

Internet of Things

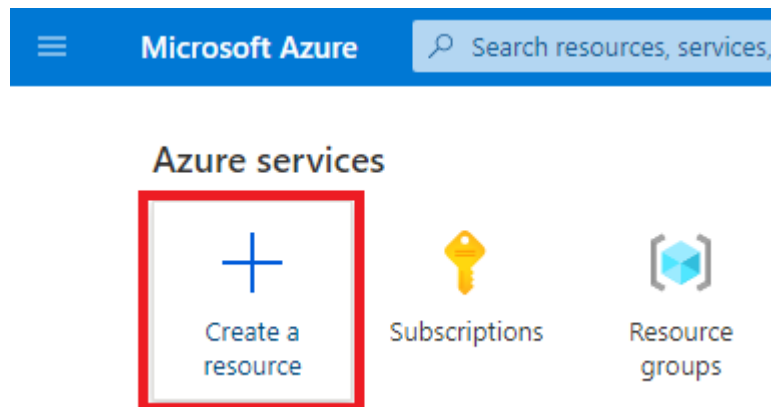
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Exercise 1: IoT Hub provisioning

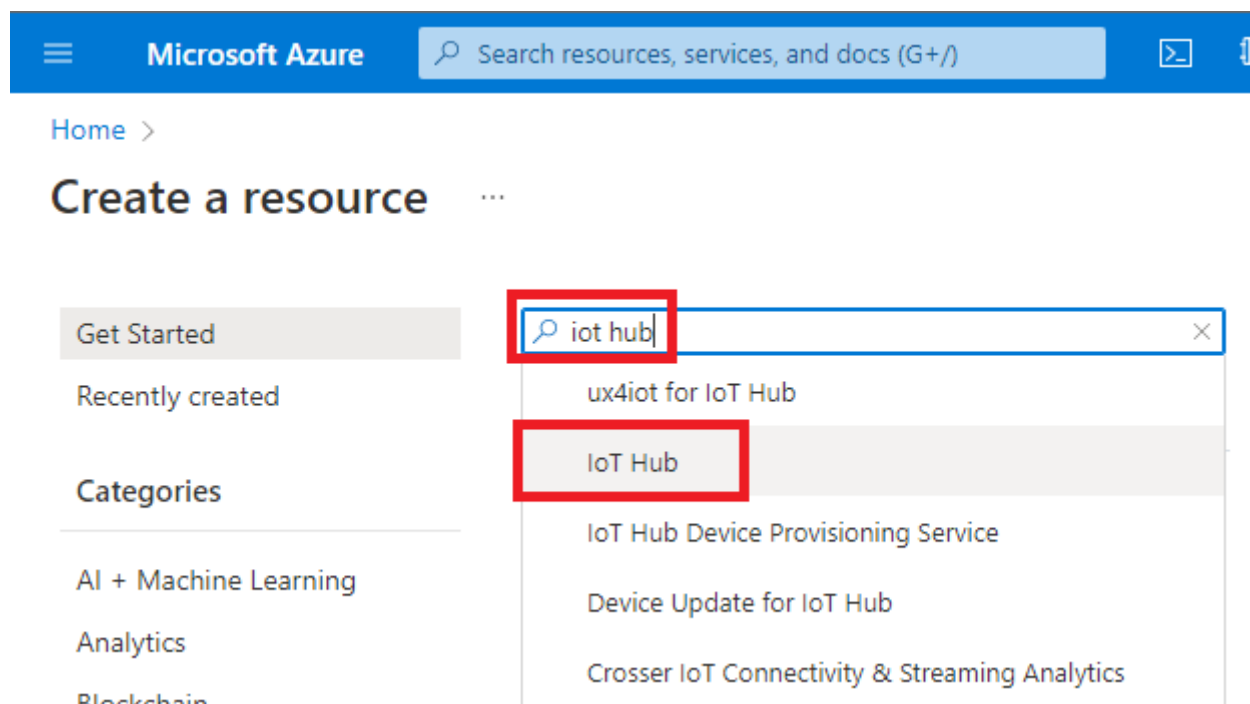
Task 1: Provision IoT Hub through the Portal

During this exercise you will use 3 different tools to create three different IoT Hubs, after this exercise we will delete two and continue the rest of the workshop with the first IoT Hub created through the Portal.

