

# **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 Group

Lecture X

2021.10.12

# Agenda

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

# Create IBM (Qiskit) account

Qiskit 0.30.1  
[see release notes](#)

## Open-Source Quantum Development

Qiskit [kiss-kit] is an open-source SDK for working with quantum computers at the level of pulses, circuits, and application modules.

[Get started](#)

Feedback

What can Qiskit do

Qiskit accelerates the development of quantum applications by providing the

1- Go to [www.qiskit.org](http://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](#).

#### Qiskit Install

Stable (recommended)

Unstable

#### Operating System

Linux

Mac

Windows

#### Terminal

```
pip install qiskit
```

copy

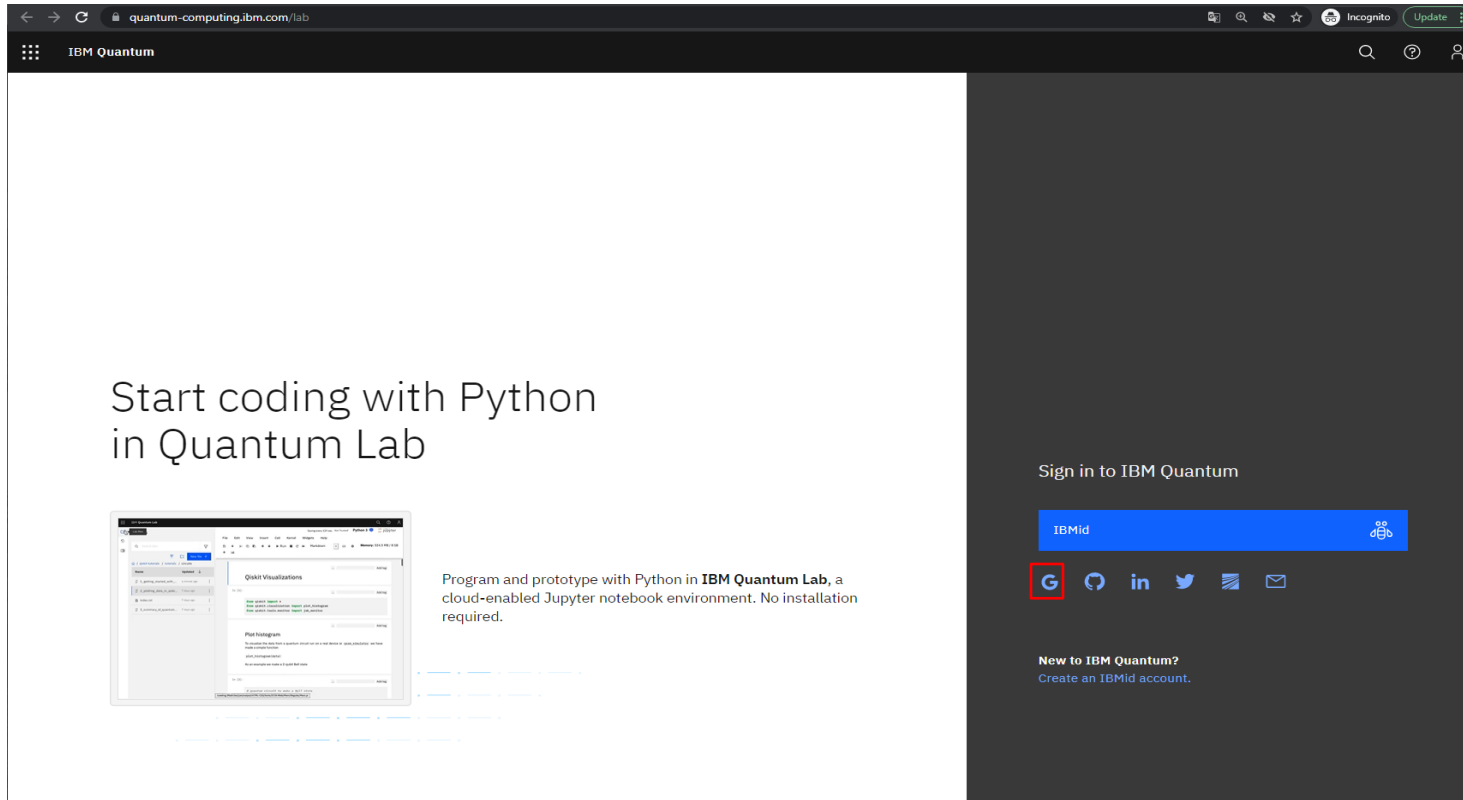
### Start Online

Get started in the cloud without installing anything with IBM Quantum Lab.

IBM Quantum Lab

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

# Create IBM (Qiskit) account



The screenshot shows the IBM Quantum Lab website in a browser window. The URL is quantum-computing.ibm.com/lab. The page features a large heading "Start coding with Python in Quantum Lab" and a sub-image of the Quantum Lab interface. Below the sub-image, text reads: "Program and prototype with Python in IBM Quantum Lab, a cloud-enabled Jupyter notebook environment. No installation required." On the right side of the page, there is a "Sign in to IBM Quantum" section with a blue "IBMid" button and a row of social media icons. The Google icon is highlighted with a red square. Below the social media icons, there is a link for "New to IBM Quantum? Create an IBMID 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

aaa@andrew.cmu.edu

[¿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](#)

Español (Latinoamérica) ▾ [Ayuda](#) [Privacidad](#) [Condiciones](#)

## Web Login

AndrewID

Password

Login

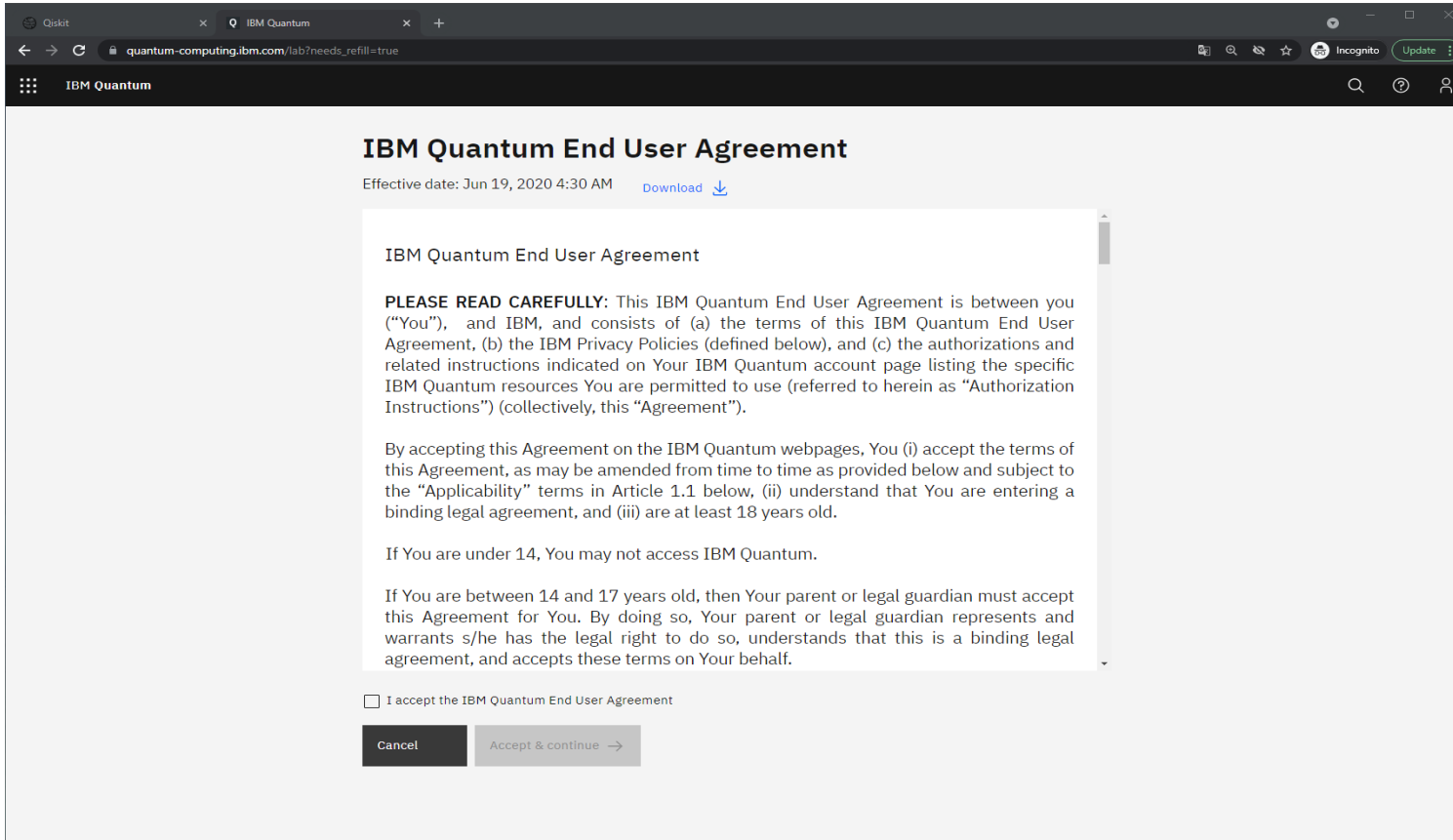


Warning: The URL for this page should begin with <https://login.cmu.edu>.  
If it does not, do not fill in any information, and report this site to [it-help@cmu.edu](mailto:it-help@cmu.edu).

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

4- Log with your credentials

# Create IBM (Qiskit) account



The screenshot shows a web browser window displaying the IBM Quantum End User Agreement. The browser's address bar shows the URL `quantum-computing.ibm.com/lab?needs_refill=true`. The page title is "IBM Quantum End User Agreement" with an effective date of "Jun 19, 2020 4:30 AM" and a "Download" link. The main content area contains the following text:

**IBM Quantum End User Agreement**

**PLEASE READ CAREFULLY:** This IBM Quantum End User Agreement is between you ("You"), and IBM, and consists of (a) the terms of this IBM Quantum End User Agreement, (b) the IBM Privacy Policies (defined below), and (c) the authorizations and related instructions indicated on Your IBM Quantum account page listing the specific IBM Quantum resources You are permitted to use (referred to herein as "Authorization Instructions") (collectively, this "Agreement").

By accepting this Agreement on the IBM Quantum webpages, You (i) accept the terms of this Agreement, as may be amended from time to time as provided below and subject to the "Applicability" terms in Article 1.1 below, (ii) understand that You are entering a binding legal agreement, and (iii) are at least 18 years old.

If You are under 14, You may not access IBM Quantum.

If You are between 14 and 17 years old, then Your parent or legal guardian must accept this Agreement for You. By doing so, Your parent or legal guardian represents and warrants s/he has the legal right to do so, understands that this is a binding legal agreement, and accepts these terms on Your behalf.

I accept the IBM Quantum End User Agreement

Buttons: Cancel, Accept & continue →

## 5- Read the End User Agreement

# Create IBM (Qiskit) account

quantum-computing.ibm.com/lab?needs\_refill=true

IBM Quantum

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:

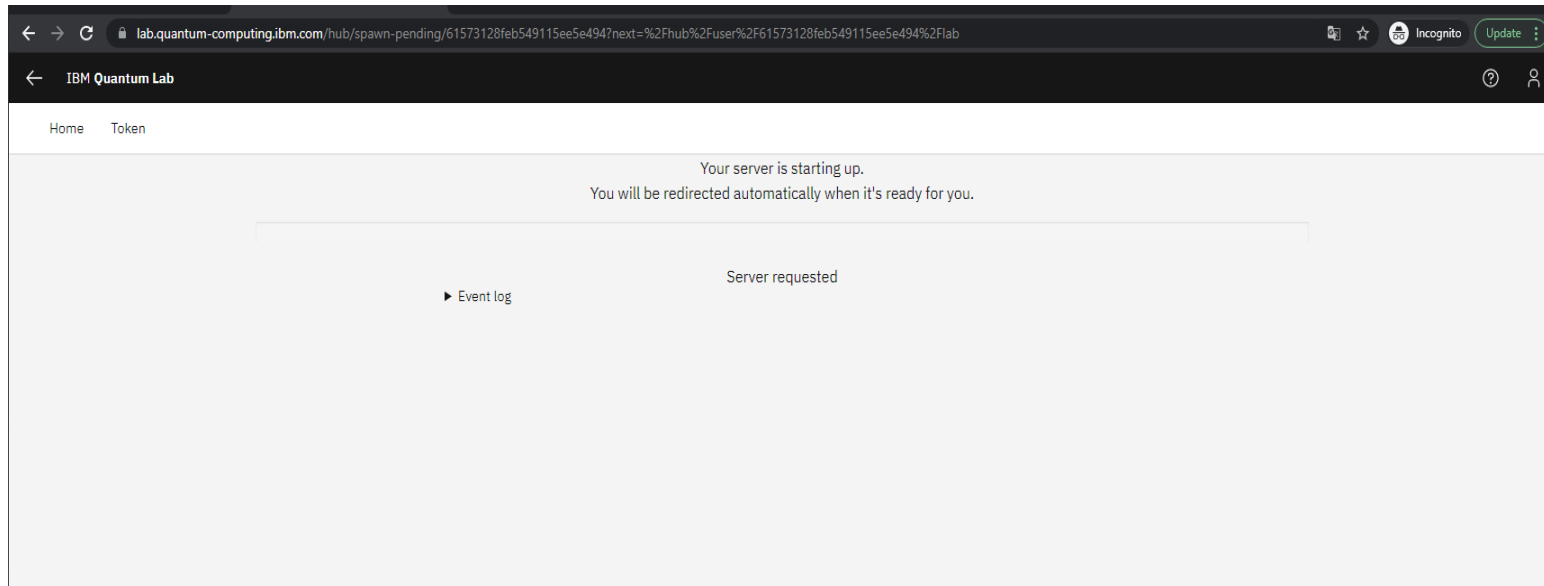
- Product updates and announcements
- IBM Quantum newsletter
- Tips about using our tools
- Requests for feedback to help improve our tools

