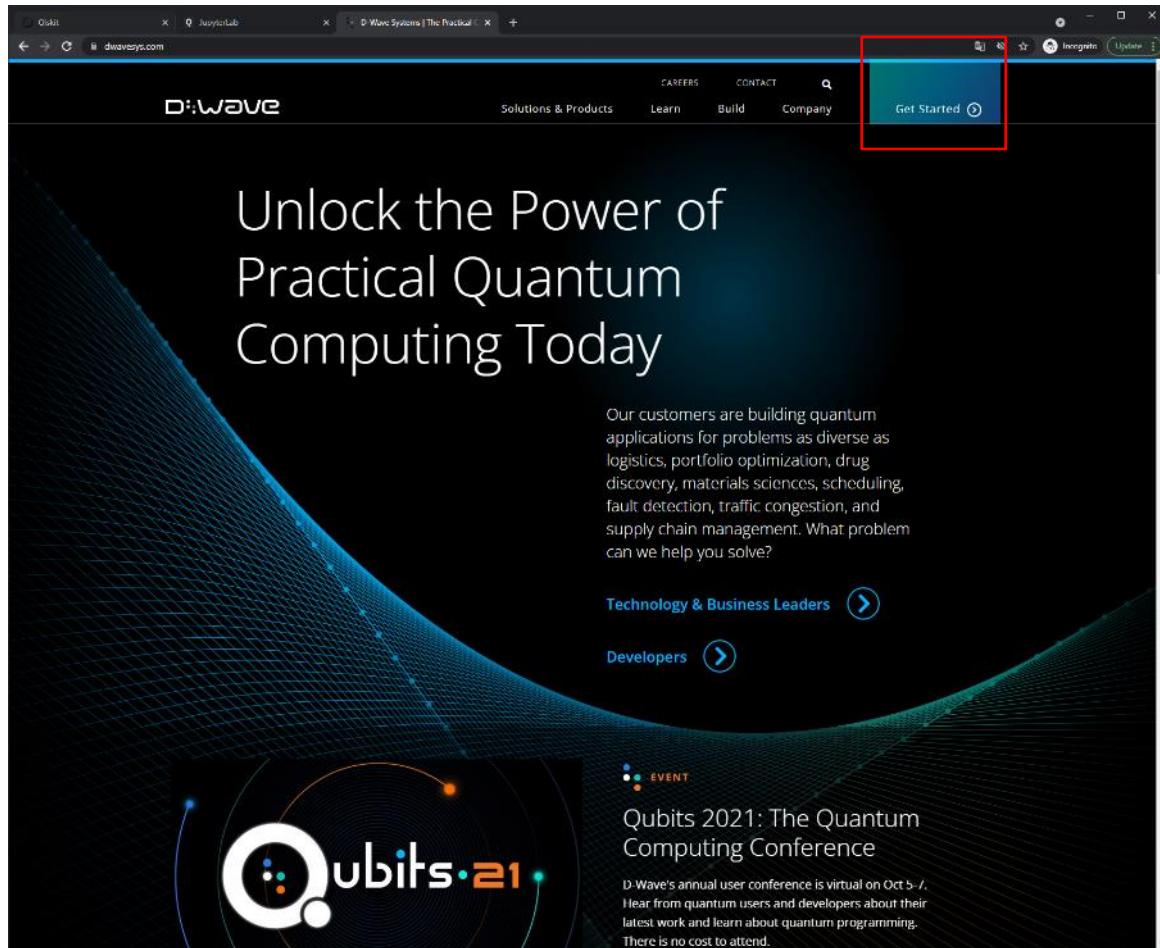
7- Wait while the server is starting up

Create IBM (Qiskit) account



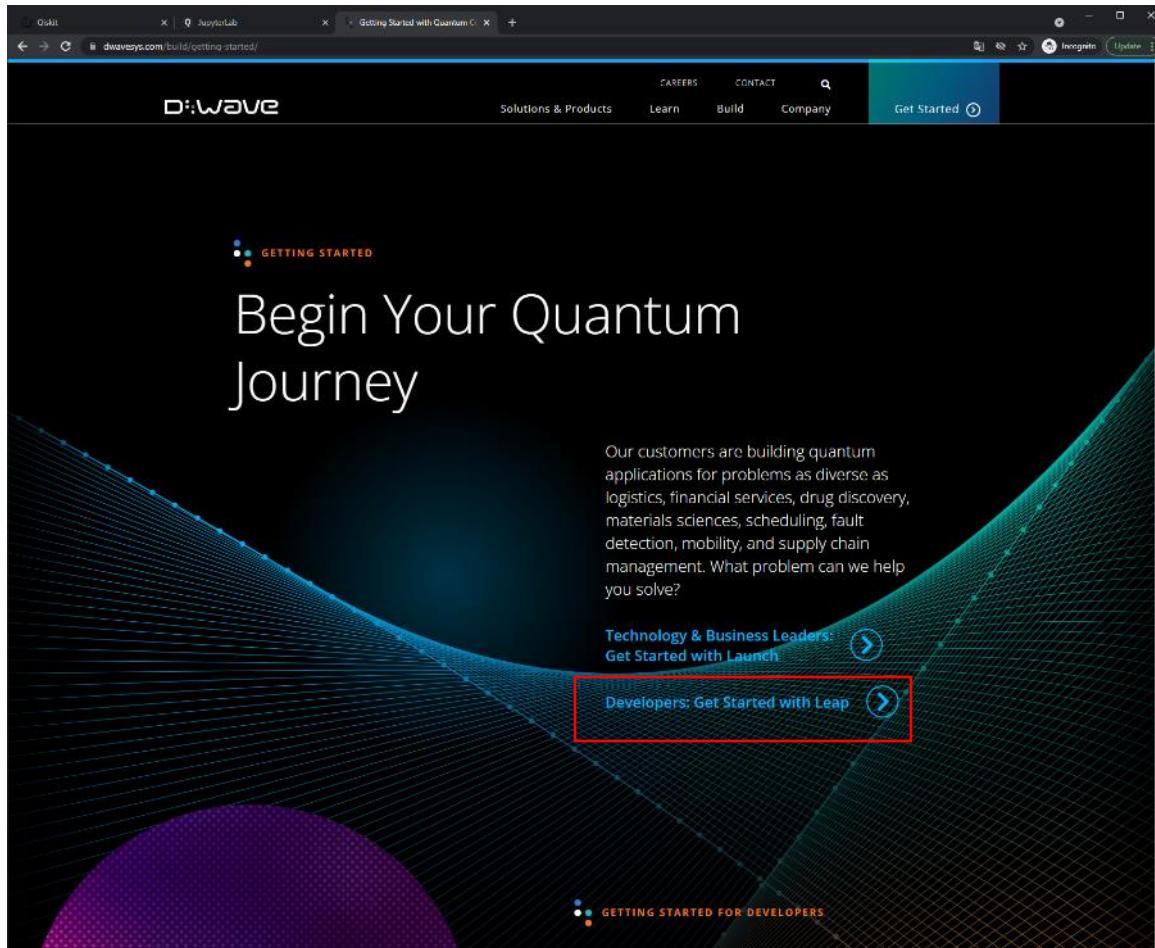
8- Your account should be created successfully!

Create D-WAVE (Leap) account



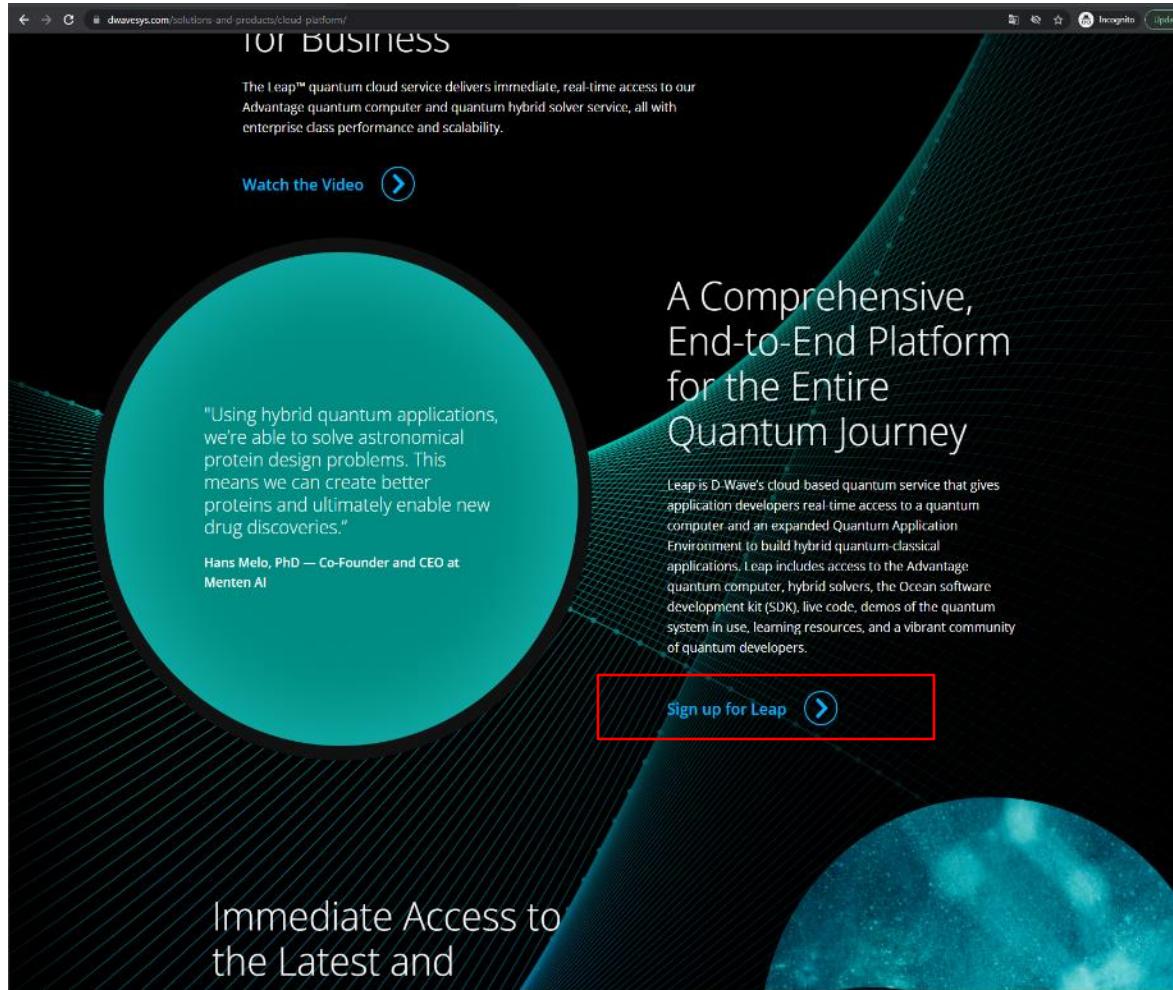
- 1- Go to dwavesys.com
- 2- Click on “Get Started”