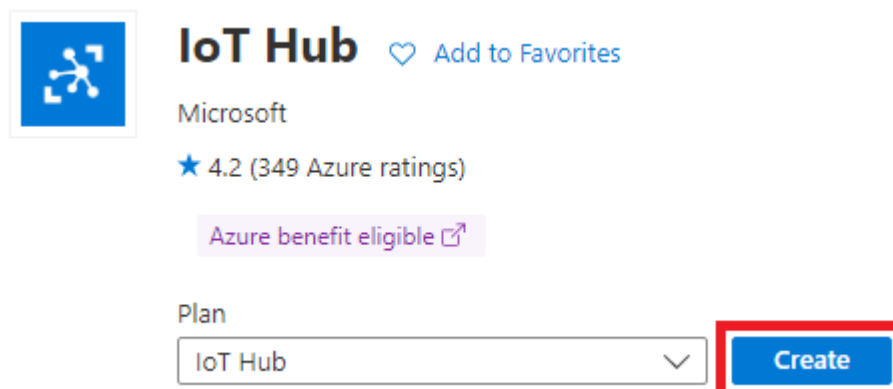
1. In your browser, navigate to the [Azure portal](#), select **+Create a resource** in the navigation pane, enter **iot** into the **Search the Marketplace** box.



2. Select **IoT Hub** from the results



3. Select **Create**.



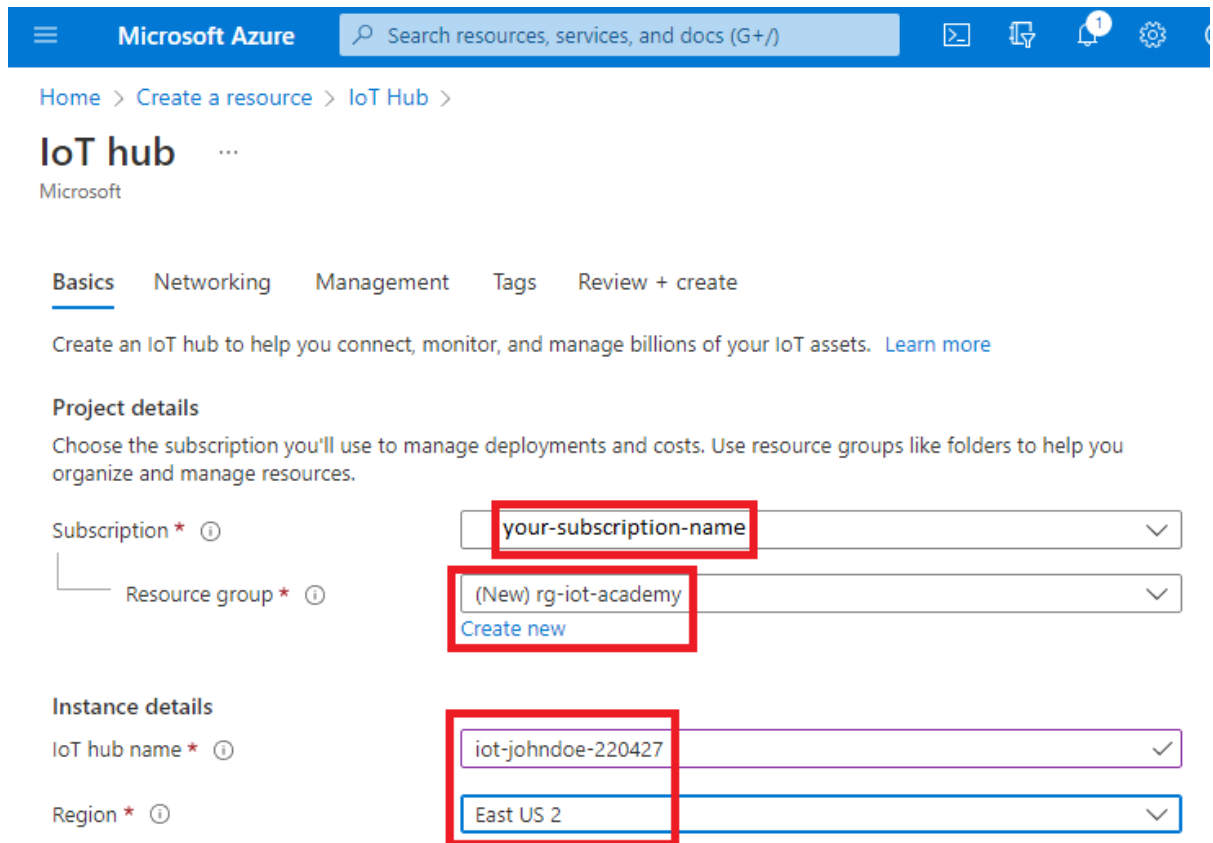
4. On the **IoT Hub** blade **Basics** tab, enter the following:

- **Subscription:** Select the subscription you are using for this hands-on lab.
- **Resource group:** Click Create new underneath Resource group. Enter the name **rg-iot-academy**

The screenshot shows the 'Basics' tab of the Azure IoT Hub blade. Under the 'Resource group' section, the 'Create new' link is highlighted. A modal dialog is open with the title 'A resource group is a container that holds related resources for an Azure solution.' The 'Name' field is populated with 'rg-iot-academy' and is highlighted by a red rectangular box. Below the name field are 'OK' and 'Cancel' buttons. In the background, the 'Instance details' section shows fields for 'IoT hub name' and 'Region'.

- **Region:** Select the location you are using for this hands-on lab.
- **IoT Hub Name:** Enter a unique name, such as **iot-academy-johndoe-220427**. The name follows best practices for naming resources in Azure. Note:
 1. the prefix **iot-**
 2. the inclusion of a name 'johndoe' and a date **220427**(YYMMDD) this combination such as **johndoe-220427** will be known as your **suffix**. You may want to copy this to your notepad so you can copy and paste it later.

As some resources in Azure require unique names, the name and the date helps to avoid naming conflicts. More can be read concerning best practices for naming Azure resources at the following link: [Azure Naming and Tagging](#) For common resource prefixes refer to the following link: [Azure Resource Abbreviations](#)



Microsoft Azure

Search resources, services, and docs (G+/)

Home > Create a resource > IoT Hub >

IoT hub

Microsoft

Basics Networking Management Tags Review + create

Create an IoT hub to help you connect, monitor, and manage billions of your IoT assets. [Learn more](#)

Project details

Choose the subscription you'll use to manage deployments and costs. Use resource groups like folders to help you organize and manage resources.

Subscription * ⓘ

Resource group * ⓘ
[Create new](#)

Instance details

IoT hub name * ⓘ

Region * ⓘ

- Click **Next: Networking**.
 - On the **Networking** tab ensure Public is selected
 - Click **Next: Management**.
 - On the **Management** tab
 1. **Pricing and scale tier**: ensure **S1: Standard tier** is selected
 2. **Number of S1 IoT hub units**: ensure **1** is selected
 3. **Defender for IoT**: set to **On**
 4. **Assign me to the IoT Hub Data Contributor role**: select the check box
 5. **Device-to-cloud partitions**: leave the default setting of **4**
 - Click **Review + create**.
 - Ensure validation passes and click **Create**.
5. After clicking create you were directed to a deployment overview page. When the deployment completes click the **Go to resource** button.

✓ Your deployment is complete



Deployment name: `iot-academy-johndoe-220427-4121...`
Subscription:
Resource group: `rg-iot-academy`

Start time: 4/12,
Correlation ID: 4

▼ Deployment details (Download)

^ Next steps

[Add and configure IoT Devices](#) Recommended

[Configure routing rules for device messaging](#) Recommended

[Go to resource](#)

Task 2: Provision IoT Hub through CLI

1. Open cloud with the below link

<https://shell.azure.com/>

If you've never used the Azure Cloud Shell before you will be prompted to mount a storage account, click **Create Storage** to continue. If you used Azure Cloud Shell before, you will skip this step.