Cancel Continue →

6- Complete the last step

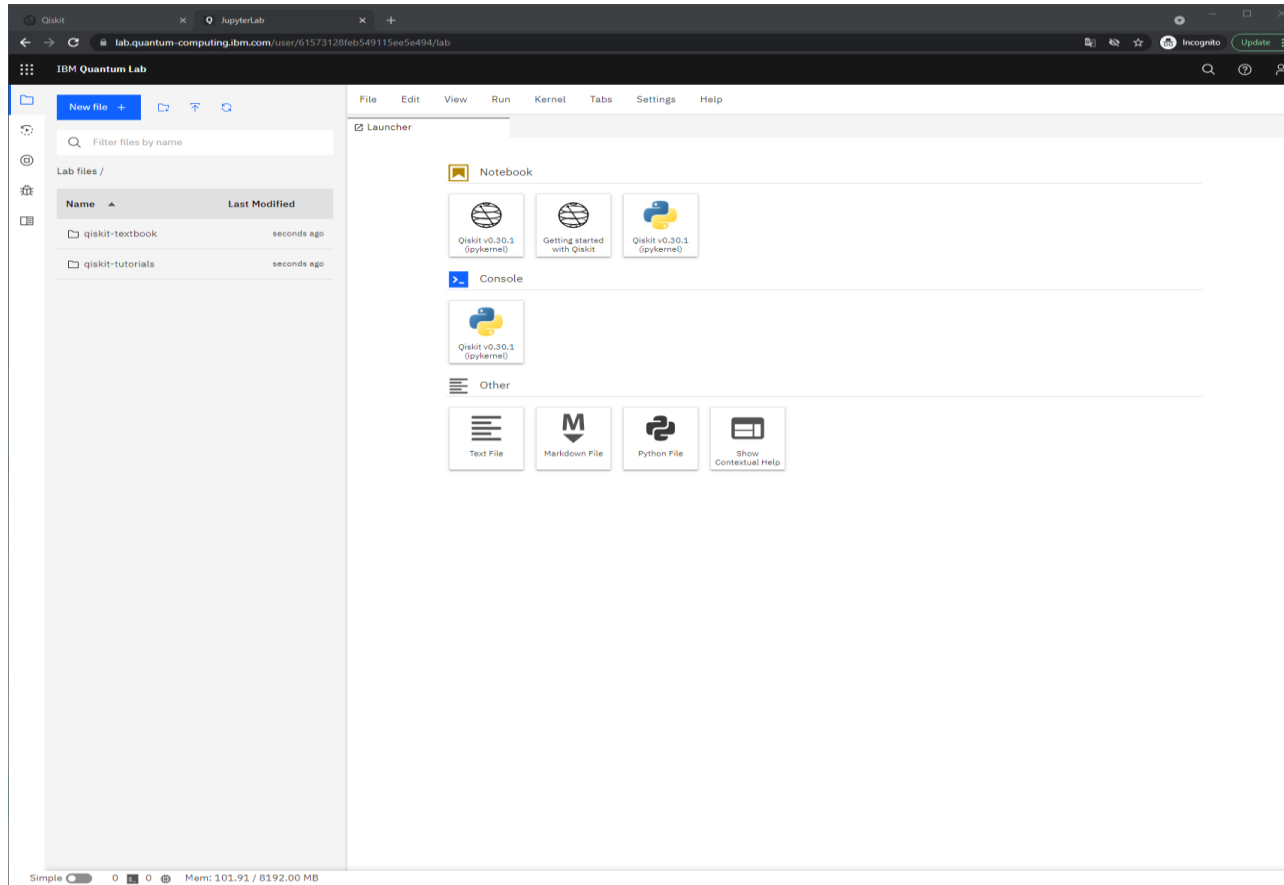


# Create IBM (Qiskit) account



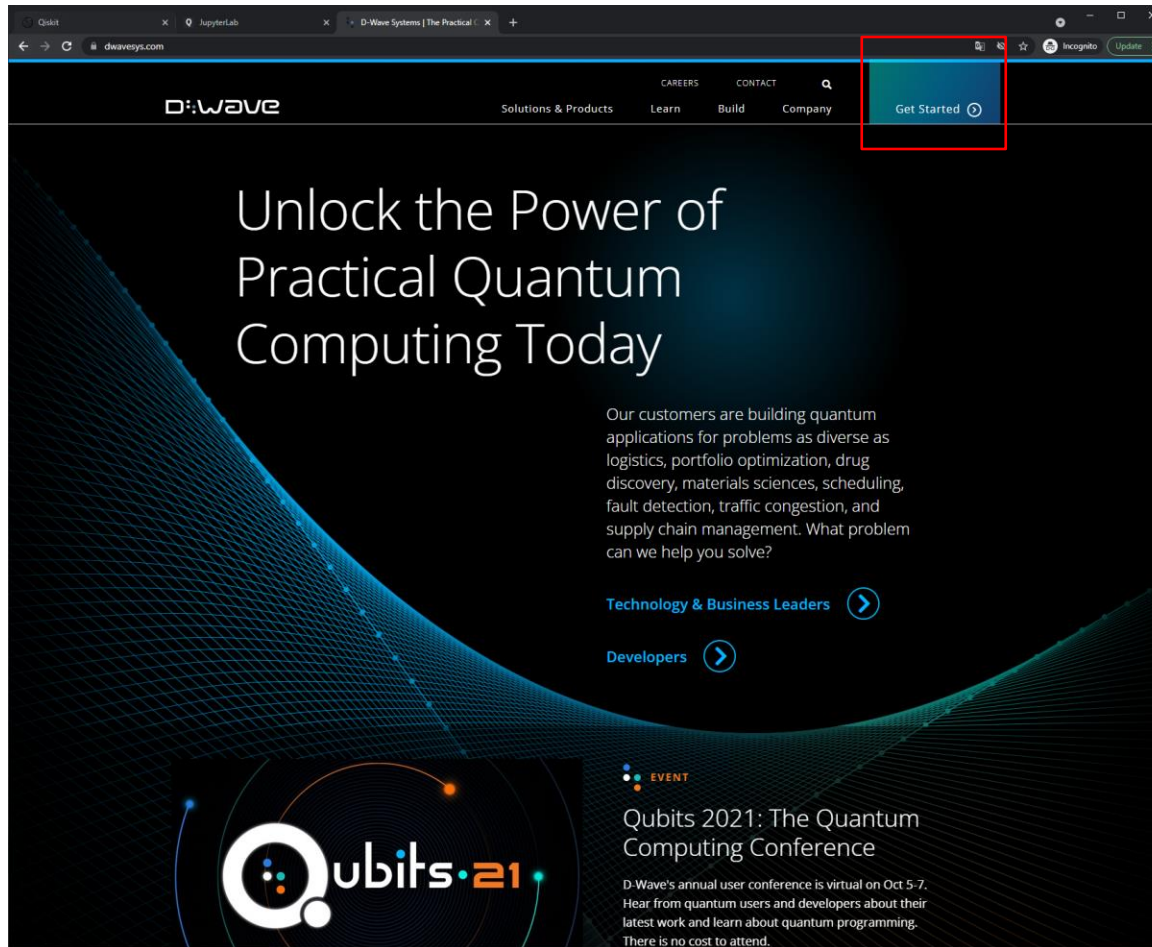
7- Wait while the server is starting up

# Create IBM (Qiskit) account



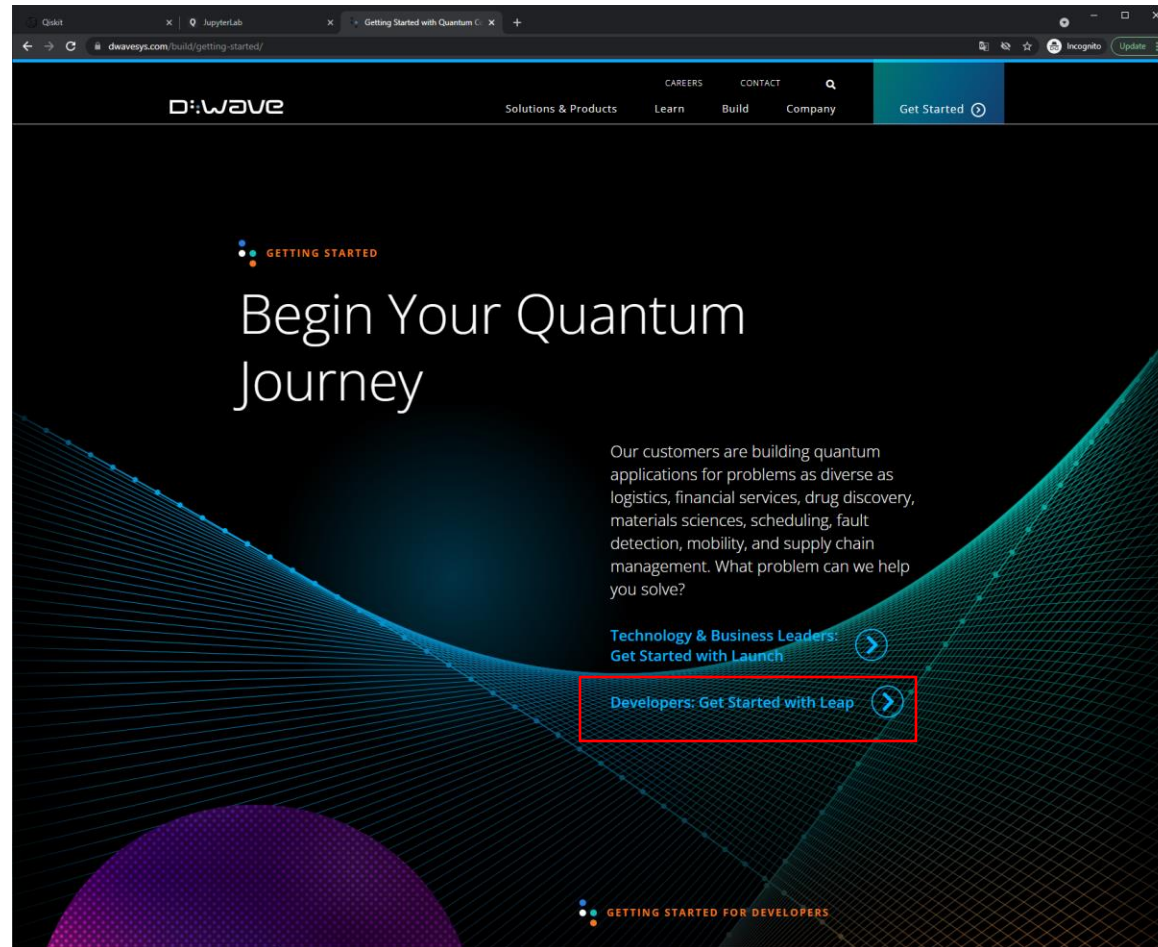
8- Your account should be created successfully!

# Create D-WAVE (Leap) account



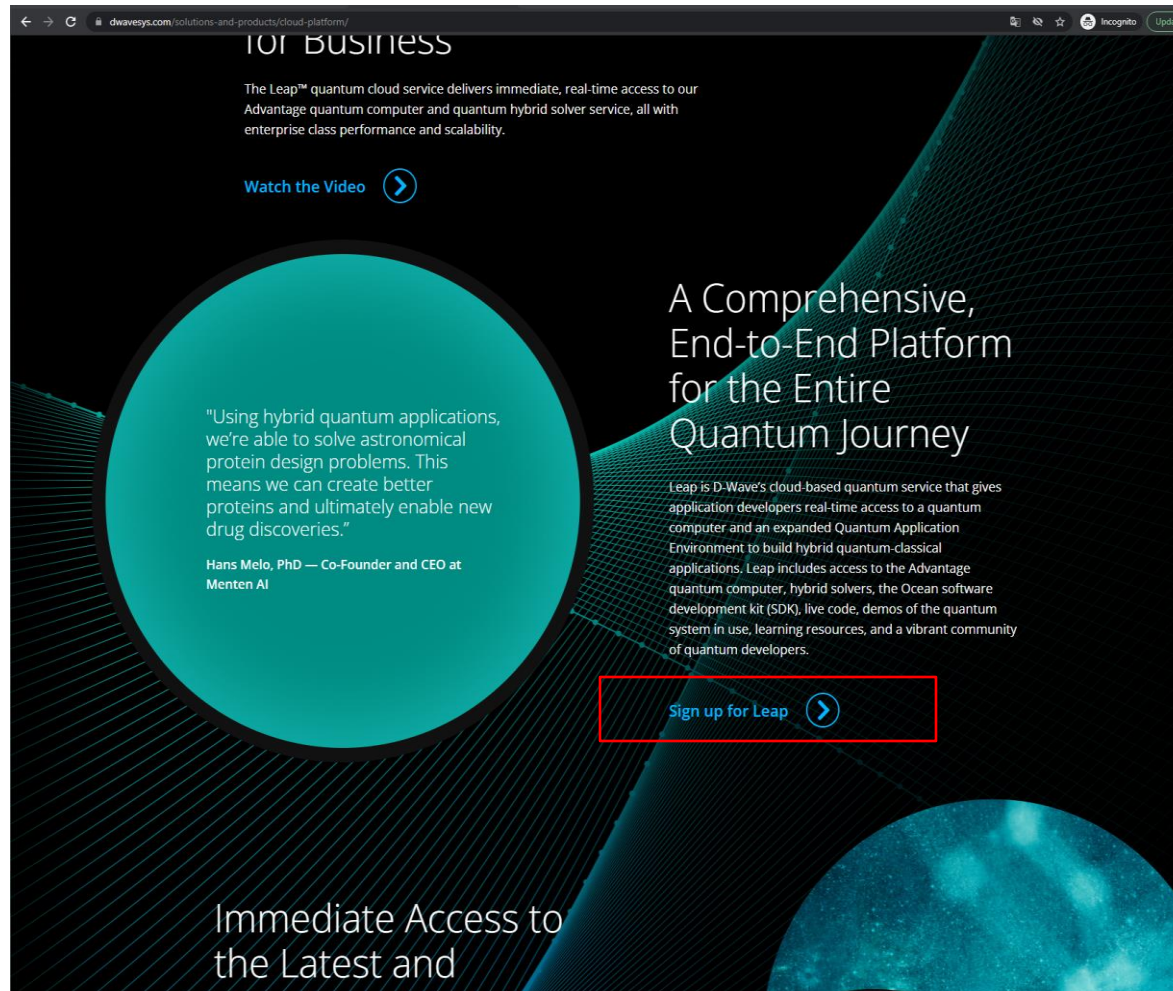
- 1- Go to [dwavesys.com](https://dwavesys.com)
- 2- Click on “Get Started”

# Create D-WAVE (Leap) account



3- Click on “Developers Get Started with Leap”