Create D-WAVE (Leap) account



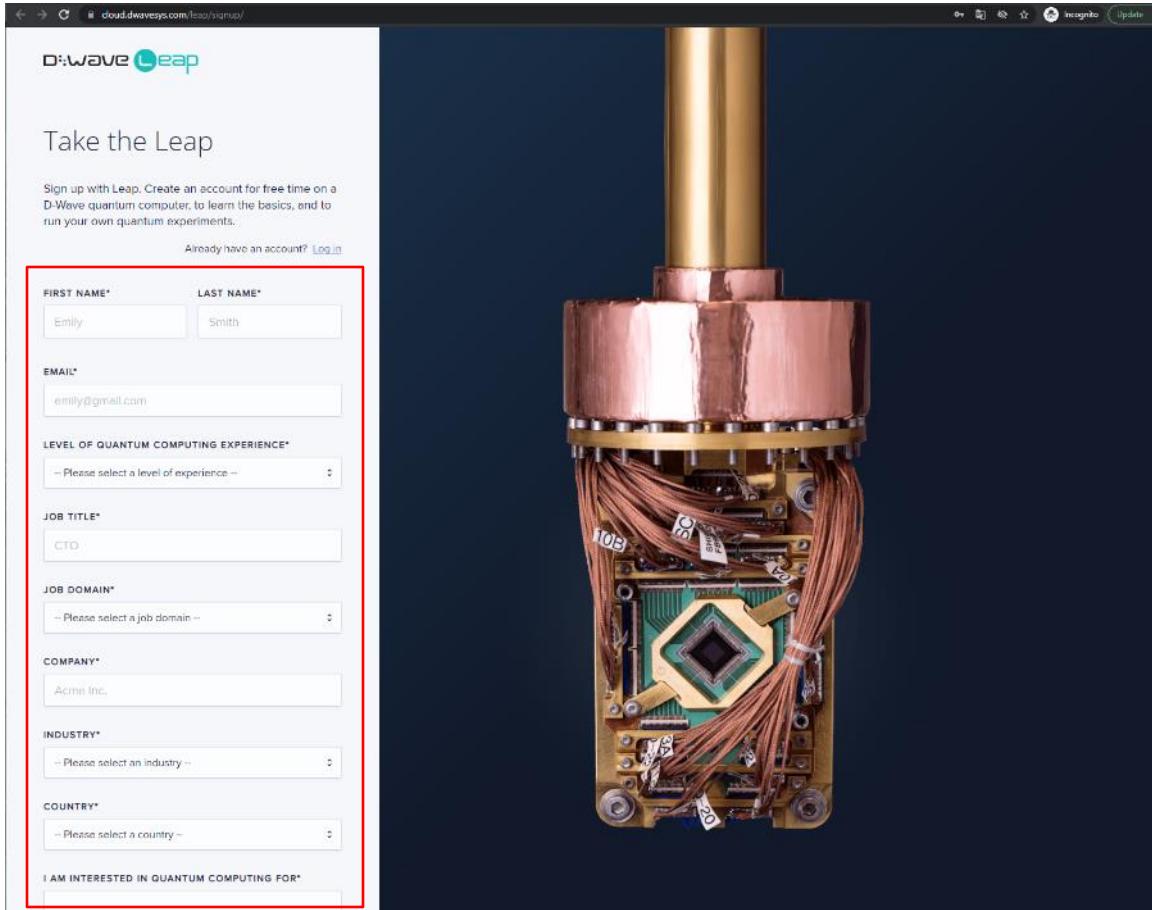
3- Click on “Developers Get Started with Leap”

Create D-WAVE (Leap) account



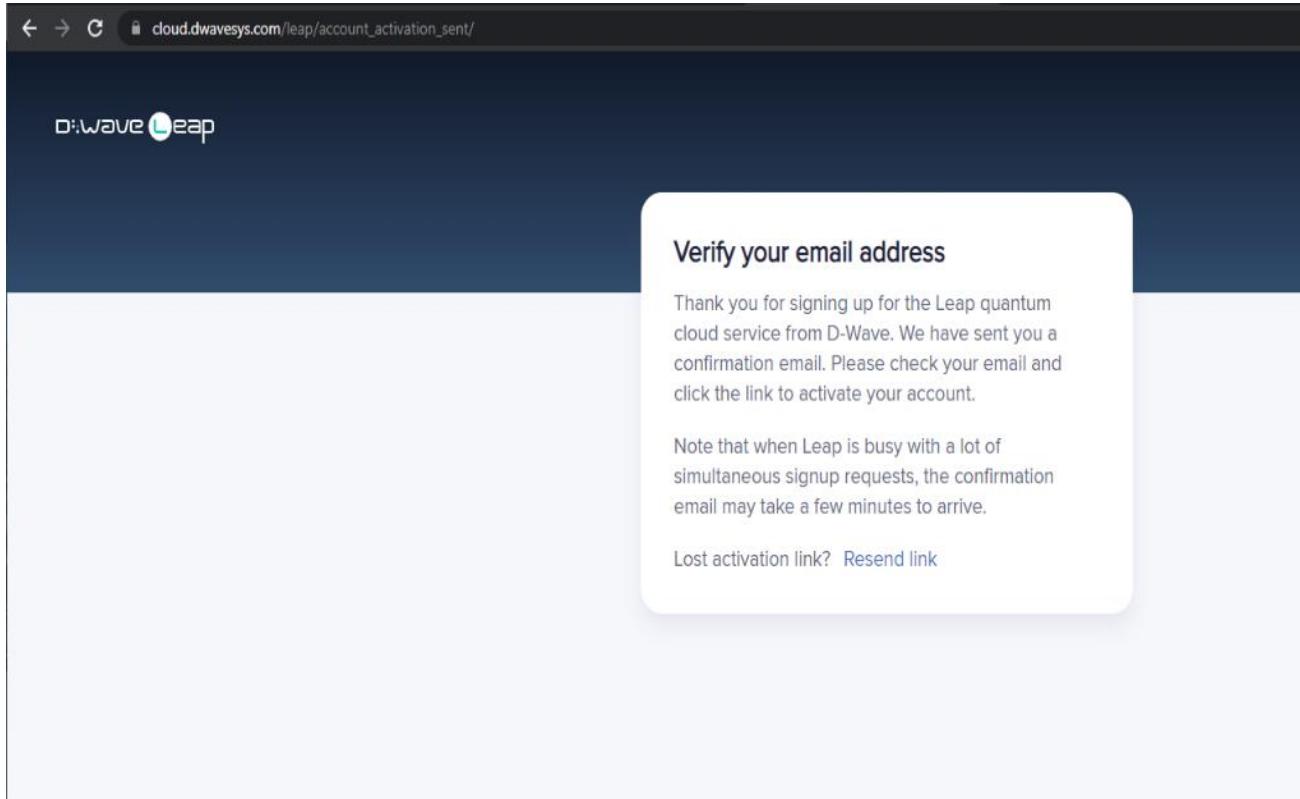
- 4- Scroll down
- 5- Click on “Sign up for Leap”

Create D-WAVE (Leap) account



6- Follow the steps

Create D-WAVE (Leap) account



7- Verify your email address

Create D-WAVE (Leap) account

Welcome to Leap - Account Activation External Inbox x

 notifications@dwavesys.com
to me ▾

Hi

Welcome to Leap, the only real-time Quantum Application Environment.

At login, you'll find access to demos about quantum computing, the Ocean quantum programming SDK, interactive coding examples, a growing quantum community and, most importantly, free time on an actual D-Wave quantum computer.

The best part, you'll get the jump on a new paradigm in quantum development. And who knows... maybe even design the first quantum killer app.

We're thrilled you're here.

Click below to confirm your registration and get started.

<https://cloud.dwavesys.com/leap/activate/Njk4NTQ/5ui-79c654686ce3c527e92c/>

This one-time link expires after three days.

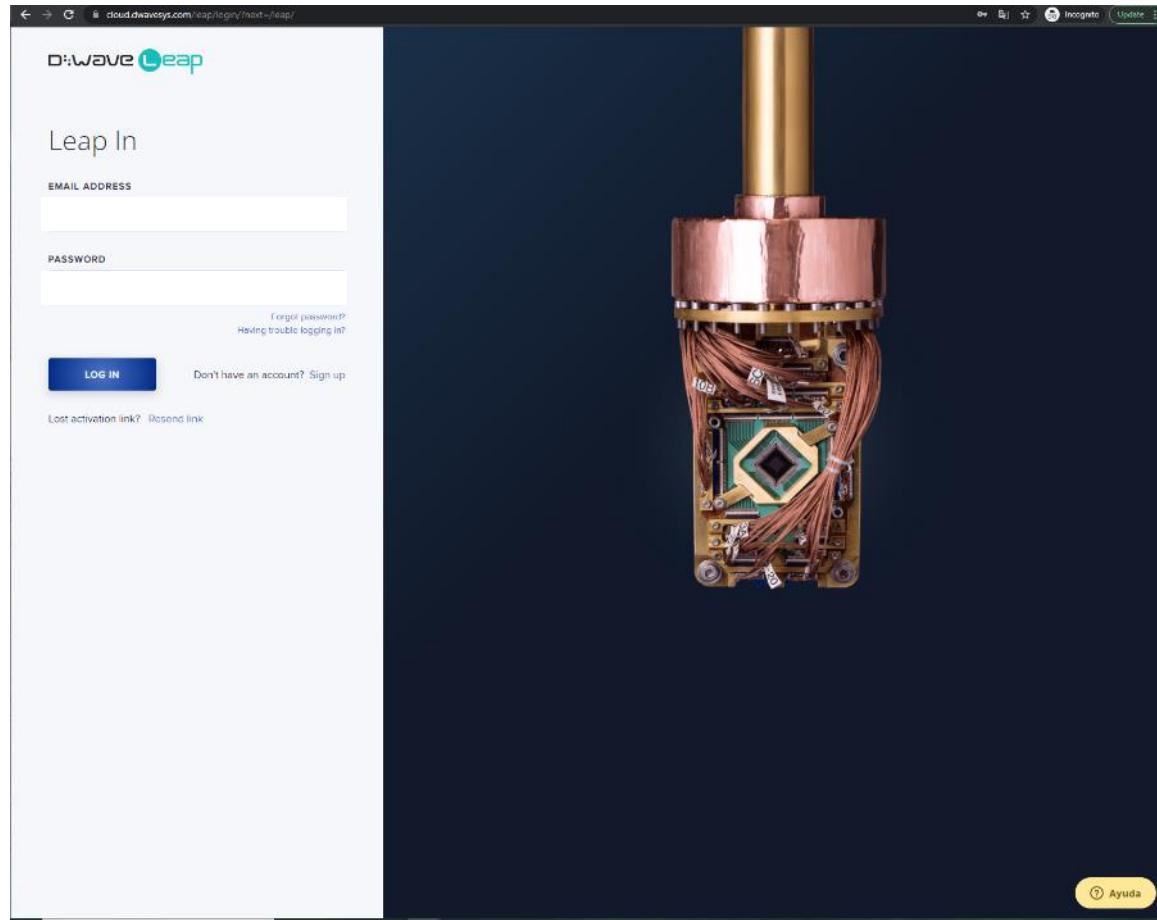
- - -

This is an unmonitored mailbox and unfortunately, this email is an automated notification unable to receive replies.

If you have a question or concern, please contact us directly at support@dwavesys.com.