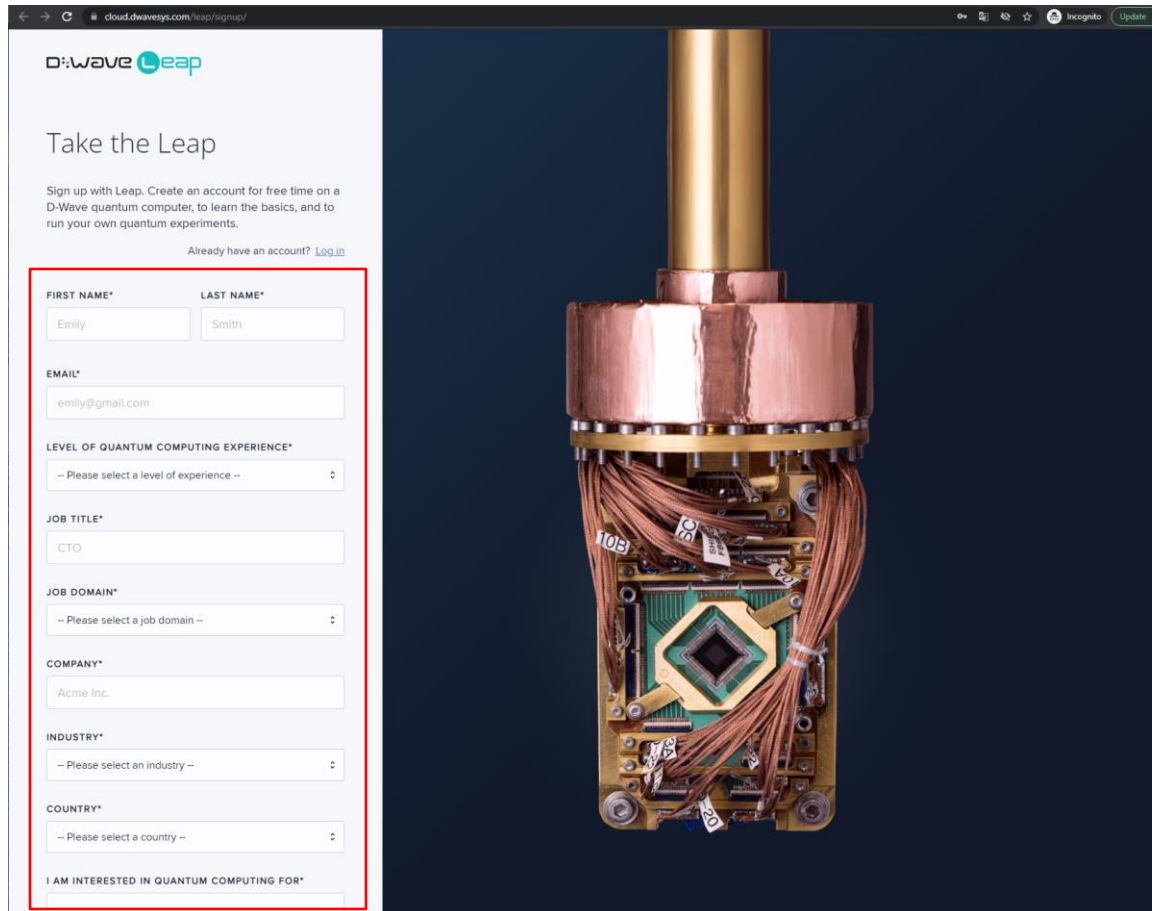
# Create D-WAVE (Leap) account



4- Scroll down

5- Click on "Sign up for Leap"

# Create D-WAVE (Leap) account



cloud.dwavesys.com/leap/signup/

D:WAVE Leap

## Take the Leap

Sign up with Leap. Create an account for free time on a D-Wave quantum computer, to learn the basics, and to run your own quantum experiments.

Already have an account? [Log in](#)

**FIRST NAME\***  **LAST NAME\***

**EMAIL\***

**LEVEL OF QUANTUM COMPUTING EXPERIENCE\***  
-- Please select a level of experience --

**JOB TITLE\***

**JOB DOMAIN\***  
-- Please select a job domain --

**COMPANY\***

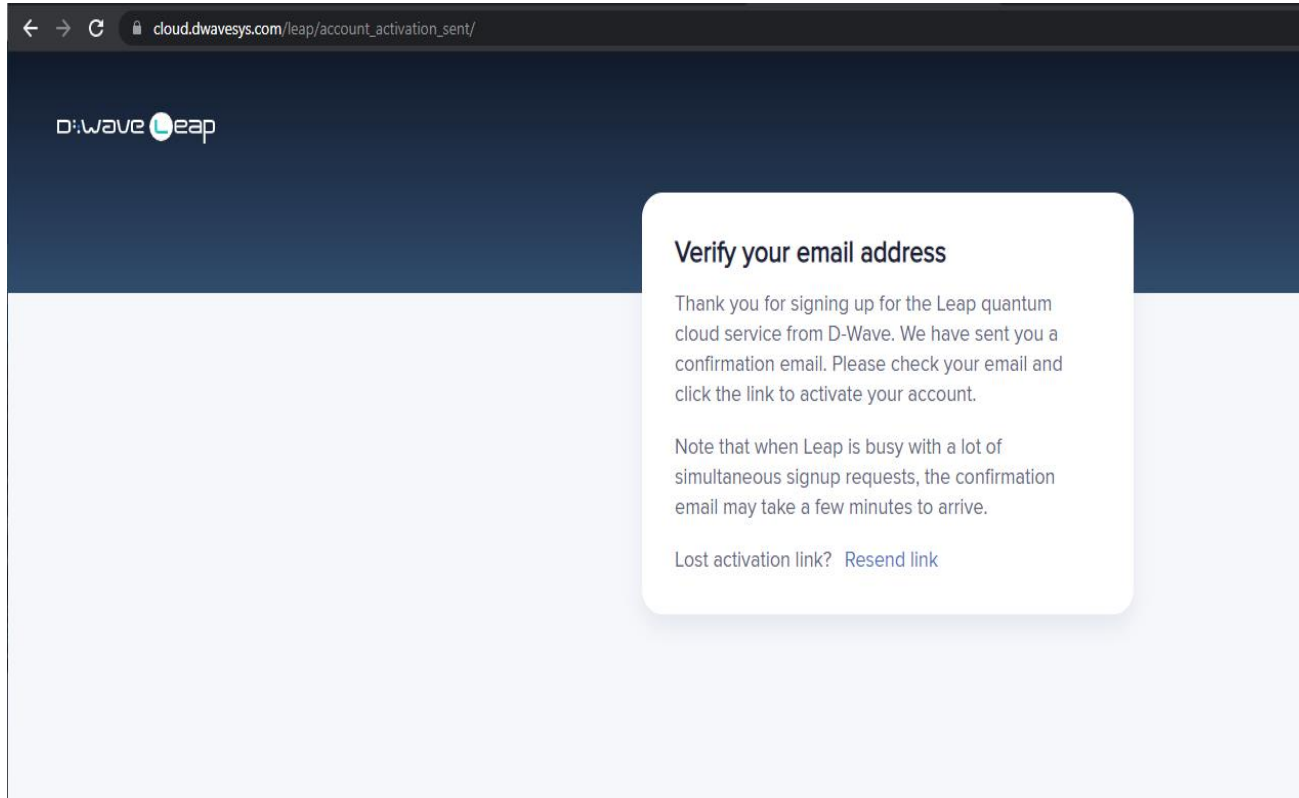
**INDUSTRY\***  
-- Please select an industry --

**COUNTRY\***  
-- Please select a country --

**I AM INTERESTED IN QUANTUM COMPUTING FOR\***

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.

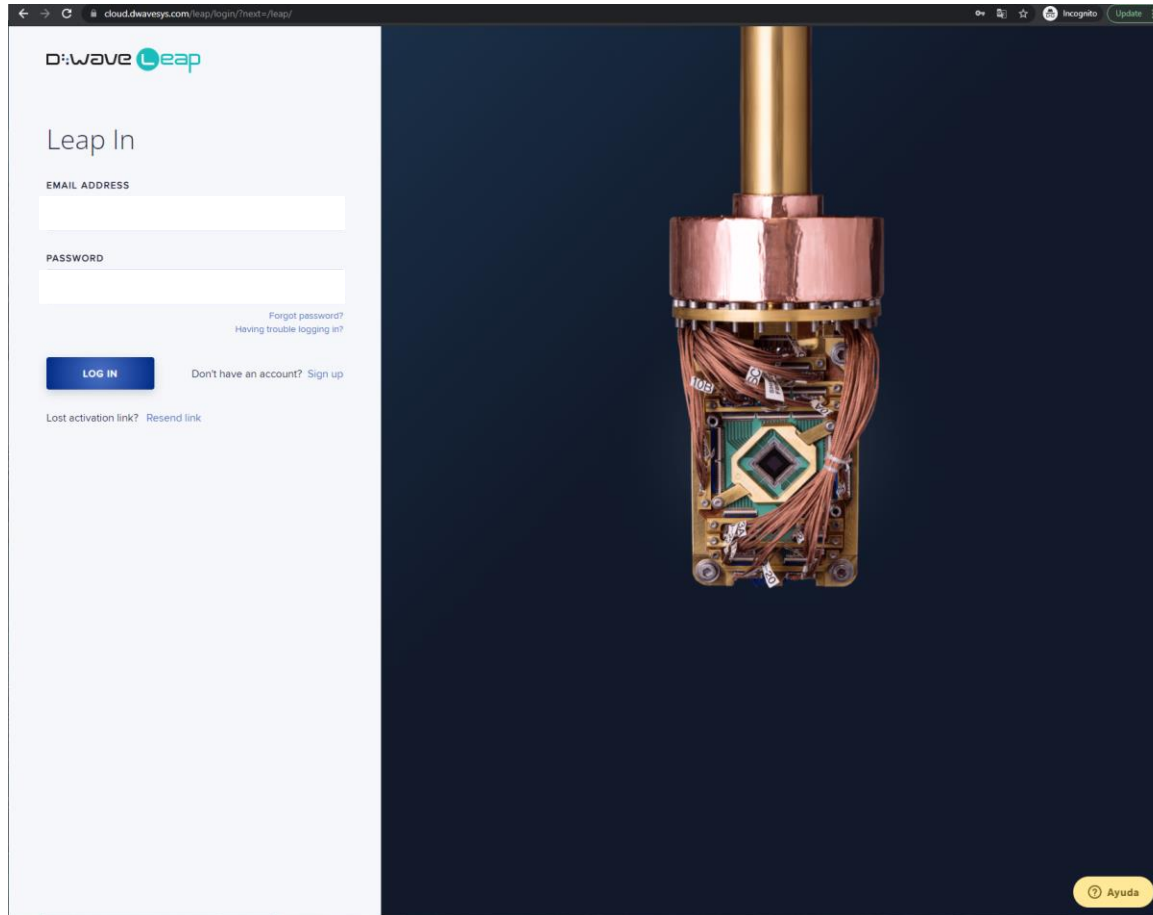
---

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](mailto:support@dwavesys.com).

## 8- Confirm your registration

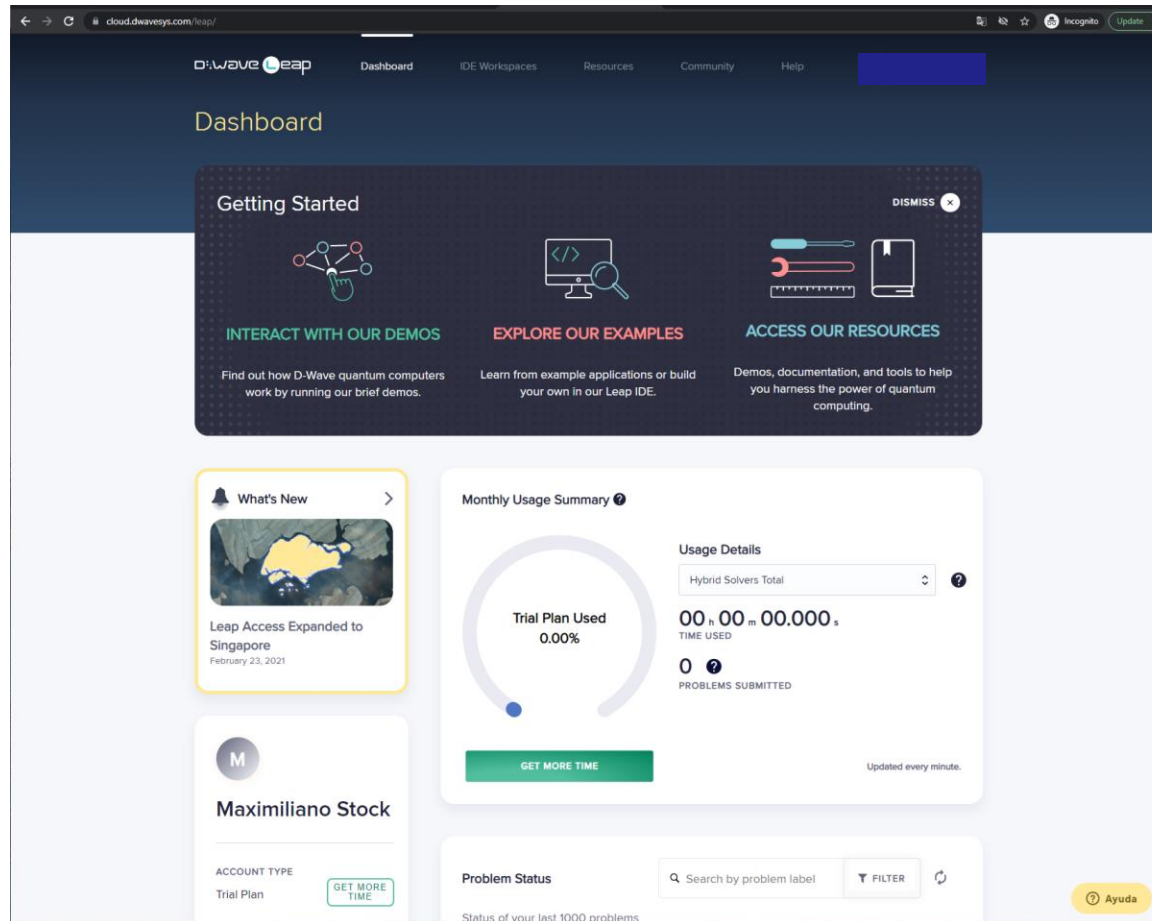


# Create D-WAVE (Leap) account



9- Log in

# Create D-WAVE (Leap) account



10- Enjoy!

# Create AWS account

aws Products Solutions Pricing Documentation Learn Partner Network AWS Marketplace Customer Enablement Events Explore More Q

Contact Us Support English My Account Complete Sign Up

¡Celebremos! | Join us in honoring Hispanic Heritage. Learn more >

## Complete your AWS Registration

Millions of customers are using AWS cloud solutions to build applications with increased flexibility, scalability, security, and reliability

[Complete Sign up](#)

Join us and start building today

**Free Tier**  
Use Amazon EC2, S3, and more—  
free for a full year  
[Learn more >](#)

**Registration FAQ**  
Explore frequently asked questions  
on sign-up flow  
[Learn more >](#)

**Contact Us**  
Reach out to us for any AWS related  
questions  
[Learn more >](#)

### Explore Our Solutions

By Industry

**Advertising & Marketing**  
Achieve cost efficiency for your advertising

**Financial Services**  
Lower cost. More resilience. Faster AWS.

**Game Tech**  
Create computationally intensive games

**Media & Entertainment**  
From content creation to distribution

- 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

**AWS DeepRacer** offers online, in-person, and hybrid events for getting started with machine learning

aws [Learn more](#)

The banner features a stylized white car with a purple brain icon on its side, connected to a laptop and a trophy. The AWS logo is in the bottom left, and a purple 'Learn more' button is in the bottom right.

3- Click “Create a new AWS account”

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English ▾

# Create AWS account



Explore Free Tier products with a new AWS account.

To learn more, visit [aws.amazon.com/free](https://aws.amazon.com/free).



## Sign up for AWS

Email address

You will use this email address to sign in to your new AWS account.

Password

Confirm password

AWS account name


Choose a name for your account. You can change this name in your account settings after you sign up.

[Continue \(step 1 of 5\)](#)

[Sign in to an existing AWS account](#)




4- Complete step 1

# Create AWS account



**Free Tier offers**

All AWS accounts can explore 3 different types of free offers, depending on the product used.

-  **Always free**  
Never expires
-  **12 months free**  
Start from initial sign-up date
-  **Trials**  
Start from service activation date

### Sign up for AWS

**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.

Country or Region

Address

City

State, Province, or Region

Postal Code

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

**Continue (step 2 of 5)**

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

6- Complete step 2

# Create AWS account



## Secure verification

**i** 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.



## Sign up for AWS

### Billing Information

Credit or Debit card number



AWS accepts all major credit and debit cards. To learn more about payment options, review our [FAQ](#)

Expiration date

Cardholder's name

Billing address

Use my contact address

5000 Forbes Av  
Pittsburgh Pennsylvania 15213  
US

Use a new address

**Verify and Continue (step 3 of 5)**

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



## Welcome to Amazon Web Services

Thank you for creating an Amazon Web Services (AWS) account. For the next 12 months, you'll have free access to all AWS services within the limits of the [Free Tier](#).

If you are unable to access AWS Services, please note that some services may take up to 24 hours to fully activate. If you're still unable to access AWS Services after that time, please visit [AWS Support](#).

[Getting Started Resources »](#)

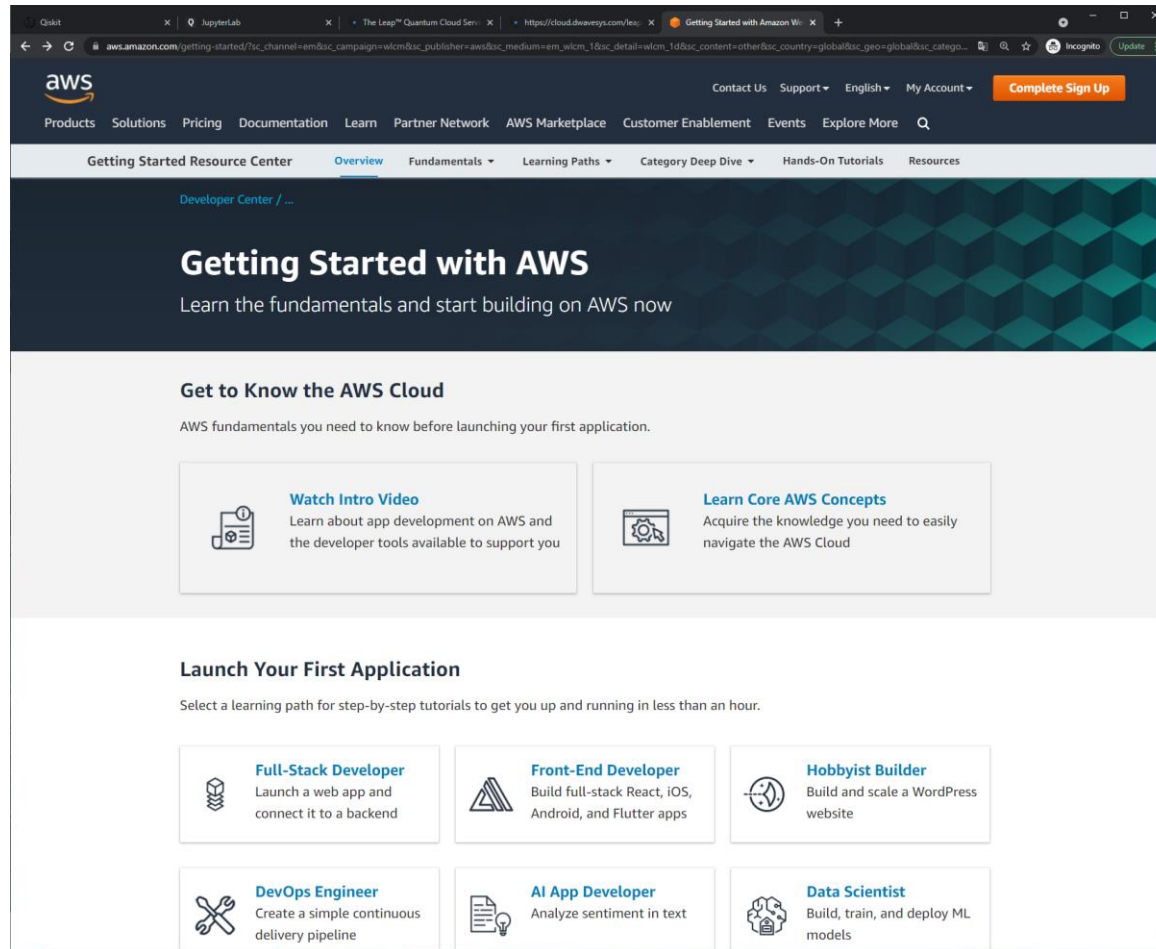
Welcome to the AWS community!

—The Amazon Web Services Team

8- Click on “Getting Started Resources”



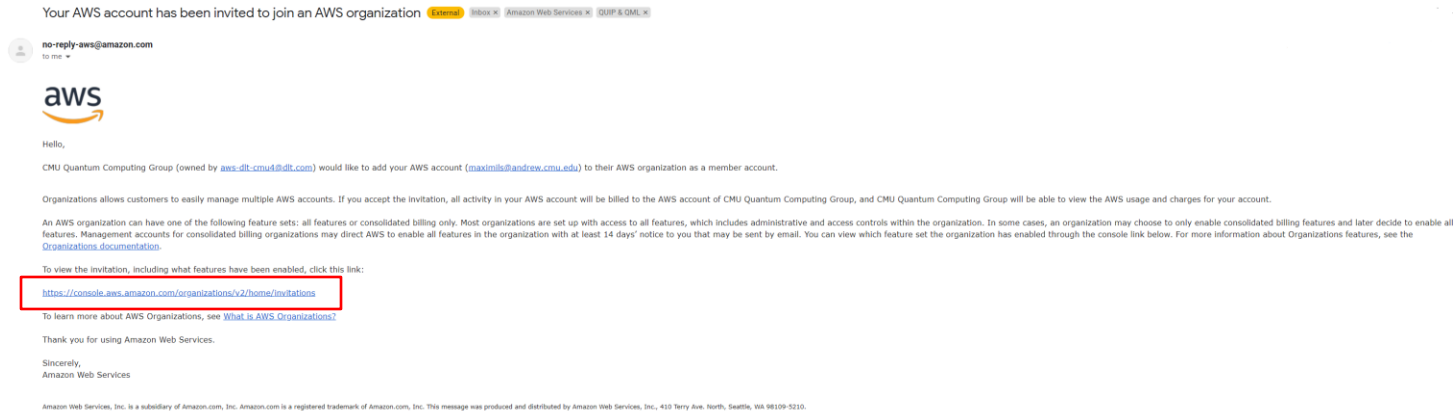
# Create AWS account



The screenshot shows the AWS Getting Started page. The browser address bar displays the URL: [aws.amazon.com/getting-started/?ic\\_channel=em&ic\\_campaign=welcome&ic\\_publisher=aws&ic\\_medium=em\\_wcom\\_1&ic\\_detail=wcom\\_1d&ic\\_content=other&ic\\_country=global&ic\\_geo=global&ic\\_category=...](https://aws.amazon.com/getting-started/?ic_channel=em&ic_campaign=welcome&ic_publisher=aws&ic_medium=em_wcom_1&ic_detail=wcom_1d&ic_content=other&ic_country=global&ic_geo=global&ic_category=...). The page features the AWS logo, navigation links (Products, Solutions, Pricing, Documentation, Learn, Partner Network, AWS Marketplace, Customer Enablement, Events, Explore More), and a 'Complete Sign Up' button. The main heading is 'Getting Started with AWS' with the subtext 'Learn the fundamentals and start building on AWS now'. Below this, there are two main sections: 'Get to Know the AWS Cloud' and 'Launch Your First Application'. The 'Get to Know the AWS Cloud' section includes 'Watch Intro Video' and 'Learn Core AWS Concepts'. The 'Launch Your First Application' section includes 'Full-Stack Developer', 'Front-End Developer', 'Hobbyist Builder', 'DevOps Engineer', 'AI App Developer', and 'Data Scientist'.

9- You should be redirected to [aws.amazon.com/getting-started](https://aws.amazon.com/getting-started)