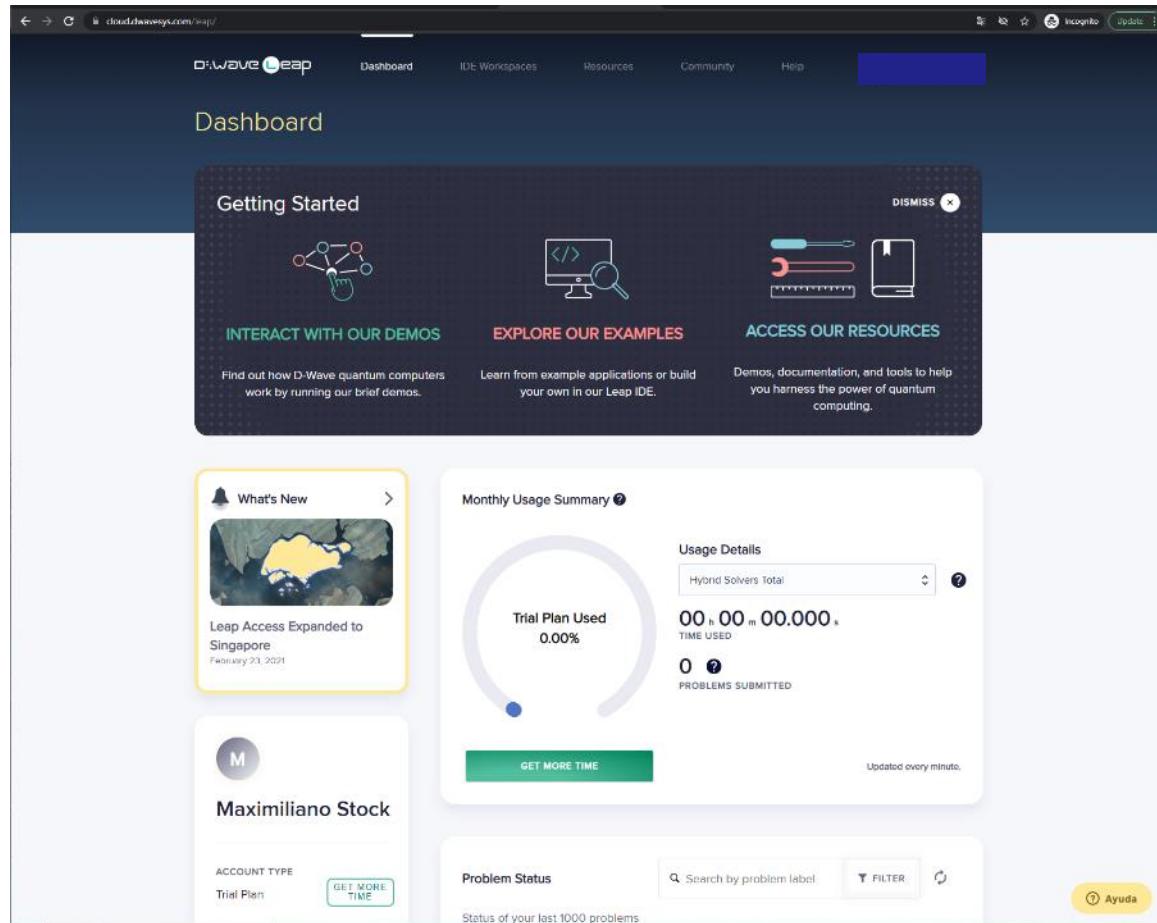
8- Confirm your registration

Create D-WAVE (Leap) account



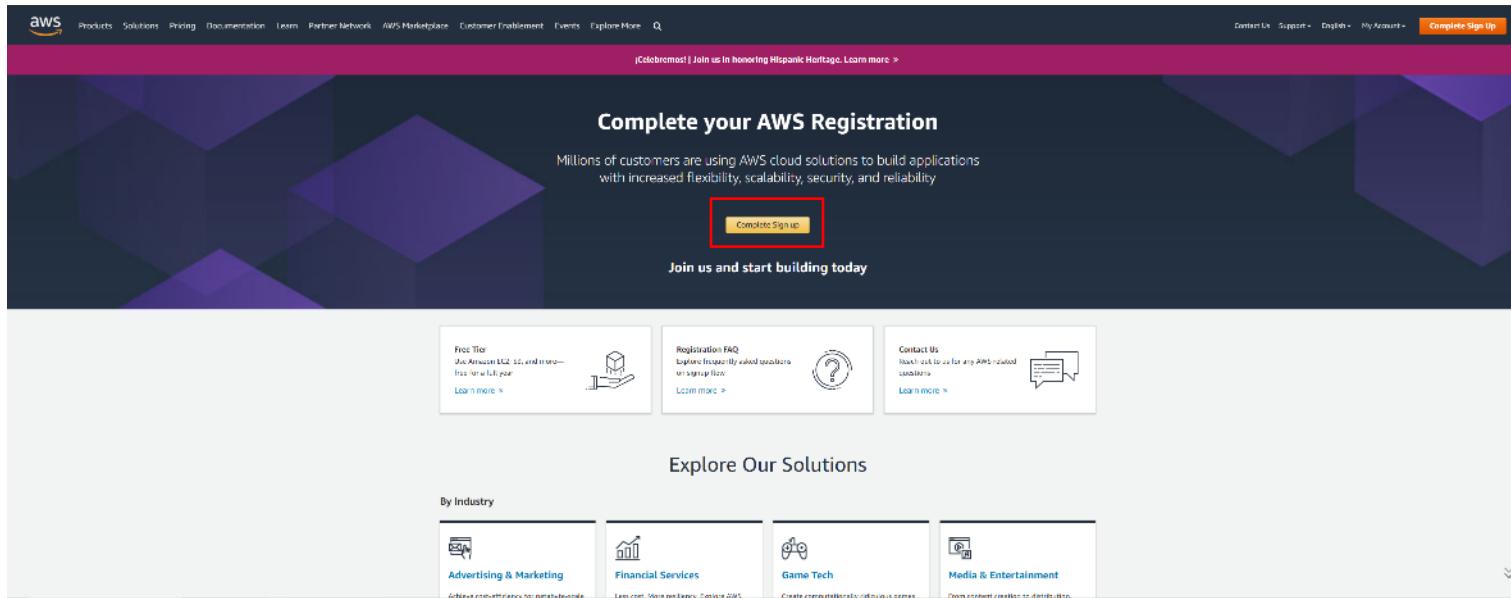
9- Log in

Create D-WAVE (Leap) account



10- Enjoy!

Create AWS account



- 1- Go to <https://aws.amazon.com/>
- 2- Click “Complete sign up”

Create AWS account



Sign in

Root user

Account owner that performs tasks requiring unrestricted access. [Learn more](#)

IAM user

User within an account that performs daily tasks. [Learn more](#)

Root user email address

username@example.com

Next

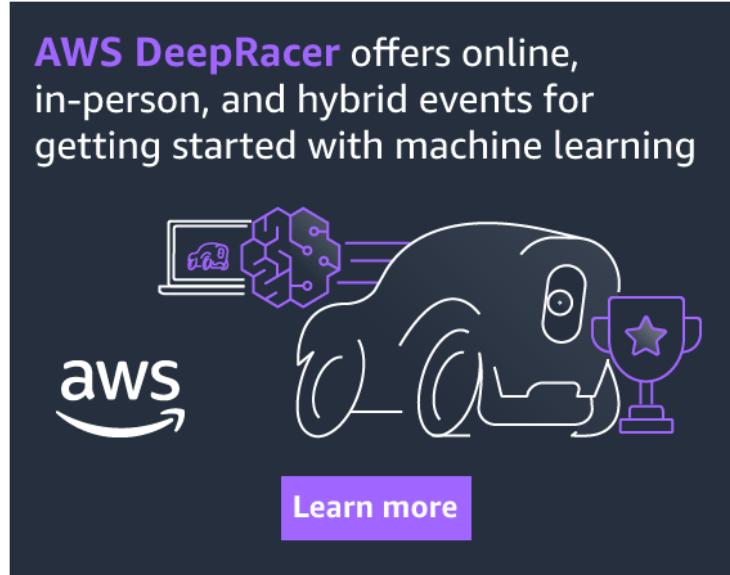
By continuing, you agree to the [AWS Customer Agreement](#) or other agreement for AWS services, and the [Privacy Notice](#). This site uses essential cookies. See our [Cookie Notice](#) for more information.

New to AWS?

[Create a new AWS account](#)

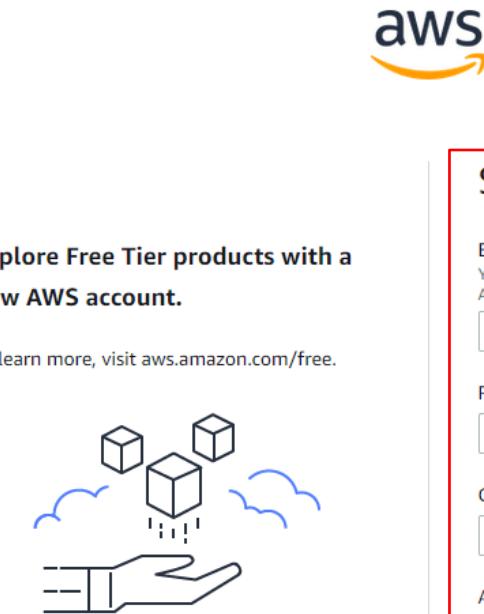
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English ▾



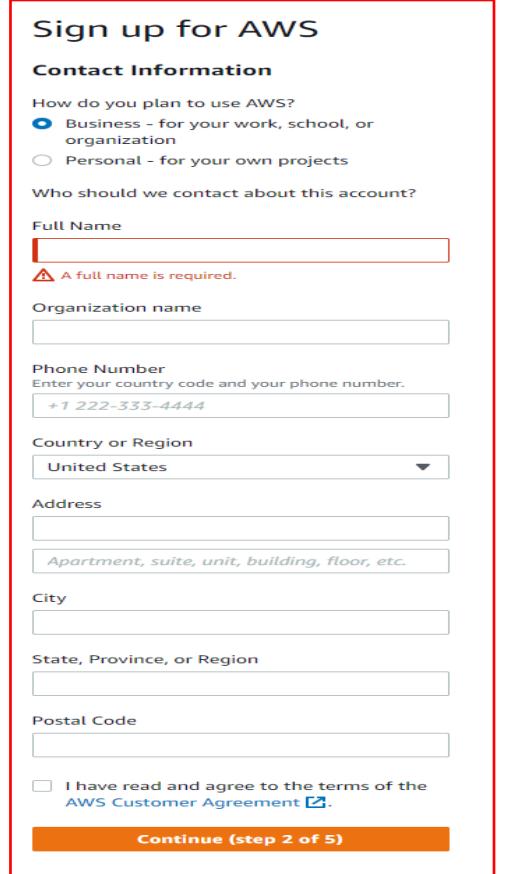
3- Click “Create a new AWS account”

Create AWS account



4- Complete step 1

Create AWS account



The image shows the AWS sign-up process. On the left, there's a sidebar titled "Free Tier offers" listing three options: "Always free" (never expires), "12 months free" (start from initial sign-up date), and "Trials" (start from service activation date). The main area is titled "Sign up for AWS" and "Contact Information". It asks how the user plans to use AWS (radio buttons for "Business - for your work, school, or organization" and "Personal - for your own projects"), who to contact about the account, and for personal details like Full Name (with a required field note), Organization name, Phone Number (with a placeholder "+1 222-333-4444"), Country or Region (United States dropdown), Address, City, State, Province, or Region, and Postal Code. At the bottom, there's a checkbox for accepting the AWS Customer Agreement and a "Continue (step 2 of 5)" button.

Contact Information

How do you plan to use AWS?

Business - for your work, school, or organization

Personal - for your own projects

Who should we contact about this account?

Full Name

A full name is required.

Organization name

Phone Number

Enter your country code and your phone number.

+1 222-333-4444

Country or Region

United States

Address

Apartment, suite, unit, building, floor, etc.

City

State, Province, or Region

Postal Code

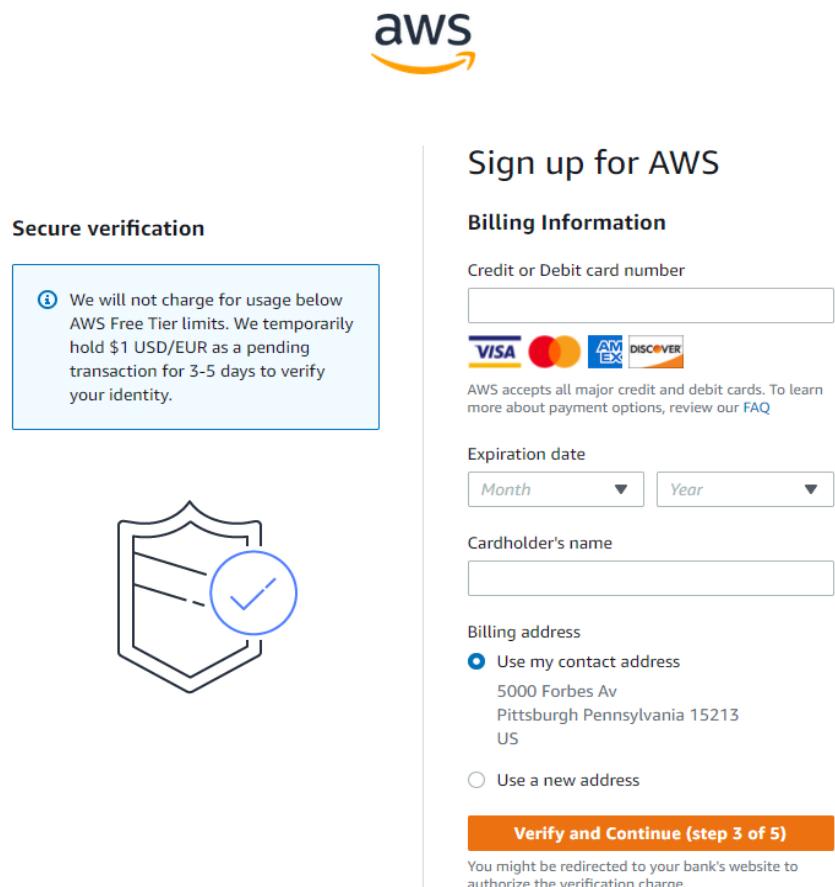
I have read and agree to the terms of the AWS Customer Agreement [\[link\]](#).