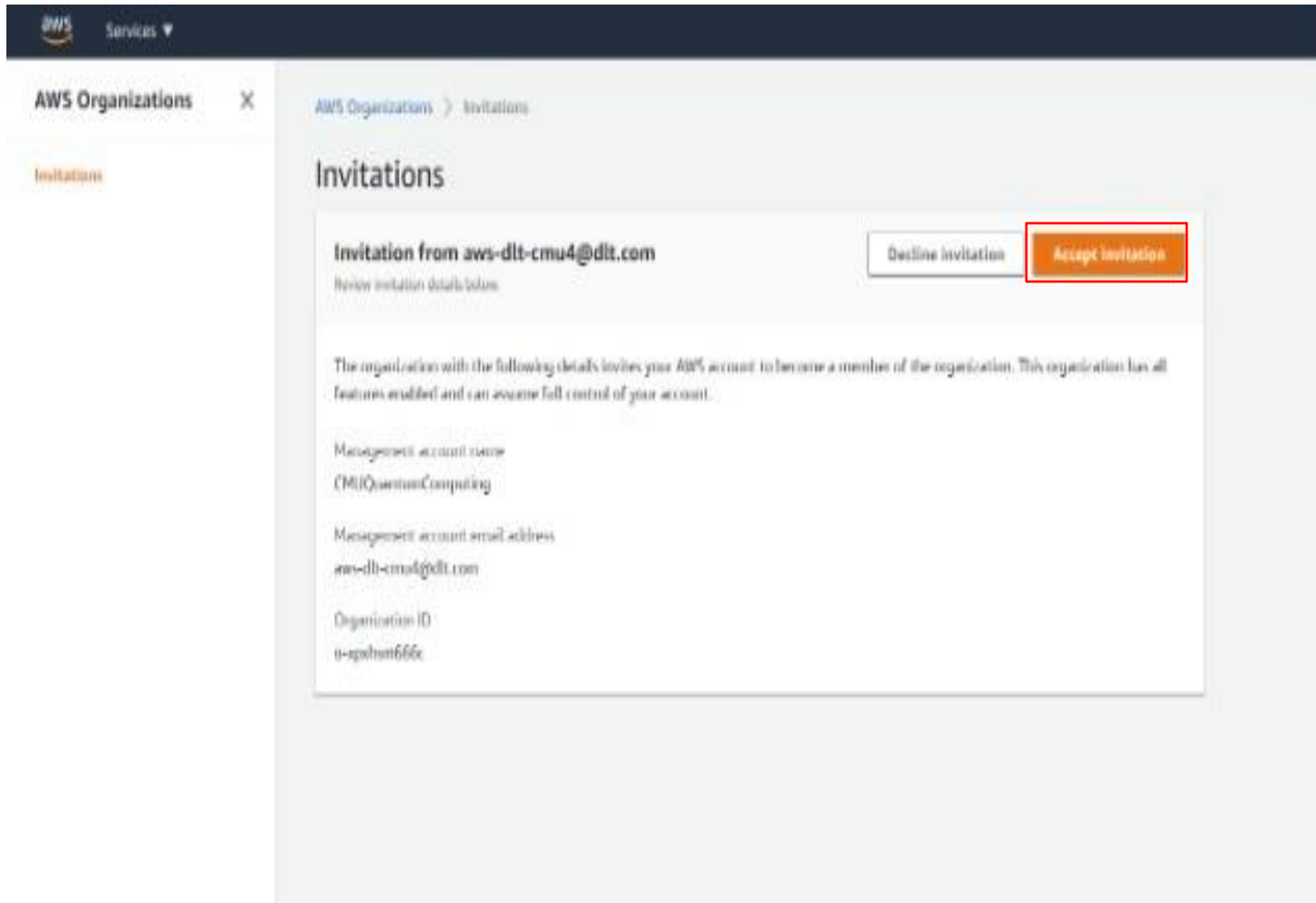
# Create AWS account



10- Check your email

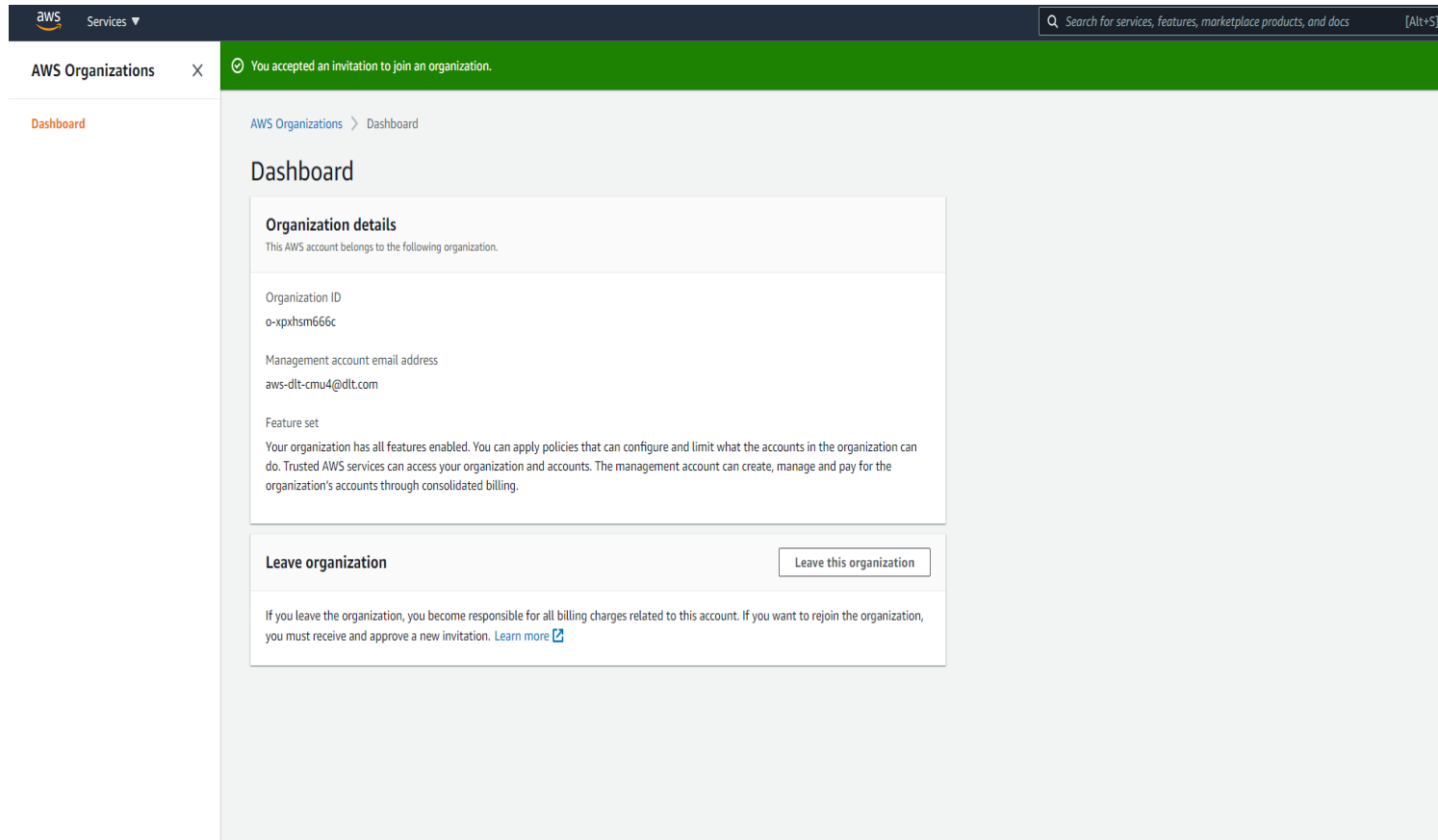
11- Click the link to view the invitation to join an AWS Organization

# Create AWS account



12- Accept invitation

# Create AWS account



The screenshot shows the AWS Organizations console dashboard. At the top, there is a navigation bar with the AWS logo, a search bar, and a notification: "You accepted an invitation to join an organization." The main content area is titled "Dashboard" and contains two sections:

- Organization details**: This section provides information about the organization the account belongs to.
  - Organization ID: o-xpzhsm666c
  - 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.
- Leave organization**: This section includes a "Leave this organization" button and a warning: "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](#)." The "Learn more" link is a blue hyperlink.

13- Enjoy!

# Amazon Braket

The screenshot shows the Amazon Braket website. At the top right, the 'Complete Sign Up' button is highlighted with a red box. The main content area features the heading 'Amazon Braket' and the sub-heading 'Accelerate quantum computing research'. A prominent callout box states '1 free hour of simulation time per month for a year with AWS Free Tier'. Below this, three key benefits are listed: 'Easily work with different types of quantum computers and circuit simulators using a consistent set of development tools.', 'Build quantum projects on a trusted cloud with simple pricing and management controls for both quantum and classical workloads.', and 'Innovate quickly with expert guidance and tech support, or collaborate with consultants in the Amazon Quantum Solutions Lab.' The 'How it works' section includes a five-step process: Amazon Braket (Get started with quantum computing), Build (Build your quantum algorithms on managed Jupyter notebooks or in your own development environment), Test (Test your algorithms on a local simulator or a choice of fully managed, high-performance simulators), Run (Run your algorithms on your choice of different quantum computers. Combine classical and quantum computing resources for hybrid algorithms), and Analyze (Analyze results after your algorithm has completed).

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

# Amazon Braket



## 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



## Security check

Type the characters seen in the image below




Submit

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English



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

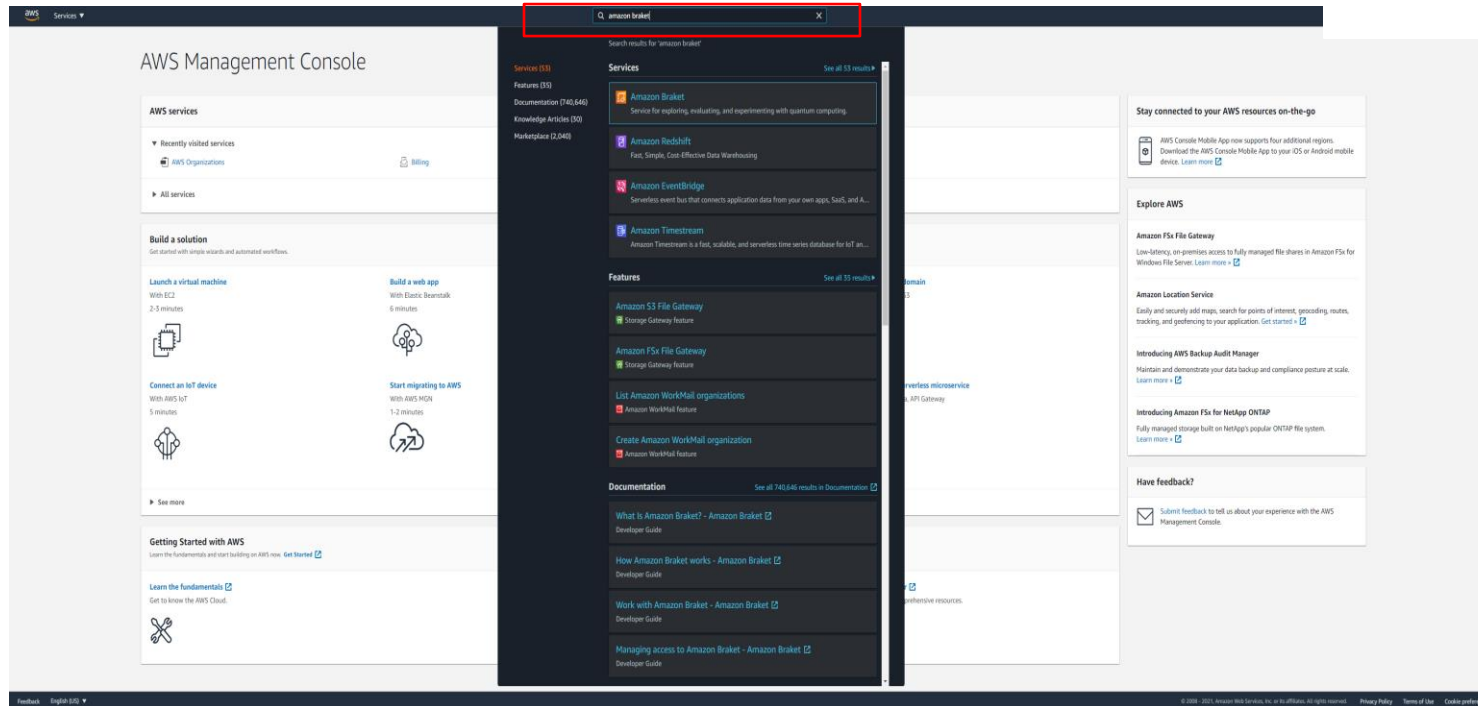
I am interested in: [select area](#) ▾

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](#).

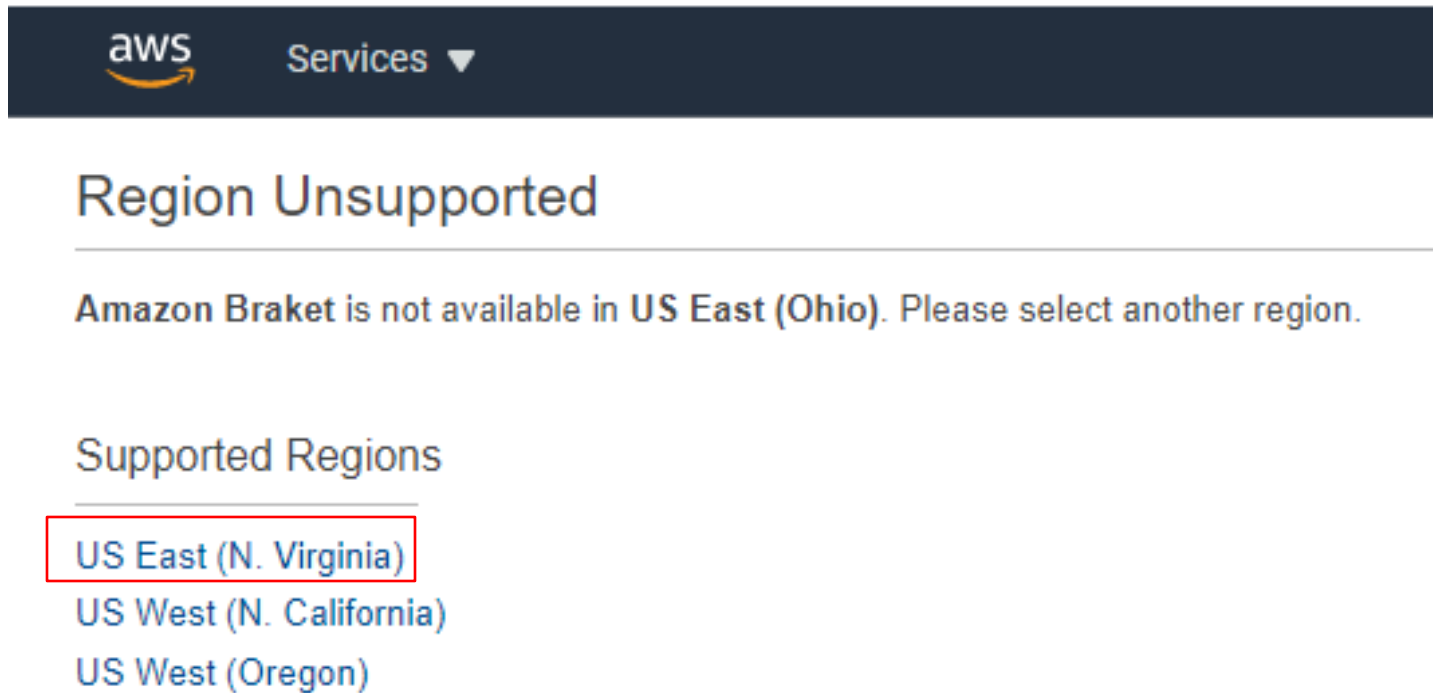


# Amazon Braket



6- Search for Amazon Braket

# Amazon Braket



The screenshot shows the AWS Services menu at the top. Below it, the text 'Region Unsupported' is displayed. A message states: 'Amazon Braket is not available in US East (Ohio). Please select another region.' Underneath, a section titled 'Supported Regions' lists three options: 'US East (N. Virginia)', 'US West (N. California)', and 'US West (Oregon)'. The 'US East (N. Virginia)' option is highlighted with a red rectangular border.

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 AWS console interface for Amazon Braket. The main heading is "Getting started with Amazon Braket". Below this, there is a brief introduction: "Amazon Braket provides a development environment to design quantum algorithms, test them on quantum simulators, and run them on a quantum computer. To successfully configure and enable Amazon Braket, you need to use an account that has the AmazonBraketFullAccess. You, or your AWS admin, can attach the policy to your role, user, or group using the IAM console." A "Learn more" link is provided.

The "Choose your data storage" section explains that Amazon Braket stores results in an Amazon S3 bucket. It offers three options: "Create new" (selected), "Specify new", and "Select existing". A confirmation message states: "We will create the new bucket amazon-braket-de78199c9526."

The "Account permissions" section states that Amazon Braket creates a service-linked role. It allows Amazon Braket to access AWS resources on behalf of the user. A "Permissions" link is provided.

The "Terms & conditions" section contains a text box with the following text: "If you use Amazon Braket to access quantum computing hardware operated by one of the third-party hardware providers listed here (each a 'Hardware Provider'), you: (1) acknowledge that the Content you provide in connection with your use of Amazon Braket may be processed by the Hardware Provider outside of facilities operated by AWS; and (2) authorize AWS to transfer such Content to the Hardware Provider for processing." Below this text is a checkbox labeled "I have read and accepted the above terms & conditions.", which is currently unchecked.

An orange "Enable Amazon Braket" button is located at the bottom right of the main content area.

The footer of the console shows "Feedback", "English (US)", "© 2008 - 2021, Amazon Web Services, Inc. or its affiliates. All rights reserved.", "Privacy Policy", "Terms of Use", and "Cookie preferences".

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

# Amazon Braket

The screenshot displays the Amazon Braket console interface. The left sidebar contains navigation options: Amazon Braket, Devices, Notebooks, Tasks, and Announcements. The main content area is titled "Amazon Braket > Devices" and is divided into two 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. Next available: AVAILABLE NOW.
- D-Wave — DW\_2000Q\_6:** Quantum Annealer based on superconducting qubits. Qubits: 2048. Status: ONLINE. Region: us-west-2. Next available: AVAILABLE NOW.
- IonQ:** Universal gate-model QPU based on trapped ions. Qubits: 11. Status: ONLINE. Region: us-east-1. Next available: 1 day 21:46:25.
- Rigetti — Aspen-8:** Universal gate-model QPU based on superconducting qubits. Qubits: 31. Status: RETIRED. Region: us-west-1. Next available: UNAVAILABLE.
- Rigetti — Aspen-9:** Universal gate-model QPU based on superconducting qubits. Qubits: 32. Status: ONLINE. Region: us-west-1. Next available: AVAILABLE NOW.

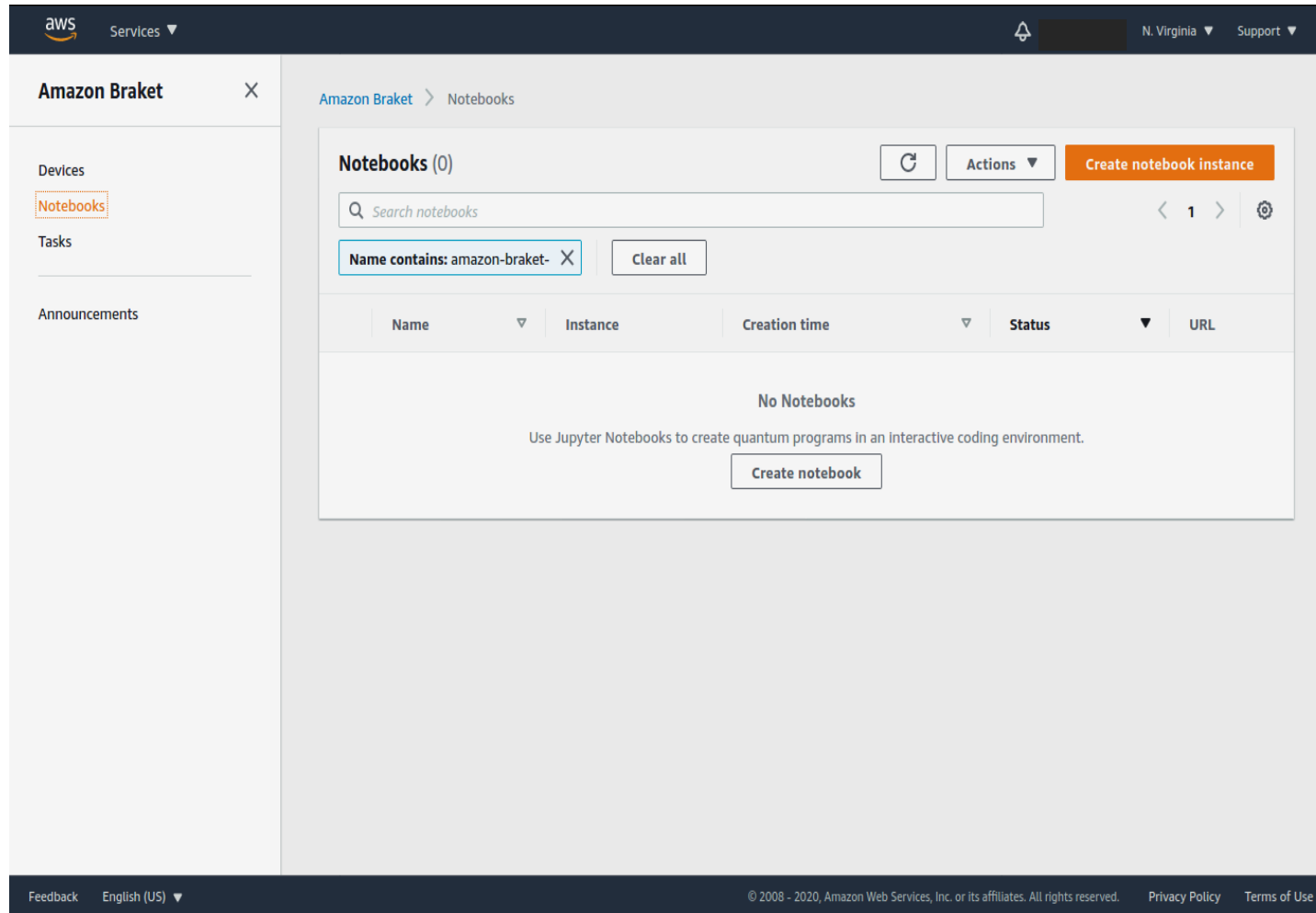
**Simulators:**

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

The footer of the console shows "Feedback", "English (US)", and copyright information: "© 2008 - 2021, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use Cookie preferences".

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

# Amazon Braket



The screenshot shows the Amazon Braket console interface. The top navigation bar includes the AWS logo, a 'Services' dropdown menu, a notification bell, and the region 'N. Virginia' with a 'Support' link. The left sidebar contains navigation options: 'Amazon Braket' (selected), 'Devices', 'Notebooks' (highlighted), 'Tasks', and 'Announcements'. The main content area is titled 'Amazon Braket > Notebooks'. It features a 'Notebooks (0)' header with a refresh icon, an 'Actions' dropdown, and a 'Create notebook instance' button. Below this is a search bar labeled 'Search notebooks' and a filter 'Name contains: amazon-braket-' with a 'Clear all' button. A table header is visible with columns: Name, Instance, Creation time, Status, and URL. The table content is empty, showing 'No Notebooks' and a message: 'Use Jupyter Notebooks to create quantum programs in an interactive coding environment.' with a 'Create notebook' button. The footer includes 'Feedback', 'English (US)', and copyright information: '© 2008 - 2020, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use'.

11- Go straight to notebooks on the left pane.

# Amazon Braket

aws Services

Amazon Braket

Devices  
Notebooks  
Tasks  
Announcements

## Create notebook instance

Amazon Braket provide fully managed notebook instances that run Jupyter. The notebook instances come preinstalled with the Amazon Braket SDK and include tutorials and example algorithms. Amazon Braket notebooks are based on SageMaker Notebook instances. [Learn more](#)

### Notebook Instance settings

Notebook instance name  
amazon-braket-Testing  
Maximum of 49 alphanumeric characters. Can include hyphens (-), but not spaces. Must be unique within your account in an AWS Region.

Notebook instance type  
Instance types comprise varying combinations of CPU, GPU, memory for building, running your quantum tasks  
ml.t3.medium

► Additional settings

### Permissions and encryption

IAM role  
Create a new role

ⓘ Passing an IAM role gives Amazon SageMaker permission to perform actions in other AWS services on your behalf. Creating a role here will grant permissions described by the [AmazonBraketFullAccess](#) IAM policy to the role you create.

Root access — optional  
 Enable - Give users root access to the notebook  
 Disable - Don't give users root access to the notebook  
Lifecycle configurations always have root access

Encryption key — optional  
Encrypt your notebook data. Choose an existing KMS key or enter a key ARN.  
No custom encryption key

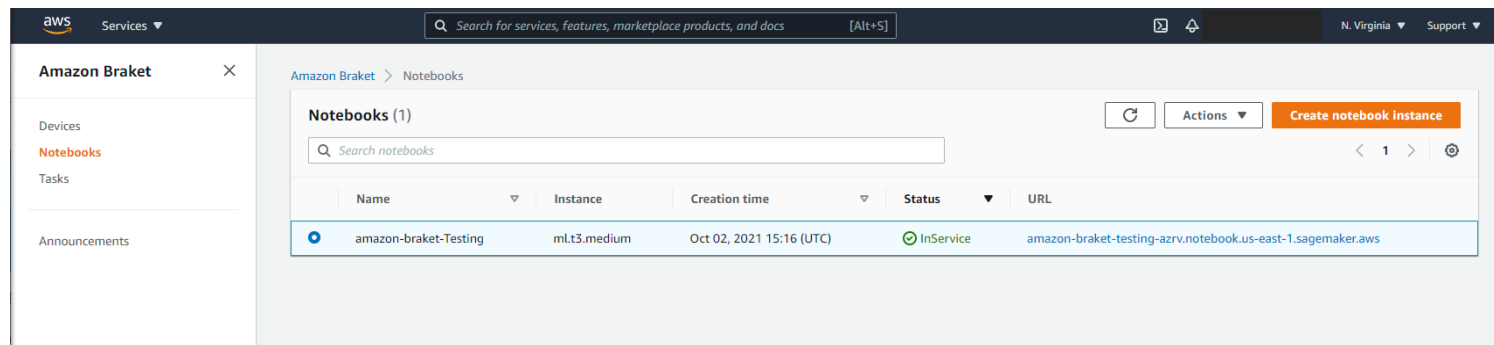
► Network — optional

Cancel Create notebook instance

Feedback English (US)

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

# Amazon Braket



The screenshot shows the Amazon Braket console interface. The left sidebar contains navigation options: Devices, Notebooks (highlighted), Tasks, and Announcements. The main content area displays the 'Notebooks (1)' section with a search bar and a 'Create notebook instance' button. Below this is a table with the following data:

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 displays the Amazon Braket console interface. The top navigation bar includes the AWS logo, a search bar, and the current region (N. Virginia). The left sidebar shows navigation options: Amazon Braket, Devices, Notebooks, Tasks, and Announcements. The main content area is titled "Quantum Processing Units (QPUs)" and is divided into two sections: "QPUs" and "Simulators".

**Quantum Processing Units (QPUs)**

Device Name	Qubits	Status	Region	Next available
D-Wave — Advantage_system4.1	5760	ONLINE	us-west-2	AVAILABLE NOW
D-Wave — Advantage_system1.1	5760	ONLINE	us-west-2	AVAILABLE NOW
D-Wave — DW_2000Q_6	2048	ONLINE	us-west-2	AVAILABLE NOW
IonQ	11	ONLINE	us-east-1	AVAILABLE NOW
Rigetti — Aspen-8	31	RETIRED	us-west-1	UNAVAILABLE
Rigetti — Aspen-9	32	ONLINE	us-west-1	19:04:13

**Simulators**

Simulator Name	Qubits	Status	Region	Next available
Amazon Web Services — SV1	34	ONLINE	us-east-1, us-west-1, us-west-2	AVAILABLE NOW
Amazon Web Services — TN1	50	ONLINE	us-east-1, us-west-2	AVAILABLE NOW
Amazon Web Services — DM1	17	ONLINE	us-east-1, us-west-1, us-west-2	AVAILABLE NOW

The footer of the console shows "Feedback", "English (US)", and copyright information: "© 2008 - 2021, Amazon Web Services, Inc. or its affiliates. All rights reserved. Privacy Policy Terms of Use 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 console interface. The main content area displays the details for the device 'D-Wave — Advantage\_system4.1'. The device is a Quantum Annealer based on superconducting qubits. The console provides a detailed description of the device's architecture and capabilities. A table of key attributes is shown below the description, with the 'Device ARN' field highlighted by a red box. The Device ARN is 'arn:aws:braket::device/qpu/d-wave/Advantage\_system4'. Below the table, the 'Topology' section shows a JSON representation of the device's qubit connectivity.

Hardware provider	D-Wave	Region	us-west-2	Location	British Columbia, Canada
Availability	Everyday, 00:00:00 - 23:59:59 UTC	Next available	AVAILABLE NOW	Cost	\$0.30 / task + \$0.00019 / shot
Device ARN	arn:aws:braket::device/qpu/d-wave/Advantage_system4				
		Status	ONLINE	Qubits	5760

```

1 {
2   "type": "pegasus",
3   "shape": [
4     16
5   ]
6 }

```

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

# Amazon Braket

The screenshot shows the Amazon Braket console interface. The main content area displays the 'IonQ' device page, which includes a detailed description of the 'Universal gate-model QPU based on trapped ions'. Below the description, there is a table of device specifications:

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
<b>Device ARN</b> arn:aws:braket::device/qpu/ionq/ionqDevice	Status 🟢 ONLINE	Qubits 11

Below the specifications, there is a 'Topology' section with a diagram of a quantum circuit, and a 'Calibration' section indicating the last update on Sep 21, 2021 at 13:00 UTC.

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

# Amazon Braket

**Rigetti — Aspen-9**

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 with 3-fold (2-fold for edges) connectivity and features both CZ 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 ~20 $\mu$ s.

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
<b>Device ARN</b> arn:aws:braket::device/qpu/rigetti/Aspen-9	Status ONLINE	Qubits 32

**Topology**

**Calibration**

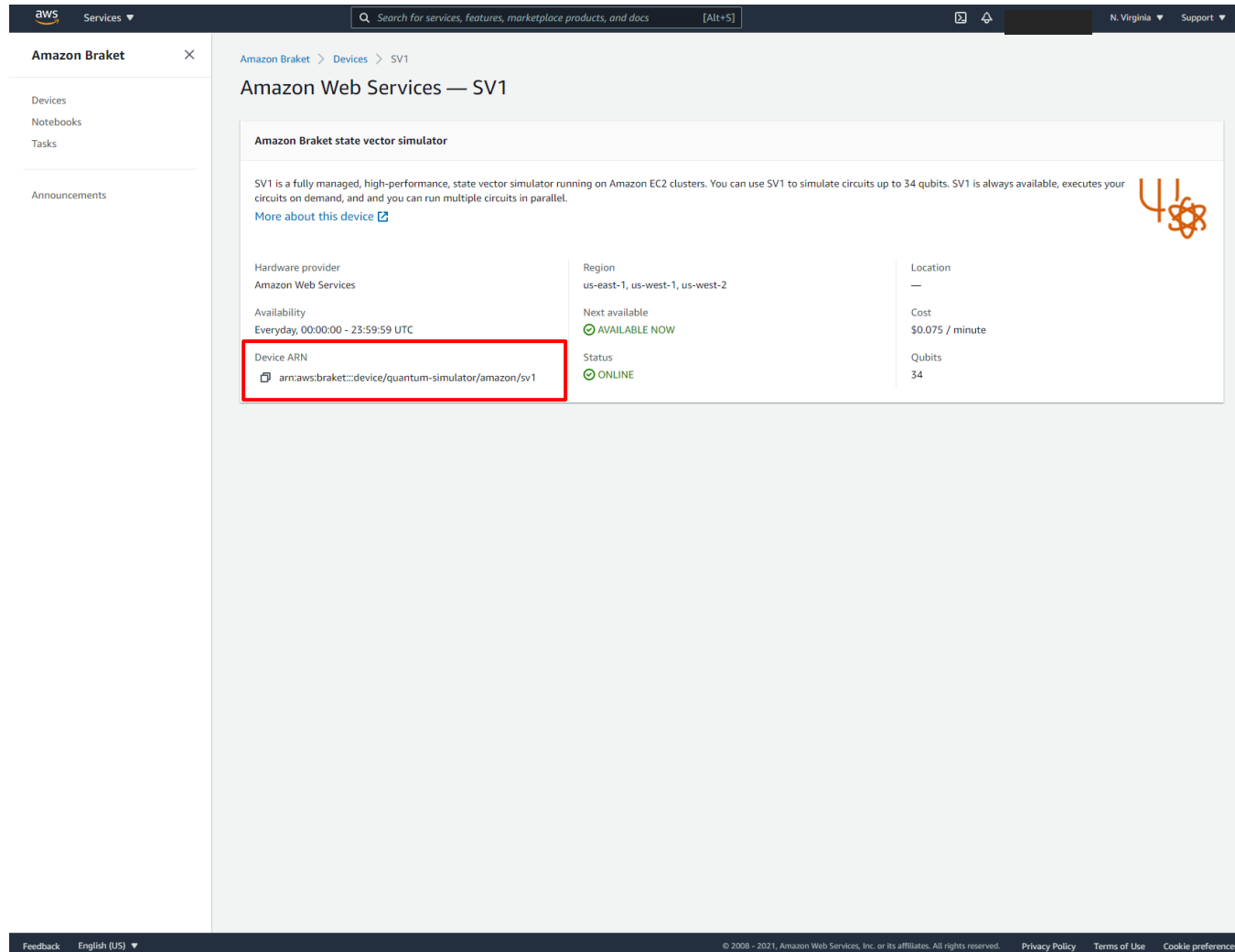
Last updated: Oct 12, 2021 19:58 (UTC)

Qubit

Qubit	T1 ( $\mu$ s)	T2 ( $\mu$ s)	Fidelity (RB) (%)	Fidelity (simultaneous RB) (%)	Readout fidelity (%)	Active reset fidelity (%)
0	27.661	12.521	99.900 $\pm$ 0.009	99.612 $\pm$ 0.027	97.000	99.850
1	35.419	10.563	97.817 $\pm$ 0.120	96.277 $\pm$ 0.623	85.800	97.200
2	24.699	4.462	99.759 $\pm$ 0.021	99.512 $\pm$ 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 console interface. The main content area displays the 'Amazon Braket state vector simulator' details for the SV1 device. A red box highlights the 'Device ARN' field, which contains the value 'arn:aws:braket::device/quantum-simulator/amazon/sv1'. Other details include the hardware provider (Amazon Web Services), region (us-east-1, us-west-1, us-west-2), location (—), next available status (AVAILABLE NOW), cost (\$0.075 / minute), and status (ONLINE). The console also shows a search bar at the top and a navigation menu on the left.