Continue (step 2 of 5)

5- Select “Business – for your work, school, or organization”

6- Complete step 2

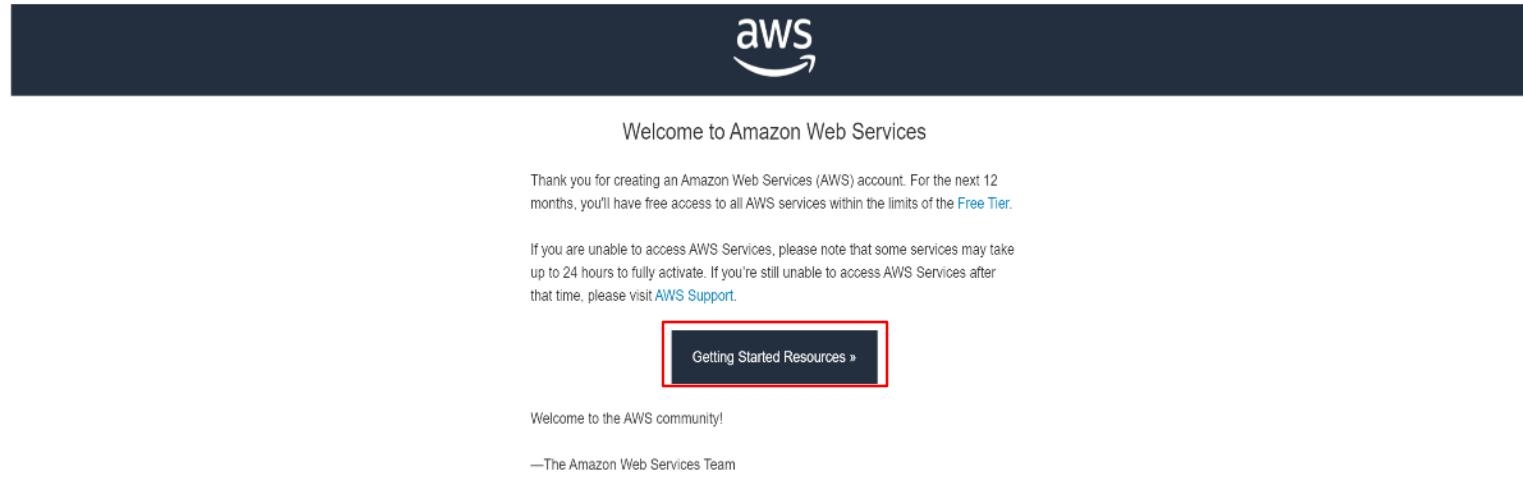
Create AWS account



The image shows the "Sign up for AWS" page. At the top, there's a "Secure verification" section containing a message: "We will not charge for usage below AWS Free Tier limits. We temporarily hold \$1 USD/EUR as a pending transaction for 3-5 days to verify your identity." Below this is a shield icon with a checkmark inside. The main form area starts with "Billing Information" which includes fields for "Credit or Debit card number" (with icons for VISA, MasterCard, AMEX, and Discover) and "Expiration date" (with dropdown menus for Month and Year). There's also a field for "Cardholder's name". Under "Billing address", there are two radio button options: "Use my contact address" (selected) and "Use a new address". The "Use my contact address" option is set to "5000 Forbes Av, Pittsburgh Pennsylvania 15213 US". At the bottom is a large orange "Verify and Continue (step 3 of 5)" button. A small note at the bottom says: "You might be redirected to your bank's website to authorize the verification charge."

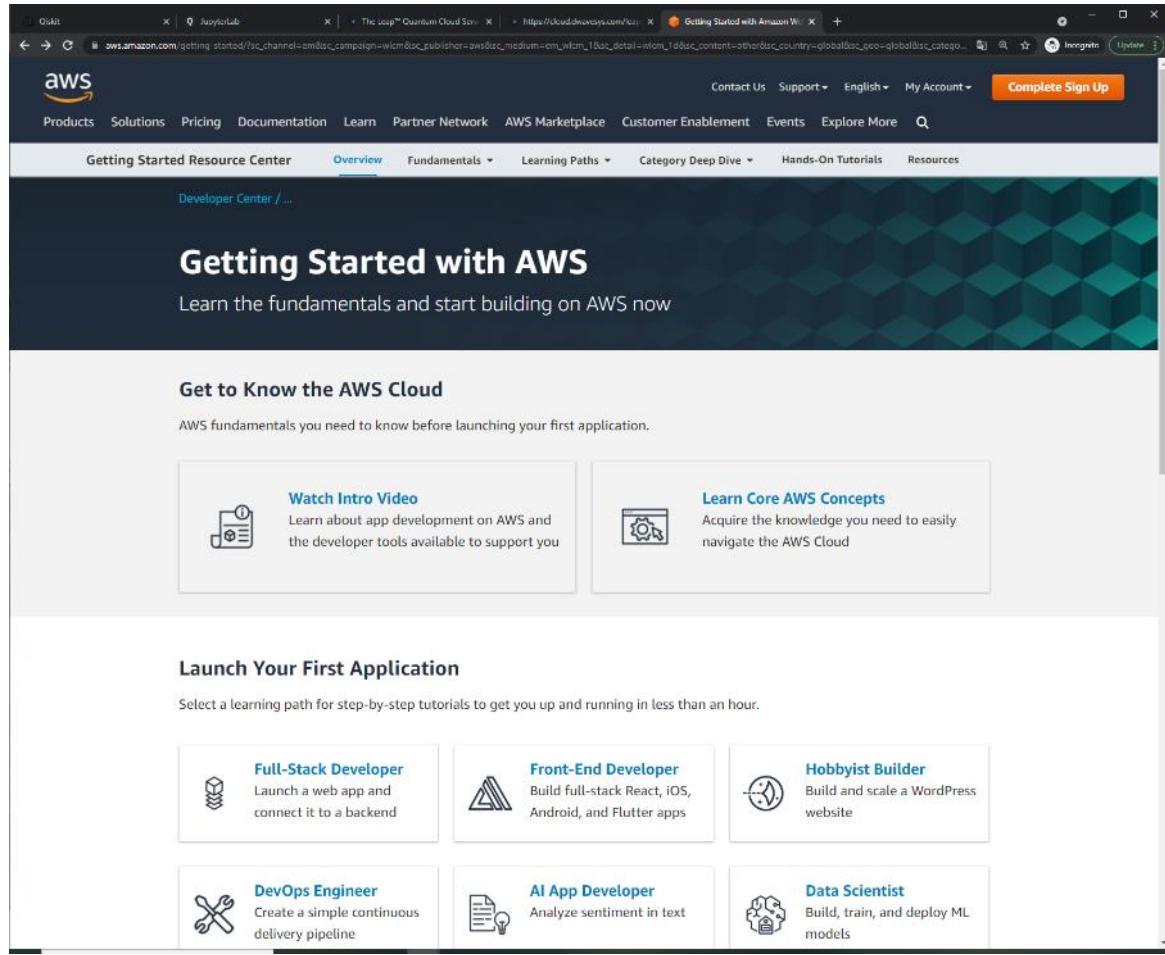
7- Ignore step 3 and wait for the welcome email from AWS.

Create AWS account



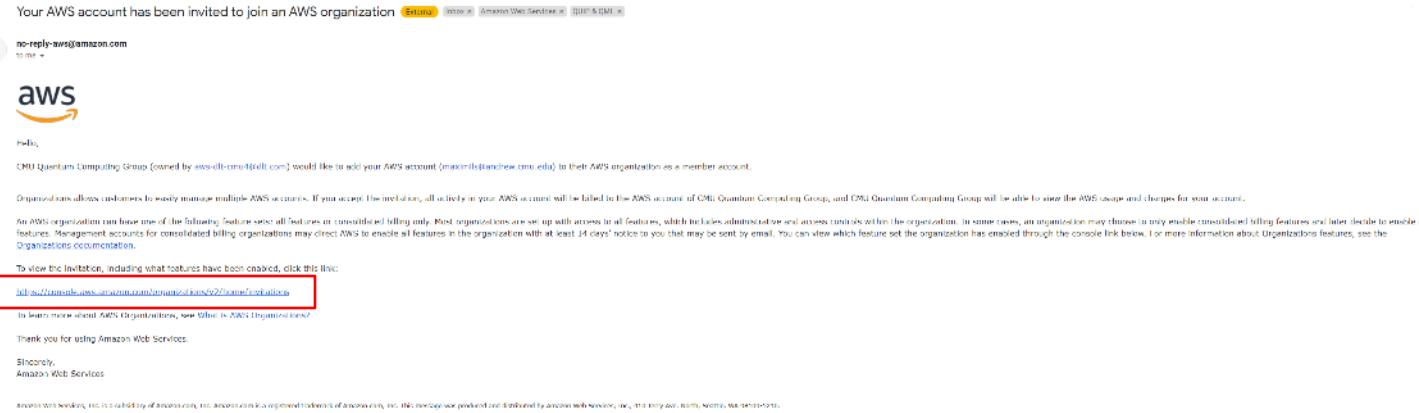
8- Click on “Getting Started Resources”

Create AWS account



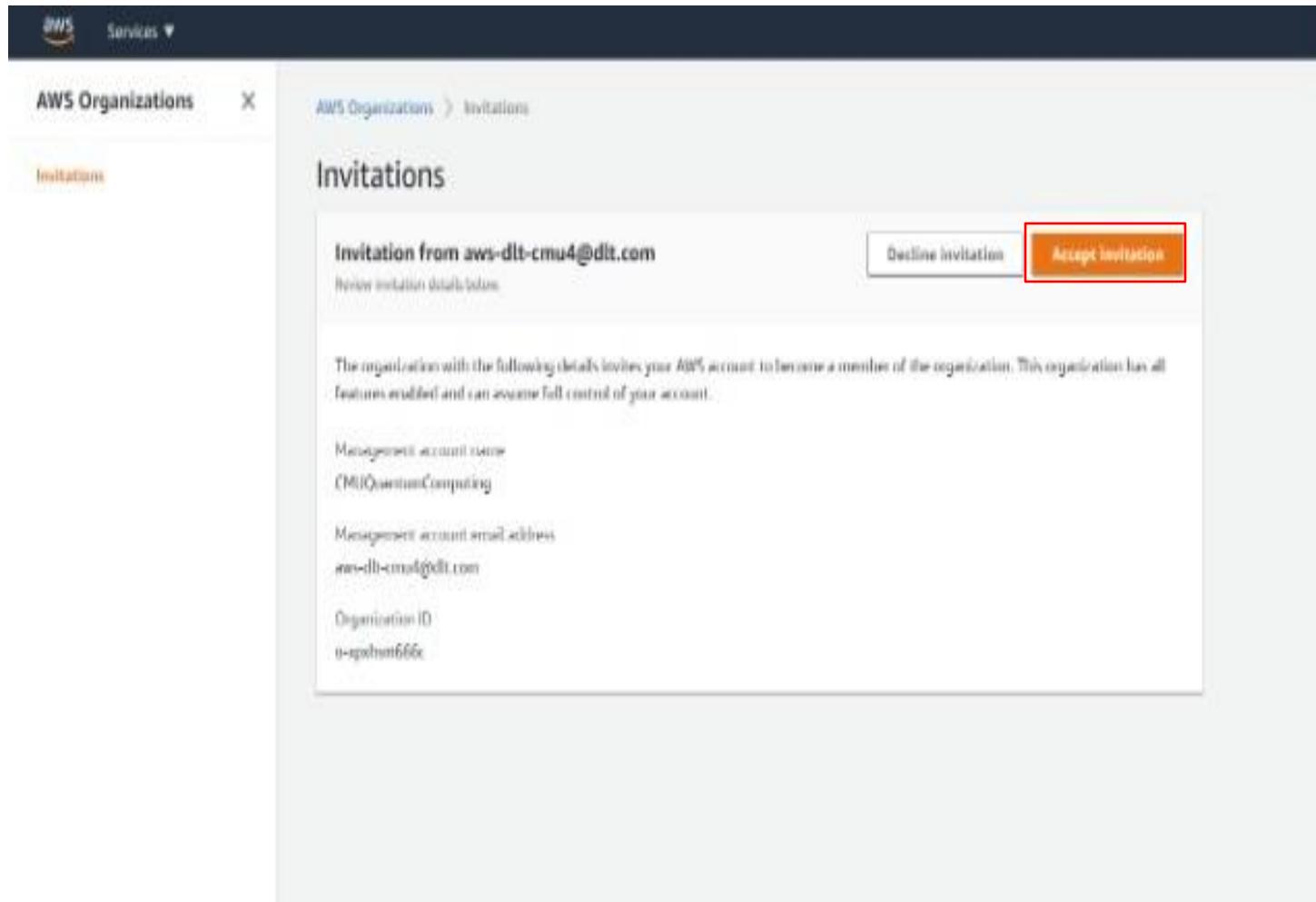
9- You should be redirected to
aws.amazon.com/getting-started

Create AWS account



- 10- Check your email
- 11- Click the link to view the invitation to join an AWS Organization

Create AWS account



12- Accept invitation

Create AWS account

The screenshot shows the AWS Organizations Dashboard. At the top, a green banner displays the message: "You accepted an invitation to join an organization." Below this, the dashboard header includes "AWS Organizations" and "Dashboard". The main content area is titled "Organization details" and contains the following information:

- Organization ID: o-xpxhsm666c
- Management account email address: aws-dlt-cmu4@dlt.com
- Feature set: Your organization has all features enabled. You can apply policies that can configure and limit what the accounts in the organization can do. Trusted AWS services can access your organization and accounts. The management account can create, manage and pay for the organization's accounts through consolidated billing.

At the bottom of the main content area, there is a "Leave organization" button and a note: "If you leave the organization, you become responsible for all billing charges related to this account. If you want to rejoin the organization, you must receive and approve a new invitation. [Learn more](#)".

13- Enjoy!

Amazon Braket

- 1- Go to
<https://aws.amazon.com/es/braket/>
- 2- Complete Sign up

Amazon Braket

aws

Sign in

Root user
Account owner that performs tasks requiring unrestricted access. Learn more

IAM user
User within an account that performs daily tasks. Learn more

Root user email address
username@example.com

Next

By continuing, you agree to the AWS Customer Agreement or other agreement for AWS services, and the Privacy Notice. This site uses essential cookies. See our Cookie Notice for more information.

New to AWS? [Create a new AWS account](#)



aws

Security check

Type the characters seen in the image below

614c37 t
a d21

Submit

aws training and certification

Propel your career

Get AWS Certified

Start your journey »

3- Sign up

Amazon Braket



Sign up for AWS

Select a support plan

Choose a support plan for your business or personal account. [Compare plans and pricing examples](#). You can change your plan anytime in the AWS Management Console.

<input checked="" type="radio"/> Basic support - Free <ul style="list-style-type: none"> Recommended for new users just getting started with AWS 24x7 self-service access to AWS resources For account and billing issues only Access to Personal Health Dashboard & Trusted Advisor 	<input type="radio"/> Developer support - From \$29/month <ul style="list-style-type: none"> Recommended for developers experimenting with AWS Email access to AWS Support during business hours 12 (business)-hour response times 	<input type="radio"/> Business support - From \$100/month <ul style="list-style-type: none"> Recommended for running production workloads on AWS 24x7 tech support via email, phone, and chat 1-hour response times Full set of Trusted Advisor best-practice recommendations 
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Need Enterprise level support?

From \$15,000 a month you will receive 15-minute response times and concierge-style experience with an assigned Technical Account Manager. [Learn more](#)

Complete sign up

4- Complete Sign up

Amazon Braket



Congratulations!

Thank you for signing up with AWS.

We are activating your account, which should take a few minutes. You will receive an email when this is complete.

[Go to the AWS Management Console](#)

[Sign up for another account](#) or [Contact Sales](#)

5- Go to the AWS Management Console

As an additional step, tell us more about yourself

We would love to learn more about your preferences so that we can provide recommendations catered to your role and interests.

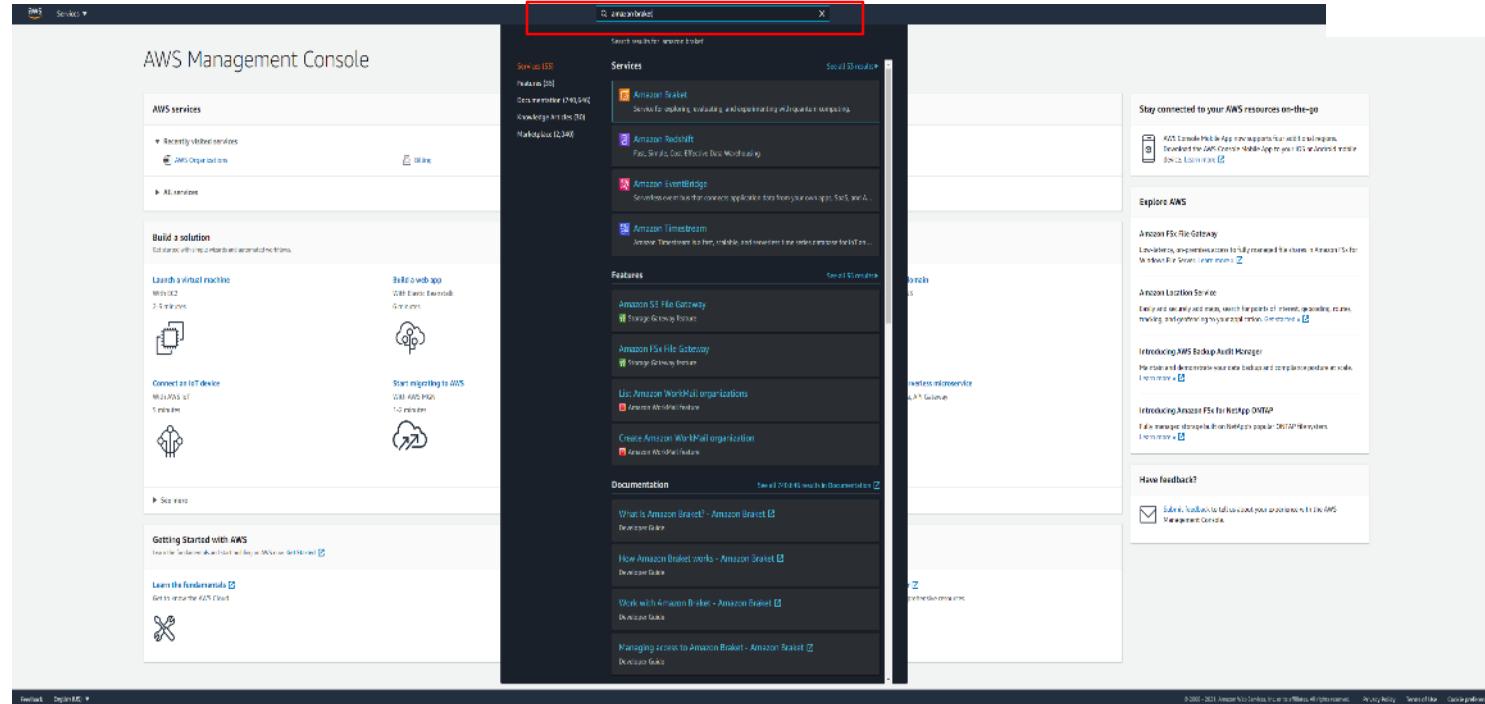
My role is: [select role ▾](#)

I am interested in: [select area ▾](#)

Yes, I'd like Amazon Web Services (AWS) to share the latest news about AWS services and related offerings with me by email, post or telephone.

You may unsubscribe from receiving AWS news and offers at any time by following the instructions in the communications received. AWS handles your information as described in the [AWS Privacy Notice](#).

Amazon Braket



6- Search for Amazon Braket

Amazon Braket



Region Unsupported

Amazon Braket is not available in US East (Ohio). Please select another region.

Supported Regions

[US East \(N. Virginia\)](#)

[US West \(N. California\)](#)

[US West \(Oregon\)](#)

7- Upon opening the Amazon Braket service, the website may say it is unavailable in your location. If so, change to a suitable location, for instance *US East (N. Virginia)*

Amazon Braket

The screenshot shows the 'Getting started with Amazon Braket' wizard. It consists of three main sections:

- Choose your data storage:** A step where users can create a new S3 bucket for their algorithms. A note says: "We will create the new bucket amazon-braket-de78199c9526." Options include "Create new" (selected), "Specify new", and "Select existing".
- Account permissions:** A step explaining that Braket creates a service-linked role with specific AWS permissions. A link to "Learn more" is provided.
- Terms & conditions:** A step detailing the legal terms for using Braket with third-party hardware providers. It includes a note about Content processing and transfer, and a checkbox for accepting the terms.

At the bottom right of the wizard is an orange "Enable Amazon Braket" button.

- 8- Accept terms & conditions
- 9- Enable Amazon Braket

Amazon Braket

The screenshot shows the Amazon Braket home page with two main sections: "Quantum Processing Units (QPUs)" and "Simulators".

Quantum Processing Units (QPUs):

- D-Wave — Advantage_system1.1:** Quantum Annealer based on superconducting qubits. Qubits: 5760, Status: ONLINE, Region: us-west-2.
- D-Wave — DW_2000Q_6:** Quantum Annealer based on superconducting qubits. Qubits: 2048, Status: ONLINE, Region: us-west-2.
- IonQ:** Universal gate-model QPU based on trapped ions. Qubits: 11, Status: ONLINE, Region: us-east-1.
- Rigetti — Aspen-8:** Universal gate-model QPU based on superconducting qubits. Qubits: 31, Status: RETIRED, Region: us-west-1.
- Rigetti — Aspen-9:** Universal gate-model QPU based on superconducting qubits. Qubits: 32, Status: ONLINE, Region: us-west-1.

Simulators:

- Amazon Web Services — SV1:** Amazon Braket state vector simulator. Qubits: 34, Status: ONLINE, Region: us-east-1, us-west-1, us-west-2.
- Amazon Web Services — TN1:** Amazon Braket tensor network simulator. Qubits: 50, Status: ONLINE, Region: us-east-1, us-west-2.
- Amazon Web Services — DM1:** Amazon Braket density matrix simulator. Qubits: 17, Status: ONLINE, Region: us-east-1, us-west-1, us-west-2.

10- Start Amazon Braket. Locate home page with various machines and simulators.

Amazon Braket

The screenshot shows the Amazon Braket web interface. At the top, there's a navigation bar with the AWS logo, 'Services ▾', a bell icon for notifications, 'N. Virginia ▾', and 'Support ▾'. Below this, the main header says 'Amazon Braket' with a close button ('X'). On the left, a sidebar has 'Devices', 'Notebooks' (which is selected and highlighted in orange), and 'Tasks'. Under 'Announcements', there's a link to 'Feedback' and language settings 'English (US) ▾'. The main content area is titled 'Notebooks (0)' and includes a search bar ('Search notebooks'), a filter for 'Name contains: amazon-braket-' (with a clear all button), and sorting options for 'Name', 'Instance', 'Creation time', 'Status', and 'URL'. A large message 'No Notebooks' is displayed, followed by the text 'Use Jupyter Notebooks to create quantum programs in an interactive coding environment.' and a 'Create notebook' button.

11- Go straight to notebooks on the left pane.

Amazon Braket

The screenshot shows the 'Create notebook instance' wizard in the Amazon Braket console. The left sidebar includes links for Devices, Notebooks, Tasks, and Announcements. The main form has the following sections:

- Notebook instance settings:** Contains fields for 'Notebook instance name' (set to 'amazon-braket-1 Testing') and 'Notebook instance type' (set to 'ml.t3.medium').
- Permissions and encryption:** Includes an 'IAM role' dropdown set to 'Create a new role'. A note explains that this grants SageMaker permission to perform actions in other AWS services. It also includes options for 'Root access — optional' (set to 'Enable') and 'Encryption key — optional' (set to 'No custom encryption key').
- Network — optional:** This section is currently collapsed.

At the bottom right of the form are 'Cancel' and 'Create notebook instance' buttons.