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

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

## Go back to Notebooks tab

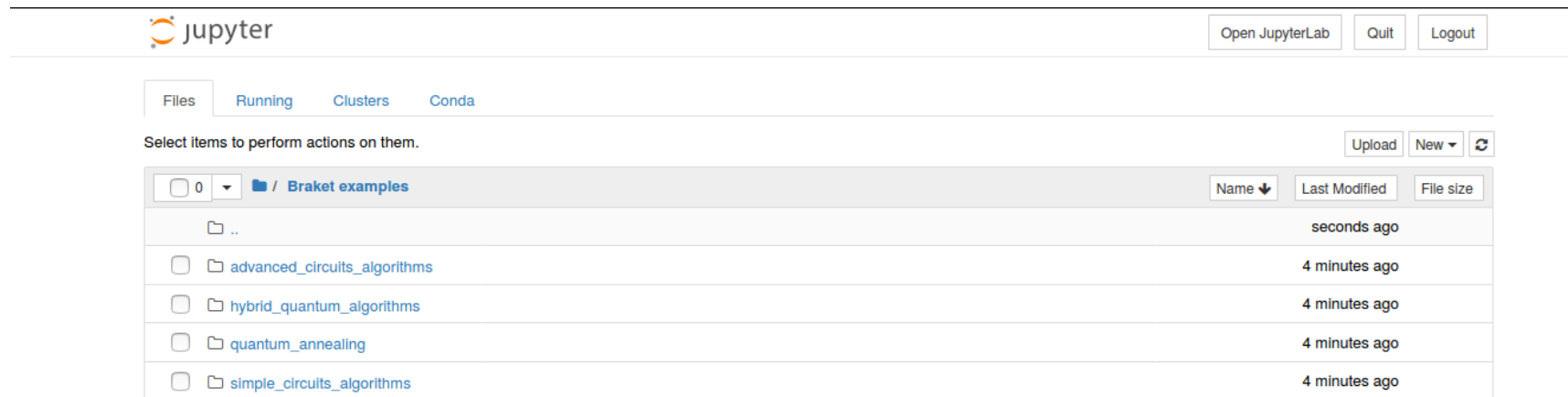
19. Your Notebook may be green i.e. “In Service”

The screenshot displays the AWS SageMaker console interface. On the left is a navigation sidebar with options like 'Amazon SageMaker Studio', 'Dashboard', 'Search', 'Ground Truth', and 'Labeling jobs'. The main content area is titled 'Amazon SageMaker > Notebook Instances'. It features a search bar, a 'Create notebook instance' button, and a table of instances. The table has columns for Name, Instance, Creation time, Status, and Actions. One instance is listed with the name 'amazon-braket-Testina', instance type 'ml.t3.medium', creation time 'Sep 21, 2020 22:10 UTC', and status 'InService'. The Actions column for this instance contains links for 'Open Jupyter' and 'Open JupyterLab'.

20. Under Actions, click on the notebook

The screenshot shows the JupyterLab web interface. At the top, there's a header with the Jupyter logo and buttons for 'Open JupyterLab', 'Quit', and 'Logout'. Below the header are tabs for 'Files', 'Running', 'Clusters', and 'Conda'. The main content area is a file browser. It has a search bar and a list of items. One item, 'Braket examples', is visible with a '3 minutes ago' timestamp. There are also buttons for 'Upload', 'New', and a refresh icon.

# Open Bracket Examples



The screenshot shows the JupyterLab interface. At the top, there is a 'jupyter' logo and three buttons: 'Open JupyterLab', 'Quit', and 'Logout'. Below the header, there are tabs for 'Files', 'Running', 'Clusters', and 'Conda'. The 'Files' tab is active, showing a file browser for the directory '/ Braket examples'. The browser contains a table of files and folders:

<input type="checkbox"/>	Name	Last Modified	File size
<input type="checkbox"/>	..	seconds ago	
<input type="checkbox"/>	advanced_circuits_algorithms	4 minutes ago	
<input type="checkbox"/>	hybrid_quantum_algorithms	4 minutes ago	
<input type="checkbox"/>	quantum_annealing	4 minutes ago	
<input type="checkbox"/>	simple_circuits_algorithms	4 minutes ago	

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)

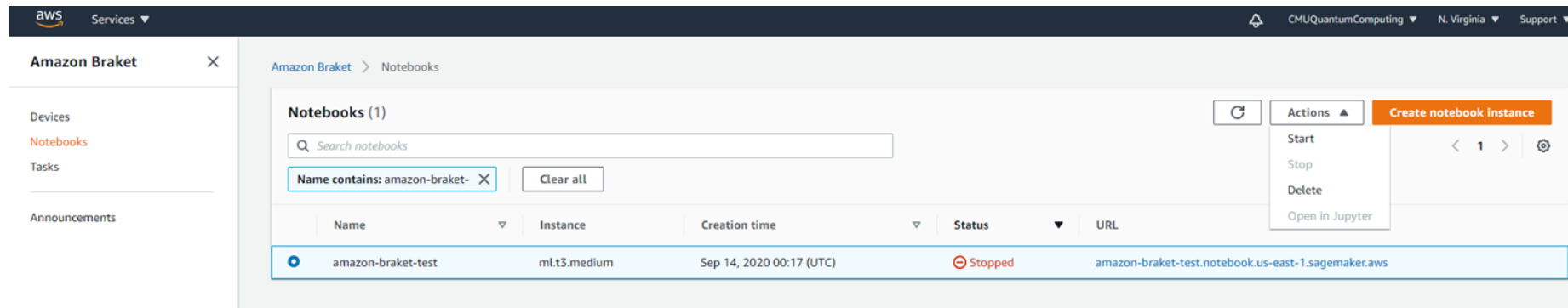
# Make sure to Stop your notebooks before you Log Out!

Play Around.

You are ALL SET Here!

We will be covering during this class

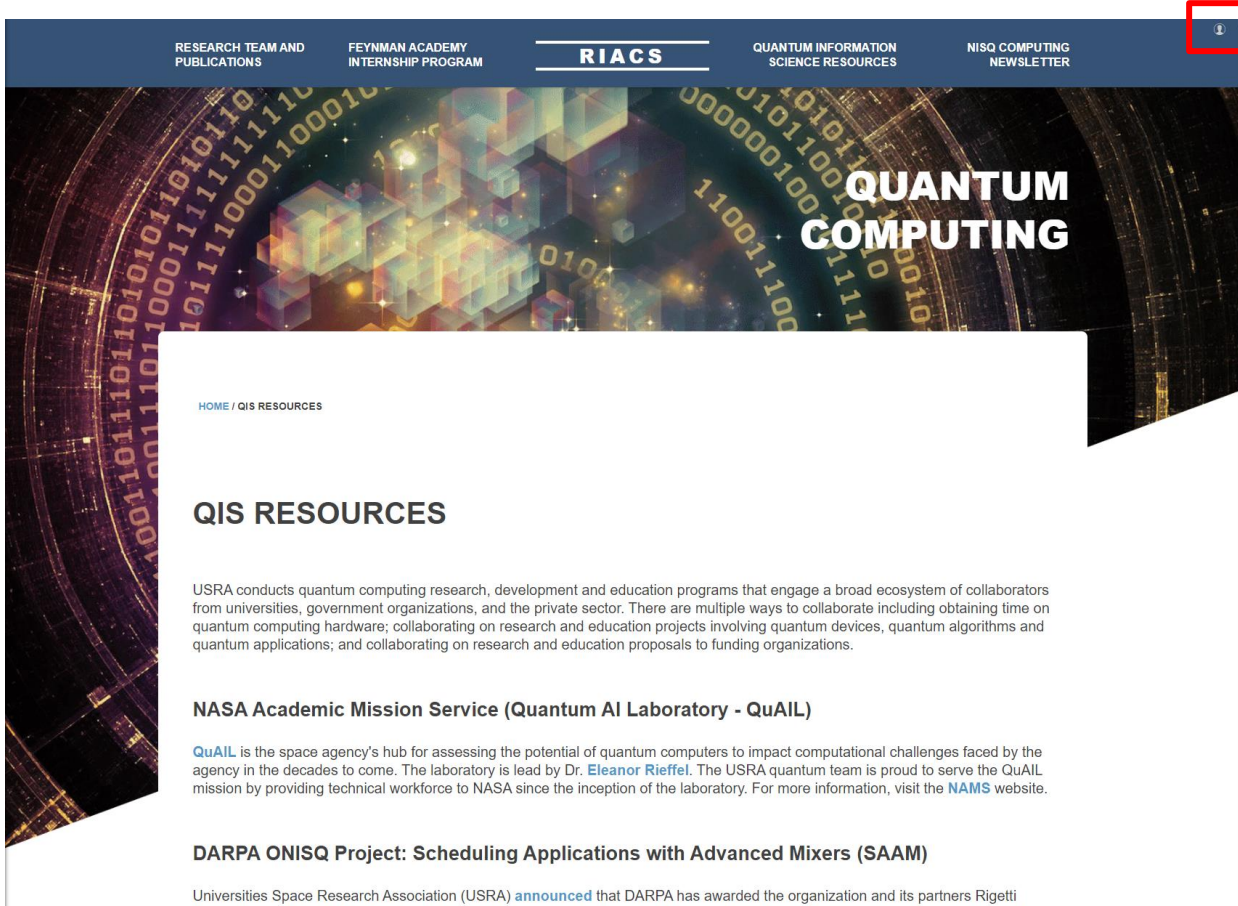
- quantum\_annealing/D-Wave\_anatomy.ipynb
- hybrid\_quantum\_algorithms/QAOA.ipynb



The screenshot shows the AWS Amazon Braket console interface. The top navigation bar includes the AWS logo, 'Services', and user information for 'CMUQuantumComputing' in 'N. Virginia' with a 'Support' link. The left sidebar contains navigation options: 'Amazon Braket', 'Devices', 'Notebooks', 'Tasks', and 'Announcements'. The main content area is titled 'Amazon Braket > Notebooks'. It features a search bar with the text 'Search notebooks' and a filter 'Name contains: amazon-braket-' with a 'Clear all' button. Below the search bar is a table with columns: Name, Instance, Creation time, Status, and URL. A single notebook instance is listed with the name 'amazon-braket-test', instance type 'ml.t3.medium', creation time 'Sep 14, 2020 00:17 (UTC)', and status 'Stopped'. An 'Actions' menu is open over the table, showing options: 'Start', 'Stop', 'Delete', and 'Open in Jupyter'. A 'Create notebook instance' button is also visible in the top right of the notebook list area.

Name	Instance	Creation time	Status	URL
amazon-braket-test	ml.t3.medium	Sep 14, 2020 00:17 (UTC)	Stopped	amazon-braket-test.notebook.us-east-1.sagemaker.aws

# Accessing USRA resources



RESEARCH TEAM AND PUBLICATIONS   FEYNMAN ACADEMY INTERNSHIP PROGRAM   **RIACS**   QUANTUM INFORMATION SCIENCE RESOURCES   NISQ COMPUTING NEWSLETTER

**QUANTUM COMPUTING**

HOME / QIS RESOURCES

## QIS RESOURCES

USRA conducts quantum computing research, development and education programs that engage a broad ecosystem of collaborators from universities, government organizations, and the private sector. There are multiple ways to collaborate including obtaining time on quantum computing hardware; collaborating on research and education projects involving quantum devices, quantum algorithms and quantum applications; and collaborating on research and education proposals to funding organizations.

### NASA Academic Mission Service (Quantum AI Laboratory - QuAIL)

QuAIL is the space agency's hub for assessing the potential of quantum computers to impact computational challenges faced by the agency in the decades to come. The laboratory is lead by Dr. [Eleanor Rieffel](#). The USRA quantum team is proud to serve the QuAIL mission by providing technical workforce to NASA since the inception of the laboratory. For more information, visit the [NAMS](#) website.