12- To create Notebook instance provide a name and click “Create Notebook Instance”

Amazon Braket

The screenshot shows the AWS Amazon Braket service interface. The left sidebar has tabs for Devices, Notebooks (which is selected and highlighted in orange), and Tasks. The main content area is titled "Notebooks (1)". It shows a table with one row for "amazon-braket-Testing". The columns are Name, Instance, Creation time, Status, and URL. The URL is a long string starting with "amazon-braket-testing-azrv.notebook.us-east-1.sagemaker.aws".

Name	Instance	Creation time	Status	URL
amazon-braket-Testing	ml.t3.medium	Oct 02, 2021 15:16 (UTC)	InService	amazon-braket-testing-azrv.notebook.us-east-1.sagemaker.aws

13- Check status of Notebook. It takes a short amount of time for the notebooks to get created. During this time feel free to check out the devices available to you by clicking on “Devices” in the left tab.

Amazon Braket

The screenshot shows the Amazon Braket Devices page. The left sidebar includes links for AWS Services, Amazon Braket (selected), Devices, Notebooks, Tasks, and Announcements. The main content area displays two sections: "Quantum Processing Units (QPUs)" and "Simulators".

Quantum Processing Units (QPUs):

- D-Wave — Advantage_system4.1:** Quantum Annealer based on superconducting qubits. Qubits: 5760, Status: ONLINE, Region: us-west-2.
- D-Wave — Advantage_system1.1:** Quantum Annealer based on superconducting qubits. Qubits: 5760, Status: ONLINE, Region: us-west-2.
- D-Wave — DW_2000Q_6:** Quantum Annealer based on superconducting qubits. Qubits: 2048, Status: ONLINE, Region: us-west-2.

IonQ: Universal gate-model QPU based on trapped ions. Qubits: 11, Status: ONLINE, Region: us-east-1.

Rigetti — Aspen-8: Universal gate-model QPU based on superconducting qubits. Qubits: 31, Status: RETIRED, Region: us-west-1.

Rigetti — Aspen-9: Universal gate-model QPU based on superconducting qubits. Qubits: 32, Status: ONLINE, Region: us-west-1.

Simulators:

- Amazon Web Services — SV1:** Amazon Braket state vector simulator. Qubits: 34, Status: ONLINE, Region: us-east-1, us-west-1, us-west-2.
- Amazon Web Services — TN1:** Amazon Braket tensor network simulator. Qubits: 50, Status: ONLINE, Region: us-east-1, us-west-2.
- Amazon Web Services — DM1:** Amazon Braket density matrix simulator. Qubits: 17, Status: ONLINE, Region: us-east-1, us-west-1, us-west-2.

At the bottom, there are links for Feedback, English (US), © 2008 - 2021, Amazon Web Services, Inc. or its affiliates. All rights reserved., Privacy Policy, Terms of Use, and Cookie preferences.

14- The Devices Page: Click on each device to see what is under the hood.

Amazon Braket

The screenshot shows the Amazon Braket interface for a D-Wave Advantage_system4.1 device. The top navigation bar includes the AWS logo, Services dropdown, search bar ('Search for services, features, marketplace products, and docs [Alt+S]'), and account information ('N. Virginia Support'). The left sidebar has links for 'Amazon Braket' (selected), 'Devices' (highlighted in orange), 'Notebooks', 'Tasks', and 'Announcements'. The main content area displays the device details:

- Quantum Annealer based on superconducting qubits**
- D-Wave** The Quantum Computing Company™
- Description:** D-Wave's approach is quantum annealing, which harnesses the natural evolution of quantum states. Each D-Wave QPU is a lattice of tiny metal loops, each of which is a qubit or a coupler. Below temperatures of 9.2 kelvin, these loops become superconductors and, at even lower temperatures, exhibit quantum-mechanical effects.
- Advantage4.1:** Has more than 5627 qubits and more than 40,000 couplers. It uses around a million Josephson junctions, making it one of the most complex superconducting integrated circuit ever built. With two-and-a-half times more connectivity than the D-Wave 2000Q system, the Advantage QPU enables the embedding of larger problems with fewer physical qubits.
- QPU architecture:** Critical for translating a QUBO or Ising objective function into a format a D-Wave system can solve. Such binary objective functions can be represented as graphs; these in turn can be mapped to the QPU.
- Architecture:** Comprises a repeated structure where each qubit is coupled to twelve oppositely aligned, and three similarly aligned, qubits. A basic unit cell contains twenty-four such qubits, with each qubit coupled to one similarly aligned qubit in the cell and two similarly aligned qubits in adjacent cells. An Advantage QPU is a lattice of 16x16 such tiles, denoted as a P16 graph. The global structure can be seen as a system of diagonally arranged K_{4,4} bicliques, with couplers between oppositely aligned qubits both within and between the diagonals.
- More about this device**
- Hardware provider:** D-Wave
- Region:** us-west-2
- Availability:** Everyday, 00:00:00 - 23:59:59 UTC
- Device ARN:** arnaws.braket::device/cpu/d-wave/Advantage_system4 (highlighted with a red box)
- Location:** British Columbia, Canada
- Cost:** \$0.30 / task + \$0.00019 / shot
- Qubits:** 5760
- Status:** ONLINE
- Topology:** Shows a JSON representation of the topology: 1: { 2: "type": "pegasus", 3: "shape": [4: 16, 5: 1], 6: }.

At the bottom, there are links for Feedback, English (US) ▾, © 2008 – 2021, Amazon Web Services, Inc. or its affiliates. All rights reserved., Privacy Policy, Terms of Use, and Cookie preferences.

15- D-Wave. Note the Device ARN, it may be useful in your Notebooks

Amazon Braket

Universal gate-model QPU based on trapped ions

IonQ's trapped ion QPUs are built on a chain of trapped $^{171}\text{Yb}^+$ ions, spatially confined via a microfabricated surface electrode trap within a vacuum chamber. Gates are performed via a two-photon Raman transition using a pair of counter-propagating beams from a mode-locked pulsed laser. This allows for high-quality single and two-qubit transitions and all-to-all connectivity. Initialization is performed via optical pumping, and readout is performed with a combination of a resonant laser, a high numeric aperture lens, and photomultiplier tubes.

IonQ compiles and optimizes your high-level quantum logic gates into the smallest possible set of laser pulses to realize your program on trapped ions, mapping your gates onto ideal pairs for execution using up-to-the-minute continuous calibrations.

For single-qubit gates, IonQ uses the GPI gate, the GPI2 gate, and the G2 gate. The GPI and GPI2 gates are simply Rabi oscillations made by driving the qubits on resonance using laser beams in a Raman configuration. The G2 gate is performed by advancing/retarding the phase of this laser beam, creating a 'virtual' operation.

For entangling, two-qubit gates, IonQ uses the Mølmer-Sørensen gate. This entangling gate and the single-qubit gates above constitute a universal gate set. By irradiating any two ions in the chain with a predesigned set of pulses, it is possible to couple ions' internal states with the chain's normal modes of motion to create entanglement.

[More about this device](#)

Hardware provider IonQ	Region us-east-1	Location Maryland, USA
Availability Weekdays, 13:00:00 - 02:00:00 UTC	Next available AVAILABLE NOW	Cost \$0.30 / task + \$0.01 / shot
Device ARN arn:aws:braket::device/qpu/ionq/ionQdevice	Status ONLINE	Qubits 11

Topology

Calibration
Last updated: Sep 21, 2021 13:00 (UTC)

16- IonQ. Note the Device ARN, it may be useful in your Notebooks

Amazon Braket

Universal gate-model QPU based on superconducting qubits

Rigetti quantum processors are universal, gate-model machines based on all-tunable superconducting qubits. Just like the Rigetti Aspen-8 chip, the Aspen-9 chip features tileable lattices of alternating fixed-frequency and tunable superconducting qubits within a scalable 32-qubit node technology. Distinguishing characteristics include direct coupling between one qubit and its three nearest neighbors; fast gate times for multiple entangling gate families; rapid sampling via active register reset; and parametric control.

The Aspen chip topology is octagonal (2-fold for edges) connectivity and features both C2 and XY entangling gates that allow developers to optimize programs for performance and minimize circuit depth. Rigetti's optimizing quic compiler transforms abstract quantum algorithms into this set of native gates and produces optimal circuit implementations to be carried out on a Rigetti QPU. These gates offer fast (60ns and 160ns) 1Q and 2Q gate times and program execution rates within qubit coherence times measuring ~20μs.

Universal gate-based quantum computers powered by superconducting qubits provide users with both fine grained control and efficient variational feedback loops to explore problem spaces in chemical simulation, combinatorial optimization, and machine learning.

[More about this device](#)

Hardware provider Rigetti	Region us-west-1	Location California, USA
Availability Everyday, 15:00:00 - 19:00:00 UTC	Next available 19:00:10	Cost \$0.30 / task + \$0.00035 / shot
Device ARN <code>arn:aws:braket::device/qpu/rigetti/Aspen-9</code>	Status ONLINE	Qubits 32

Topology

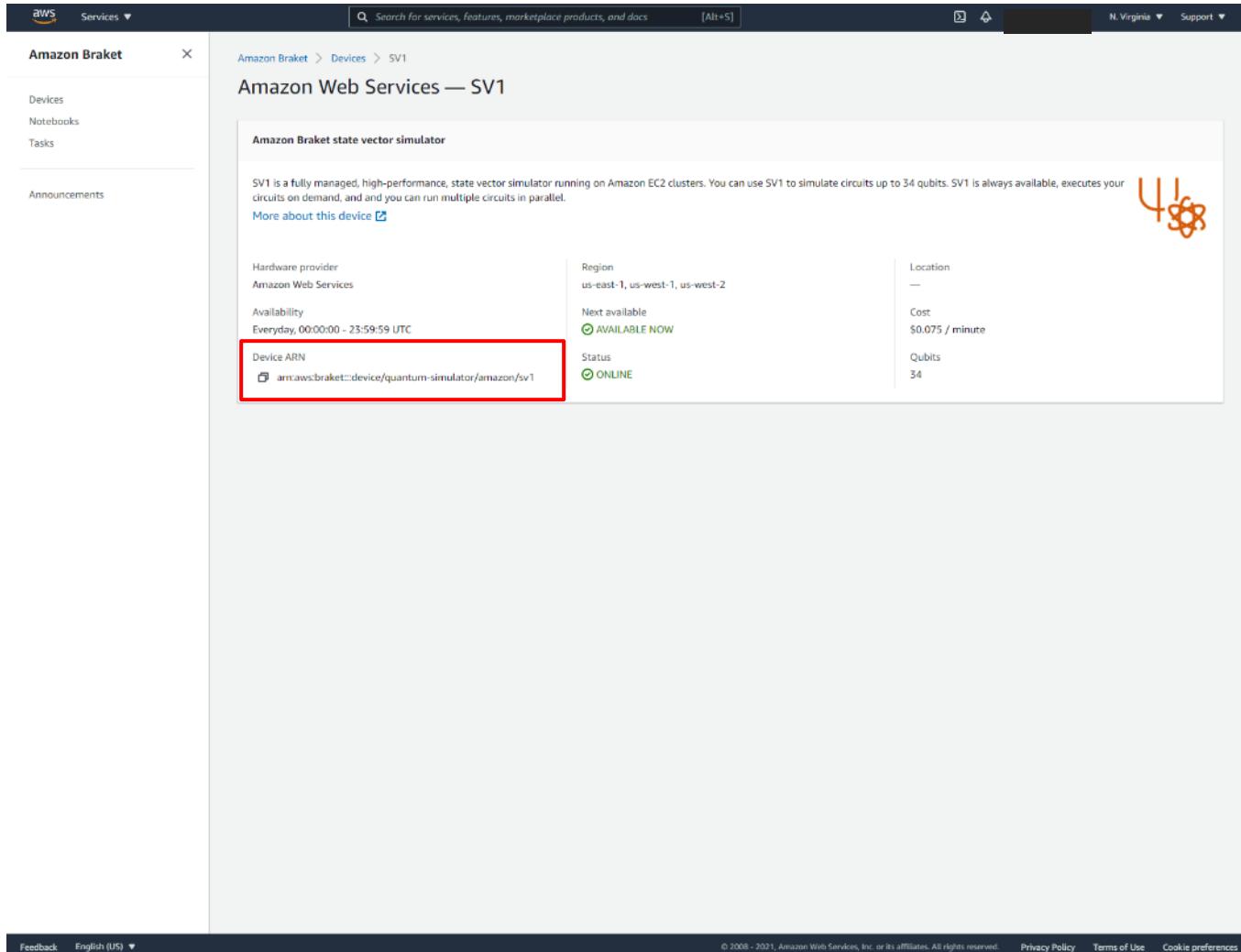
Calibration

Last updated: Oct 12, 2021 19:58 (UTC)

Qubit	T1 (μs)	T2 (μs)	Fidelity (RB) (%)	Fidelity (simultaneous RB) (%)	Readout fidelity (%)	Active reset fidelity (%)
0	27.661	12.521	99.900 ± 0.009	99.612 ± 0.027	97.000	99.850
1	35.419	10.563	97.817 ± 0.120	96.277 ± 0.623	85.800	97.200
2	24.699	4.462	99.759 ± 0.021	99.512 ± 0.027	93.700	99.650

17- Rigetti. Note the Device ARN, it may be useful in your Notebooks

Amazon Braket



The screenshot shows the Amazon Braket web interface. The top navigation bar includes the AWS logo, Services dropdown, search bar ('Search for services, features, marketplace products, and docs'), and [Alt+S] key. The top right has N. Virginia dropdown and Support dropdown. The left sidebar shows 'Amazon Braket' selected, with 'Devices', 'Notebooks', 'Tasks', and 'Announcements' options. The main content area shows 'Amazon Web Services — SV1'. The title 'Amazon Braket state vector simulator' is displayed. A description states: 'SV1 is a fully managed, high-performance, state vector simulator running on Amazon EC2 clusters. You can use SV1 to simulate circuits up to 34 qubits. SV1 is always available, executes your circuits on demand, and you can run multiple circuits in parallel.' Below this is a 'More about this device' link. The device details table includes:

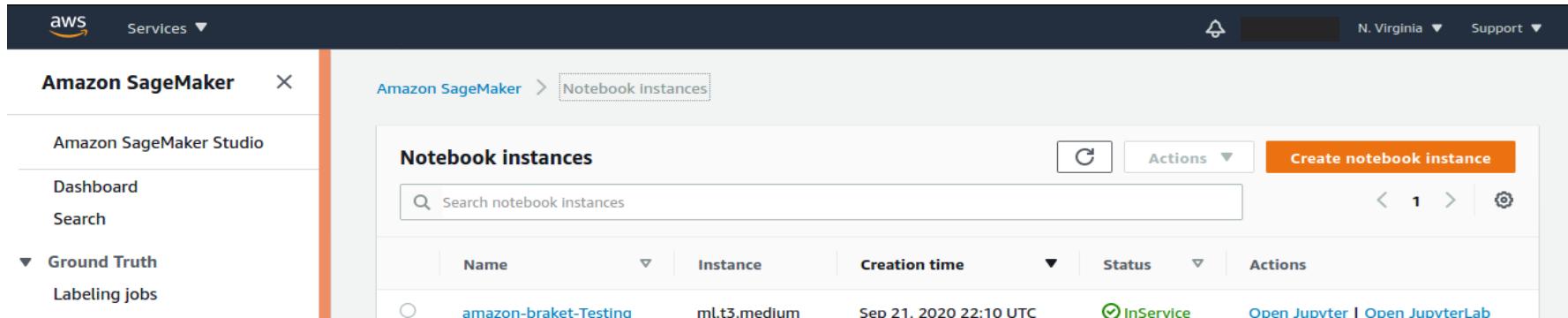
Hardware provider	Amazon Web Services	Region	us-east-1, us-west-1, us-west-2	Location	—
Availability	Everyday, 00:00:00 - 23:59:59 UTC	Next available	AVAILABLE NOW	Cost	\$0.075 / minute
Device ARN	arn:aws:braket::device/quantum-simulator/amazon/sv1	Status	ONLINE	Qubits	34

At the bottom, there are links for Feedback, English (US), and a footer with copyright information: © 2008 – 2021, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy, Terms of Use, and Cookie preferences.

18- Braket Simulator. Note the Device ARN, it may be useful in your Notebooks

Go back to Notebooks tab

19. Your Notebook may be green i.e. “In Service”



The screenshot shows the Amazon SageMaker Studio interface. On the left, there is a sidebar with the following navigation items:

- Amazon SageMaker Studio
- Dashboard
- Search
- Ground Truth
- Labeling jobs

The main content area is titled "Notebook instances". It includes a search bar labeled "Search notebook instances". A table displays the following information for a single instance:

Name	Instance	Creation time	Status	Actions
amazon-braket-Testing	ml.t3.medium	Sep 21. 2020 22:10 UTC	InService	Open Jupyter Open JupyterLab

At the top right of the main area, there are buttons for "Create notebook instance", "Actions", and a bell icon.

20. Under Actions, click on the notebook



The screenshot shows the Jupyter interface. At the top, there is a header with the Jupyter logo and buttons for "Open JupyterLab", "Quit", and "Logout". Below the header, there is a navigation bar with tabs: "Files" (selected), "Running", "Clusters", and "Conda".

The main area is a file browser with the following details:

- Header: "Select items to perform actions on them.", "Upload", "New", and a refresh icon.
- File list:
 - Count: 0
 - Path: /
 - Items:
 - Braket examples (a folder)
 - File size: 3 minutes ago

Open Braket Examples



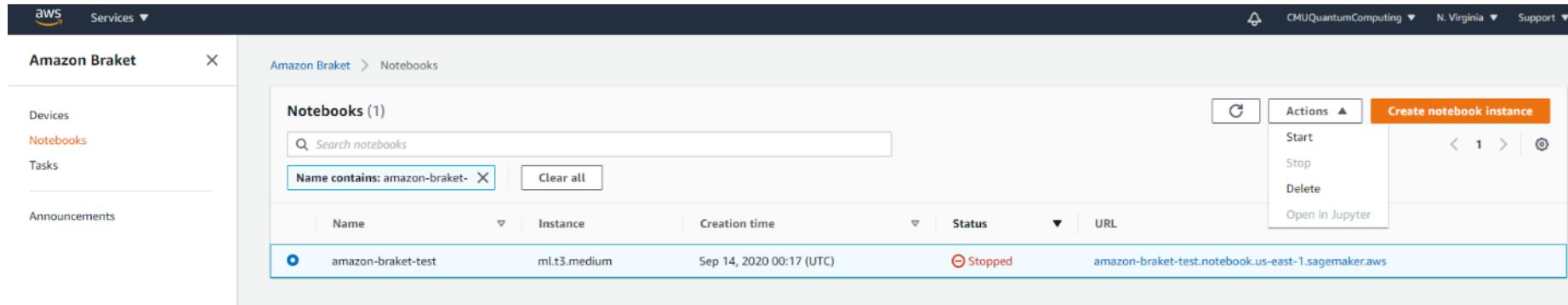
Explore the set of notebooks provided by Amazon Braket.

The results are preloaded. You can execute the code yourself, keep in mind that it costs money!
First simulate classically and then use the quantum devices (preferably DWave, Rigetti and IonQ in that order)

Make sure to Stop your notebooks before you Log Out!

Play Around.
You are ALL SET Here!

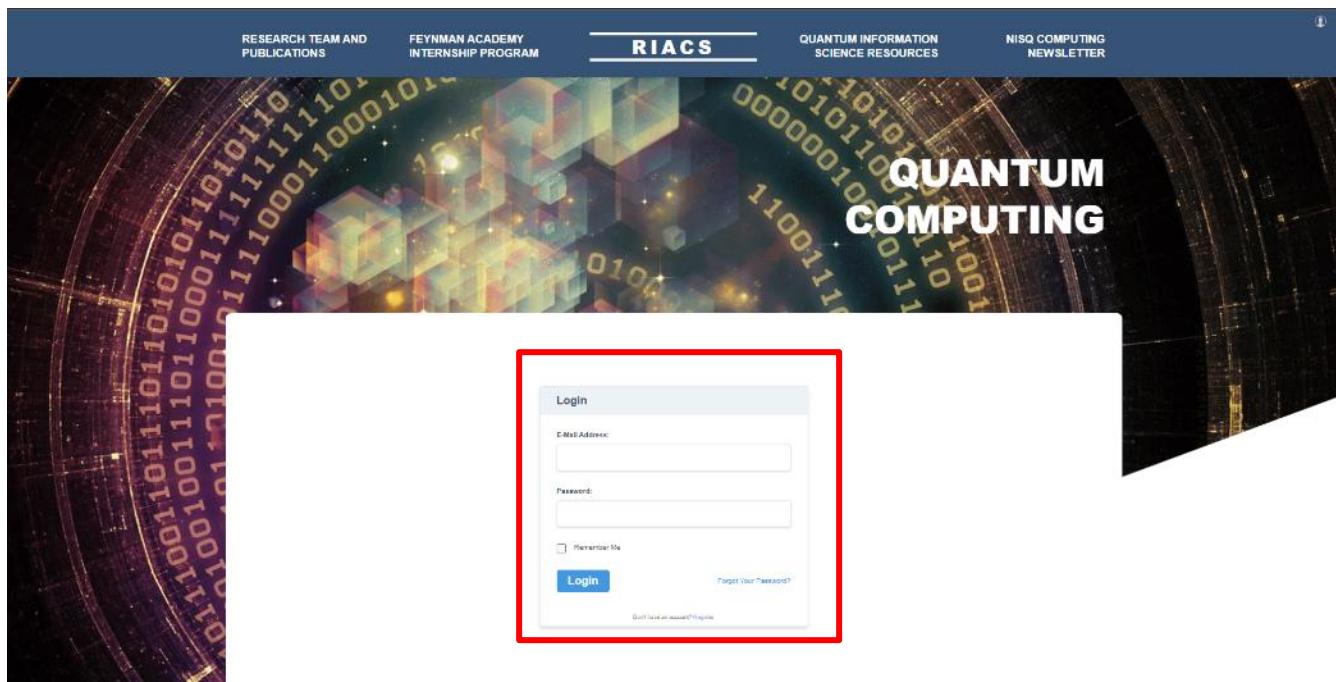
- Don't remember to stop the instances after you are done exploring them. Leaving them open costs money and we have limited resources!



Accessing USRA resources

1. Go to
<https://riacs.usra.edu/quantum/qisprogram>
2. Click on “log in”

Accessing USRA resources



3. Log in with the next credentials:
Username: AFRLguest@AFRL
Password: USRApass1

Accessing USRA resources



DARPA ONISQ Project: Scheduling Applications with Advanced Mixers (SAAM)

Universities Space Research Association (USRA) announced that DARPA has awarded the organization and its partners Rigetti Computing and the NASA Quantum Artificial Intelligence Laboratory (QuAIL) to work as a team to advance the state of art in quantum optimization. USRA, as the prime contractor of the award, will manage the collaboration.

The collaboration will focus on developing a superconducting quantum processor, hardware aware software and custom algorithms that take direct advantage of the hardware advances to solve scheduling and asset allocation problems. In addition, the team will design methods for benchmarking the hardware against classical computers to determine quantum advantage.

In particular, the work will target scheduling problems whose complexity goes beyond what has been done so far with the quantum approximate optimization algorithm (QAOA). USRA's Research Institute for Advanced Computer Science (RIACS) has been working on quantum algorithms for planning and scheduling for NASA QuAIL since 2012. RIACS as the prime contractor will manage the collaboration between NASA QuAIL and Rigetti Computing.

The grant is a part of the DARPA Optimization with Noisy Intermediate-Scale Quantum program (ONISQ). The goal of this program is to establish that quantum information processing using NISQ devices has a quantitative advantage for solving real-world-combinatorial optimization problems using the QAOA method.

NSF SpecEES Project: Advancing the Wireless Spectral Frontier with Quantum-Enabled Computational Techniques (QENeTs)

This project running 2019-2021 is investigating a multitude of new communications receiver decoding algorithms that are amenable to be used in hybrid setting with NISQ quantum computers. The designed methods will be tested on real hardware and benchmarked against the best known classical approaches. In addition to spectral efficiency, the project will also consider how quantum-enabled techniques can improve the energy efficiency of massive multiple-input/multiple-output (MIMO) algorithms. More info on the [project website](#).