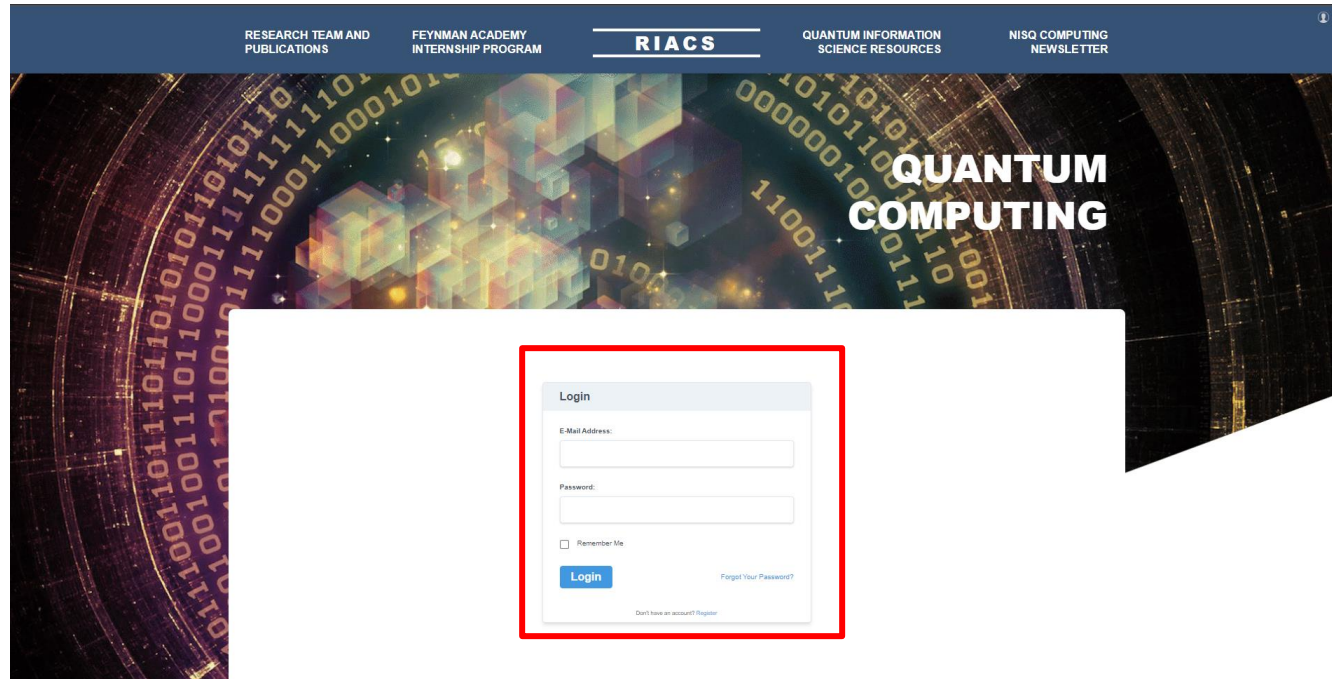
### DARPA ONISQ Project: Scheduling Applications with Advanced Mixers (SAAM)

Universities Space Research Association (USRA) [announced](#) that DARPA has awarded the organization and its partners Rigetti

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



# Accessing USRA resources

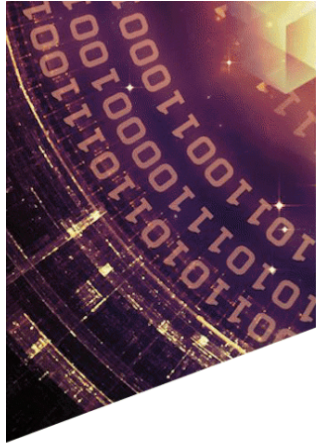


The screenshot shows the RIACS Quantum Computing website. The navigation bar includes links for "RESEARCH TEAM AND PUBLICATIONS", "FEYNMAN ACADEMY INTERNSHIP PROGRAM", "RIACS", "QUANTUM INFORMATION SCIENCE RESOURCES", and "NISQ COMPUTING NEWSLETTER". The main content area features a "QUANTUM COMPUTING" header over a background of binary code and quantum circuitry. A white login form is overlaid on the page, highlighted with a red border. The form contains the following elements:

- Login** (title)
- E-Mail Address:** (input field)
- Password:** (input field)
- Remember Me
- Login** (button)
- [Forgot Your Password?](#)
- [Don't have an account? Register](#)

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](#).

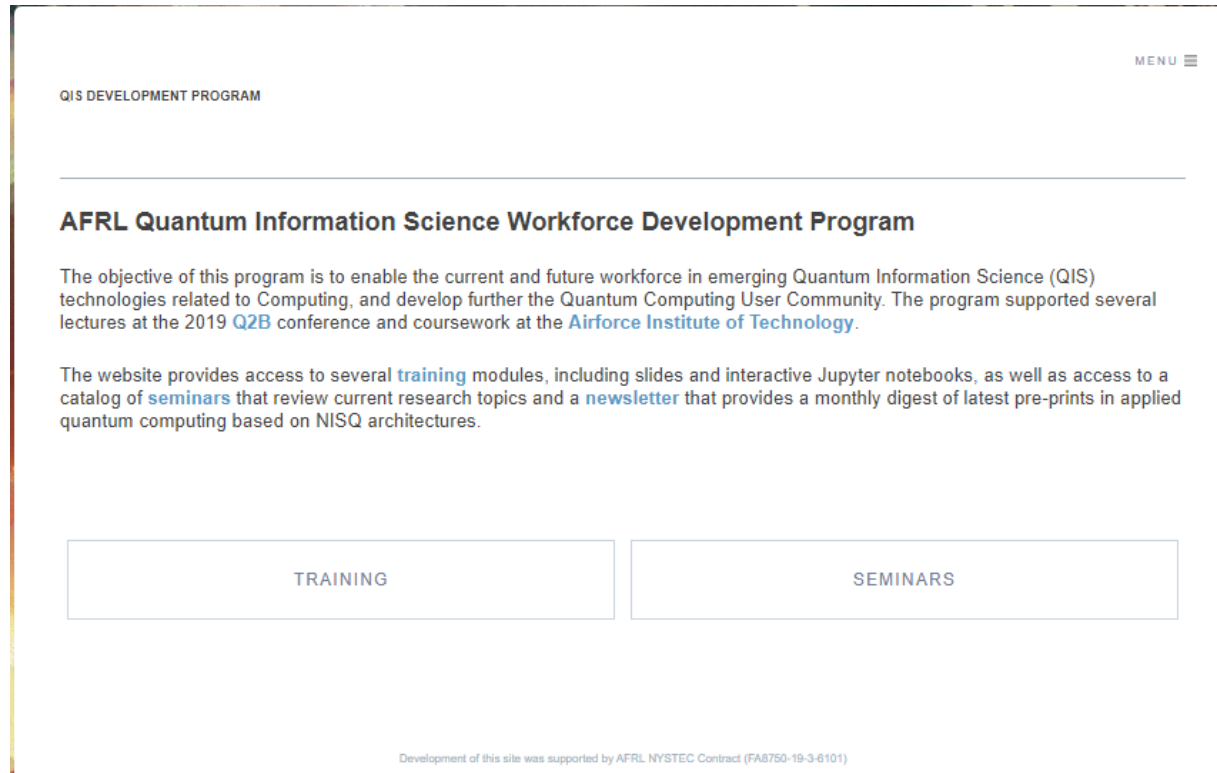
## NSF Expeditions in Computing Project: Coherent Ising Machines

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



QIS DEVELOPMENT PROGRAM

MENU

---

## AFRL Quantum Information Science Workforce Development Program

The objective of this program is to enable the current and future workforce in emerging Quantum Information Science (QIS) technologies related to Computing, and develop further the Quantum Computing User Community. The program supported several lectures at the 2019 [Q2B](#) conference and coursework at the [Airforce Institute of Technology](#).

The website provides access to several [training](#) modules, including slides and interactive Jupyter notebooks, as well as access to a catalog of [seminars](#) that review current research topics and a [newsletter](#) that provides a monthly digest of latest pre-prints in applied quantum computing based on NISQ architectures.

TRAINING

SEMINARS

Development of this site was supported by AFRL NYSPEC Contract (FA8750-19-3-6101)

There are plenty of seminars and training available to you!

# Accessing USRA resources

The screenshot shows the RIACS website with a navigation bar at the top containing links for 'RESEARCH TEAM AND PUBLICATIONS', 'FEYNMAN ACADEMY INTERNSHIP PROGRAM', 'RIACS', 'QUANTUM INFORMATION SCIENCE RESOURCES', and 'NISQ COMPUTING NEWSLETTER'. The main header features the text 'QUANTUM COMPUTING' over a background of binary code and 3D cubes. Below this, a breadcrumb trail reads 'QIS DEVELOPMENT PROGRAM / TRAININGS / QUANTUM INTEGER PROGRAMMING'. The main content area is titled 'Quantum Integer Programming' and includes a graph diagram with nodes and edges. The text describes the course objectives, prerequisites, and instructors (Davide Venturelli, David E. Bernal, Sridhar Tayur, Peter McMahon, Anil Prabhakar). A sidebar on the left lists course sections, and a detailed view of 'Lecture 0 - Course Overview (Part 1)' is shown on the right, including a list of topics and instructor information.

Including last years edited videos, codes, and notes!

# Accessing USRA resources

The screenshot shows the RIACS website with a dark blue header. The navigation menu includes: RESEARCH TEAM AND PUBLICATIONS (highlighted with a red box), FEYNMAN ACADEMY INTERNSHIP PROGRAM, RIACS, QUANTUM INFORMATION SCIENCE RESOURCES, and NISQ COMPUTING NEWSLETTER. The main content area features a background image of quantum computing with the text "QUANTUM COMPUTING". Below this, there is a paragraph of text about RIACS's history and mission. A "Funding" section lists logos for NASA, AFRL, NSF, USRA, and DARPA. A "News" section is partially visible at the bottom.

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

NASA AFRL NSF USRA DARPA

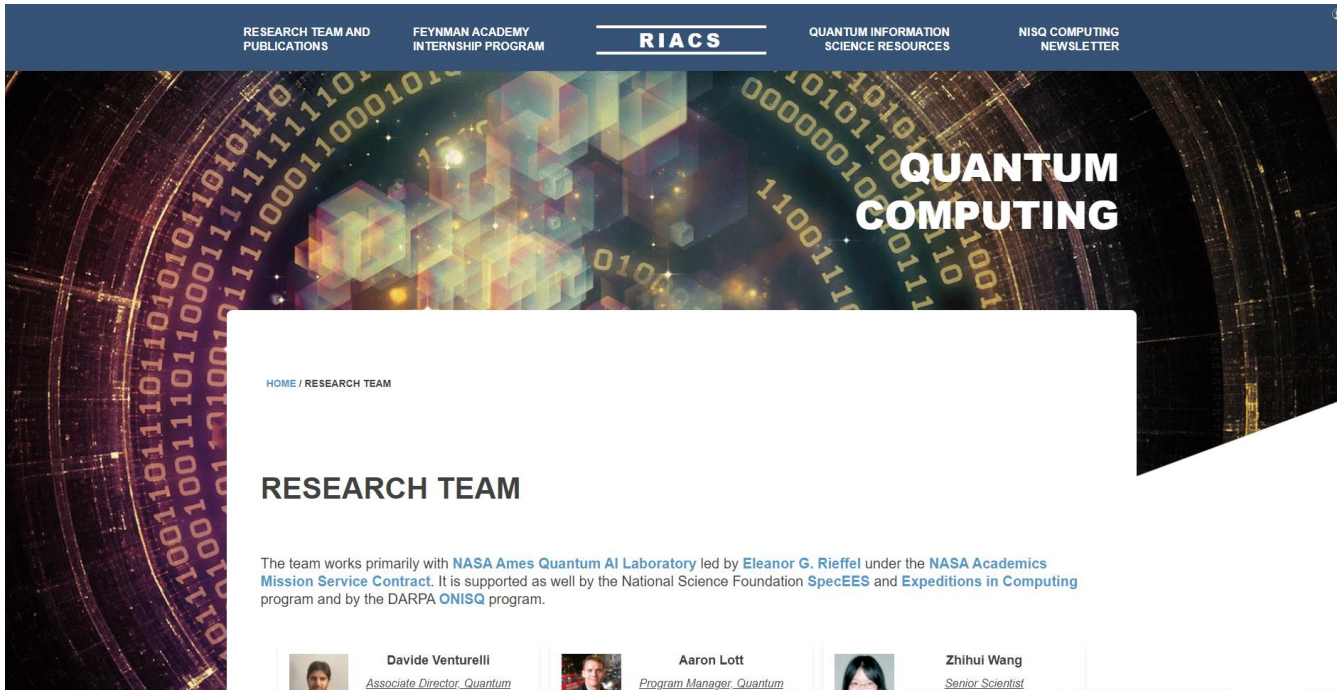
### News

NEWS

Best Paper Award MDPI Algorithms Journal

Extra: Go to “Research Team and Publications”

# Accessing USRA resources






RESEARCH TEAM AND PUBLICATIONS   FEYNMAN ACADEMY INTERNSHIP PROGRAM   **RIACS**   QUANTUM INFORMATION SCIENCE RESOURCES   NISQ COMPUTING NEWSLETTER

## QUANTUM COMPUTING

[HOME](#) / [RESEARCH TEAM](#)

### RESEARCH TEAM

The team works primarily with [NASA Ames Quantum AI Laboratory](#) led by [Eleanor G. Rieffel](#) under the [NASA Academics Mission Service Contract](#). It is supported as well by the National Science Foundation [SpecEES](#) and [Expeditions in Computing](#) program and by the DARPA [ONISQ](#) program.

 Davide Venturelli <i>Associate Director, Quantum</i>	 Aaron Lott <i>Program Manager, Quantum</i>	 Zhihui Wang <i>Senior Scientist</i>
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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 O'Gorman, 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 Jamieson

## 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 Krysh, 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 Streif, 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

Cornell University

We gratefully acknowledge support from the Simons Foundation and member institutions.

arXiv.org > quant-ph > arXiv:2012.11382

Search... All fields Search

Help | Advanced Search

**Quantum Physics**

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

**Quantum Integer Programming (QIP) 47-779: Lecture Notes**

David E. Bernal, Sridhar Tayur, Davide Venturelli

This lecture series on Quantum Integer Programming (QIP) — 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 IDS640 (at IIT-Madras, by Professors Anil Prabhakar and Prabha Mandayam) whose students (listed at the beginning of each lecture) were scribes. Dr. Vikesh 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): this https URL  
 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]	Thu, 17 Dec 2020 19:56:06 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?)

1 / 71 100% +

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

**Abstract**

This lecture series on Quantum Integer Programming (QIP) — 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 IDS640 (at IIT-Madras, by Professors Anil Prabhakar and Prabha Mandayam) whose students (listed at the beginning of each lecture) were scribes. Dr. Vikesh 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. The course website (with lecture videos and colab notebooks): <https://bernalde.github.io/QIP/>

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

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References & Citations

- INSPIRE HEP
- NASA ADS
- Google Scholar
- Semantic Scholar

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