NSF Expeditions in Computing Project: Coherent Ising Machines

USRA has received a subaward from NSF, in team with Stanford, Caltech and Cornell University, to work on the prestigious 5-year program Expeditions in Computing. Collaborators include NASA QuAIL, NTT, NII and Microsoft. This Expeditions award exploits unconventional computing architectures, called Coherent Ising Machines (CIMs), to solve a class of optimization problems. CIMs provide a platform to test ideas for computer engineering in the post-Moore's Law era. Next-generation CIMs also hold great promise to drive substantial practical advances in artificial intelligence (AI) capabilities in multiple fields. In addition, the unconventional memory format used by these machines may establish a pathway towards novel quantum information technologies. More info on [NSF press release](#) and [Project Website](#).

[Program Modules](#)



4. Go back to
<https://riacs.usra.edu/quantum/qisprogram>
5. Click on Program Modules

Accessing USRA resources

The screenshot shows a white web page with a dark blue header bar at the top. The header bar contains the text "QIS DEVELOPMENT PROGRAM" on the left and "MENU" with a three-line icon on the right. Below the header, there is a section titled "AFRL Quantum Information Science Workforce Development Program". This section includes a paragraph about the program's objective and a link to the Airforce Institute of Technology. Below this, there is a paragraph about the website's features, mentioning training modules, seminars, and a newsletter. At the bottom of the page, there are two buttons labeled "TRAINING" and "SEMINARS". A small note at the very bottom states: "Development of this site was supported by AFRL NYSTEC Contract (FA8750-19-3-6101)".

There are plenty of seminars and training available to you!

Accessing USRA resources

The screenshot shows the RIACS Quantum Information Science Resources website. At the top, there are links for "RESEARCH TEAM AND PUBLICATIONS", "FEYNMAN ACADEMY INTERNSHIP PROGRAM", "RIACS", "QUANTUM INFORMATION SCIENCE RESOURCES", and "NISQ COMPUTING NEWSLETTER". The main banner features the text "QUANTUM COMPUTING" over a background of binary code and 3D quantum cubes.

The page title is "QIS DEVELOPMENT PROGRAM / TRAININGS / QUANTUM INTEGER PROGRAMMING". On the left, there's a diagram of a graph with red and green nodes connected by lines. Below it, a section titled "Overview" lists course modules: "Lecture 0 - Course Overview (Part 1)", "Lecture 0 - Course Overview (Part 2)", "Lecture 1 - Integer programming (Part 1)", "Lecture 1 - Integer programming (Part 2)", "Lecture 2 - Test-set methods - Gröbner Basis (Part 1)", "Lecture 2 - Test-set methods - Gröbner Basis (Part 2)", and "Lecture 3 - Test-set methods - Gröbner Basis".

The central content area is titled "Quantum Integer Programming". It includes a detailed description of the course objectives, prerequisites, and topics covered. It also lists the instructors: Davide Venturelli, David E. Bernal, Sridhar Tayur, Peter McMahon, and Anil Prabhakar. The number of lessons is 25, and there are 14 interactive lessons. A "Show more..." link is present at the bottom of the description.

Including last years edited videos, codes, and notes!

Accessing USRA resources

RESEARCH TEAM AND PUBLICATIONS

FEYNMAN ACADEMY INTERNSHIP PROGRAM

RIACS

QUANTUM INFORMATION SCIENCE RESOURCES

NISQ COMPUTING NEWSLETTER

QUANTUM COMPUTING

Since its inception in June 1983, RIACS has conducted basic and applied research in computer science for the nation's aeronautics and space-related missions and programs. In 2012, USRA partnered with NASA and Google to found the Quantum Artificial Intelligence Laboratory (QuAIL): the space agency's hub to evaluate the near term impact of quantum technologies.

The mission of RIACS quantum computing team is to advance the industry and the body of knowledge in quantum information related sciences, and to continue to provide to its partners the most qualified technical support to address hard challenges in applied computer science.

Funding

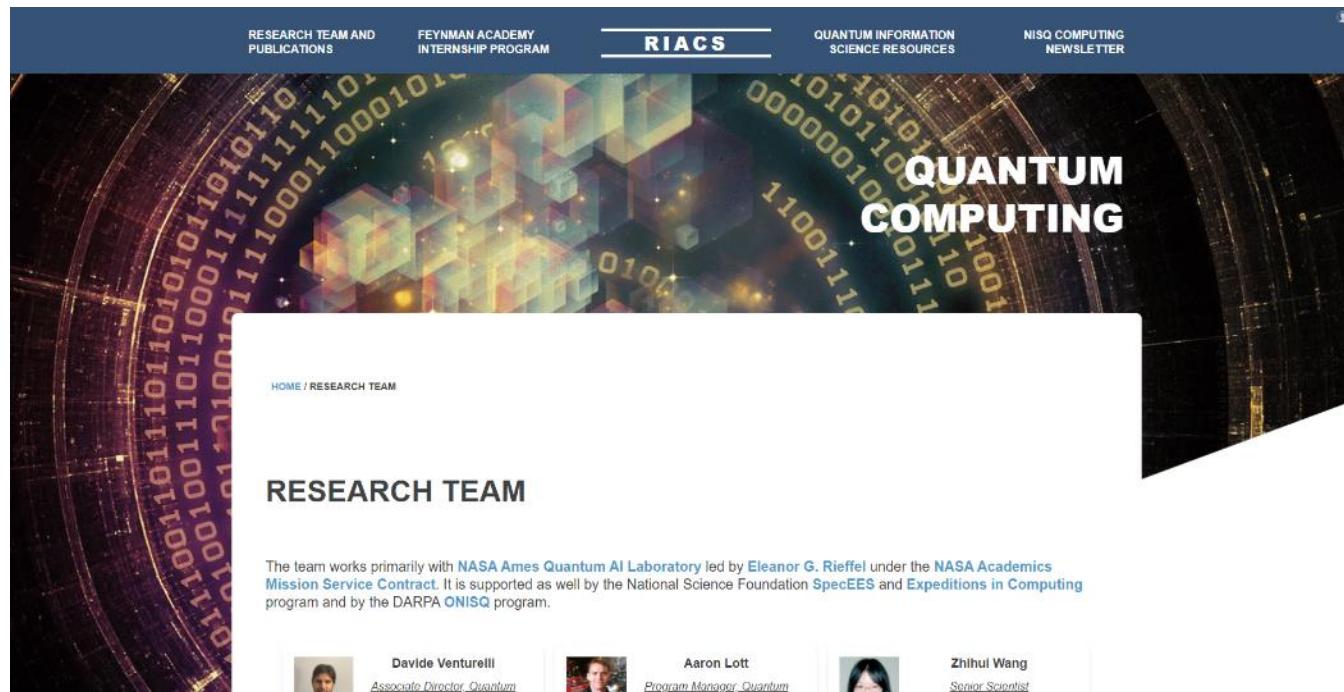
News

NEWS

Best Paper Award MDPI Algorithms Journal

Extra: Go to “Research Team and Publications”

Accessing USRA resources



Scroll down to
Quantum Integer Programming (QuIP) 47-779:
Lecture Notes

Accessing USRA resources

[arXiv preprint arXiv:2103.07036, 2021-03-12](#) Jeffrey Marshall, Gianni Mossi, Eleanor G Rieffel

Quantum-accelerated constraint programming

[arXiv preprint arXiv:2103.04502, 2021-03-08](#) Kyle EC Booth, Bryan OGorman, Jeffrey Marshall, Stuart Hadfield, Eleanor Rieffel

Entanglement across separate silicon dies in a modular superconducting qubit device

[arXiv preprint arXiv:2102.13293, 2021-02-26](#) Alysson Gold, JP Paquette, Anna Stockklauser, Matthew J Reagor, M Sohaib Alam, Andrew Bestwick, Nicolas Didier, Ani Nersisyan, Feyza Oruc, Armin Razavi et al.

Quantum Annealing for Large MIMO Downlink Vector Perturbation Precoding

[arXiv preprint arXiv:2102.12540, 2021-02-24](#) Srikar Kasi, Abhishek Kumar Singh, Davide Venturelli, Kyle Jameson

Information scrambling in computationally complex quantum circuits

[arXiv preprint arXiv:2101.08870, 2021-01-21](#) Xiao Mi, Pedram Roushan, Chris Quintana, Salvatore Mandra, Jeffrey Marshall, Charles Neill, Frank Arute, Kunal Arya, Juan Atalaya, Ryan Babbush et al.

Quantum Integer Programming (QuIP) 47-779: Lecture Notes

[arXiv preprint arXiv:2012.11382, 2020-12-17](#) David E Bernal, Sridhar Tayur, Davide Venturelli

Quantum annealing speedup of embedded problems via suppression of Griffiths singularities

[Physical Review B, 2020-12-10](#) Sergey Knysh, Eugeniu Plamadeala, Davide Venturelli

Classical symmetries and QAOA

[arXiv preprint arXiv:2012.04713, 2020-12-08](#) Ruslan Shaydulin, Stuart Hadfield, Tad Hogg, Ilya Safro

Quantum algorithms with local particle number conservation: noise effects and error correction

[arXiv preprint arXiv:2011.06873, 2020-11-13](#) Michael Streifl, Martin Leib, Filip Wudarski, Eleanor Rieffel, Zhihui Wang

Augmented fidelities for single-qubit gates

[Physical Review A, 2020-11-12](#) Filip Wudarski, Jeffrey Marshall, Andre Petukhov, Eleanor Rieffel

Click on

[Quantum Integer Programming \(QuIP\) 47-779: Lecture Notes](#)

Accessing USRA resources

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References & Citations

- INSPIRE HEP
- NASAADS
- Google Scholar
- Semantic Scholar

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arXiv.org > quant-ph > arXiv:2012.11382

Quantum Physics

(Submitted on 17 Dec 2020 (v1), last revised 11 Jan 2021 (this version, v2))

Quantum Integer Programming (QuIP) 47-779: Lecture Notes

David E. Bernal, Sridhar Tayur, Davide Venturelli

This lecture series on Quantum Integer Programming (QuIP) - created by Professor Sridhar Tayur, David E. Bernal, and Dr. Davide Venturelli, a collaboration between CMU and USRA, with the support from Amazon Braket during Fall 2020 - is intended for students and researchers interested in Integer Programming and the potential of near term quantum and quantum-inspired computing in solving optimization problems.

Originally created for Tepper School of Business course 47-779 (at CMU), these were also used for the course ID5840 (at IIT-Madras, by Professors Anil Prabhakar and Pritha Mandyam) whose students (listed at the beginning of each lecture) were scribes. Dr. Vilesh Siddhu, post-doc in CMU Quantum Computing Group, assisted during the lectures, student projects, and with proof reading this scribe.

Through these lectures one will learn to formulate a problem and map it to a Quadratic Unconstrained Binary Optimization (QUBO) problem, understand various mapping and techniques like the Ising model, Graver Augmented Multiseed Algorithm (GAMA), Simulated or Quantum Annealing and QAOA, and ideas on how to solve these Integer problems using these quantum and classical methods.

Comments: The course website (with lecture videos and Google Colab notebooks) is <https://bernalde.github.io/QuIP/>.

Subjects: Quantum Physics (quant-ph)

Cite as: arXiv:2012.11382 [quant-ph] (or arXiv:2012.11382v2 [quant-ph] for this version)

Submission history

From: David E. Bernal Neira [view email]

[v1] Mon, 17 Dec 2020 19:52:06 UTC (4,180 KB)

[v2] Mon, 11 Jan 2021 21:29:49 UTC (4,180 KB)

Bibliographic Tools Code & Data Related

Bibliographic and Citation Tools

Bibliographic Explorer (What is the Explorer?)

Litmaps (What is Litmaps?)

scite Smart Citations (What are Smart Citations?)

arXiv:2012.11382v2 [quant-ph] 11 Jan 2021

Quantum Integer Programming (QuIP) 47-779: Lecture Notes
David E. Bernal, Sridhar Tayur, Davide Venturelli
Fall 2020

Abstract

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The course website (with lecture videos and colab notebooks): <https://bernalde.github.io/QuIP/>

Keywords: Ising model, Integer Programming, Computational Algebraic Geometry, Graver Basis, Quantum Annealing, Simulated Annealing, Combinatorial Optimization, Graph coloring, discrete nonlinear optimization.

You will see the arXiv preprint with the scribed notes from 2020 Quantum Integer Programming.