You have no storage mounted

Azure Cloud Shell requires an Azure file share to persist files. [Learn more](#)

This will create a new storage account for you and this will incur a small monthly cost. [View pricing](#)

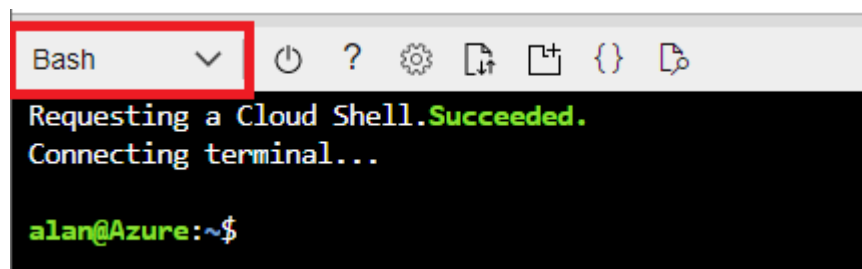
* Subscription

[Show advanced settings](#)

[Create storage](#)

[Close](#)

2. Change to **Bash** access



3. Once you are login run the following command to create an IoT Hub.

In the following command replace **iot-johndoe-cli-220427** with your iot hub name, replacing johndoe and the appropriate date, of the form iot-{yourname}-cli-{YYMMDD}

```
az iot hub create --name iot-academy-johndoe-cli-220427 --resource-group rg-  
iot-academy --sku S1
```

As the command runs you'll observe the following result.

```
Welcome to Azure Cloud Shell

Type "az" to use Azure CLI
Type "help" to learn about Cloud Shell

alan@Azure:~$ az iot hub create --name iot-academy-johndoe-cli-220427 --resource-group rg-iot-academy --sku S1
|| Running ..
```

When the command completes you'll see output as follows

```
alan@Azure:~$ az iot hub create --name iot-academy-johndoe-cli-220427 --resource-group rg-iot-academy --sku S1
{
  "etag": "AAAADGZrwC4=",
  "id": "/subscriptions/7451d6d6-9082-46d9-9373-ccd5fcd4e1a1/resourceGroups/iot-academy-johndoe-cli-220427",
  "identity": {
    "principalId": null,
    "tenantId": null,
    "type": "None",
    "userAssignedIdentities": null
  },
  "location": "eastus2",
  "name": "iot-academy-johndoe-cli-220427",
  "properties": {
    "allowedFqdnList": [],
    "authorizationPolicies": null,
  }
}
```

4. Browse to the [Azure Portal](#) to verify your newly created IoT Hub.
5. Delete the IoT Hub just created using the delete command.

Again, replace johndoe and the appropriate date

```
az iot hub delete --name iot-johndoe-cli-220427 --resource-group rg-iot-  
academy
```

Also, delete the IoT Hub created through the portal

```
az iot hub delete --name iot-academy-johndoe-220427 --resource-group rg-iot-  
academy
```

Task 3: Provision IoT Hub through VS Code

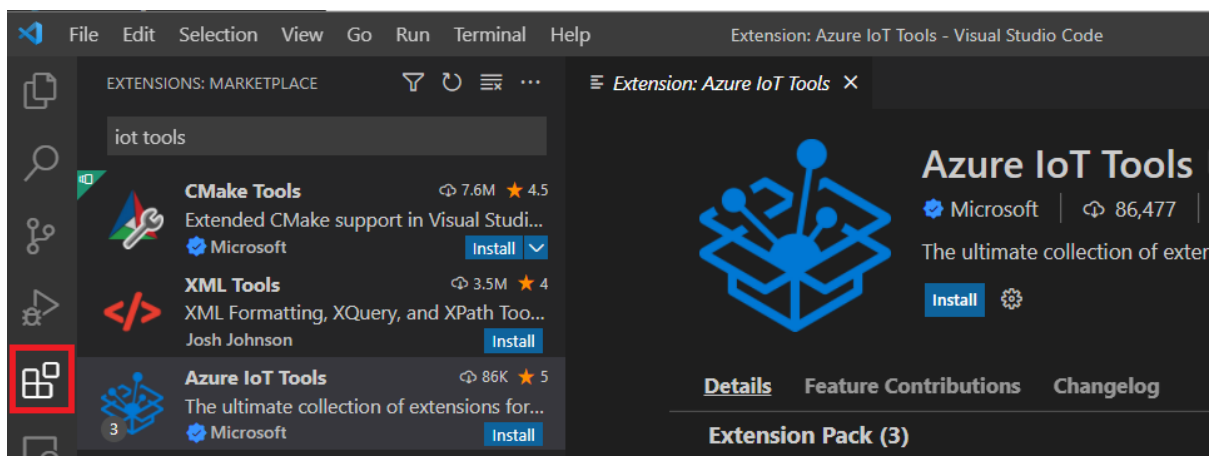
If you have not yet installed Visual Studio Code download and install from the following link:

<https://code.visualstudio.com/download>

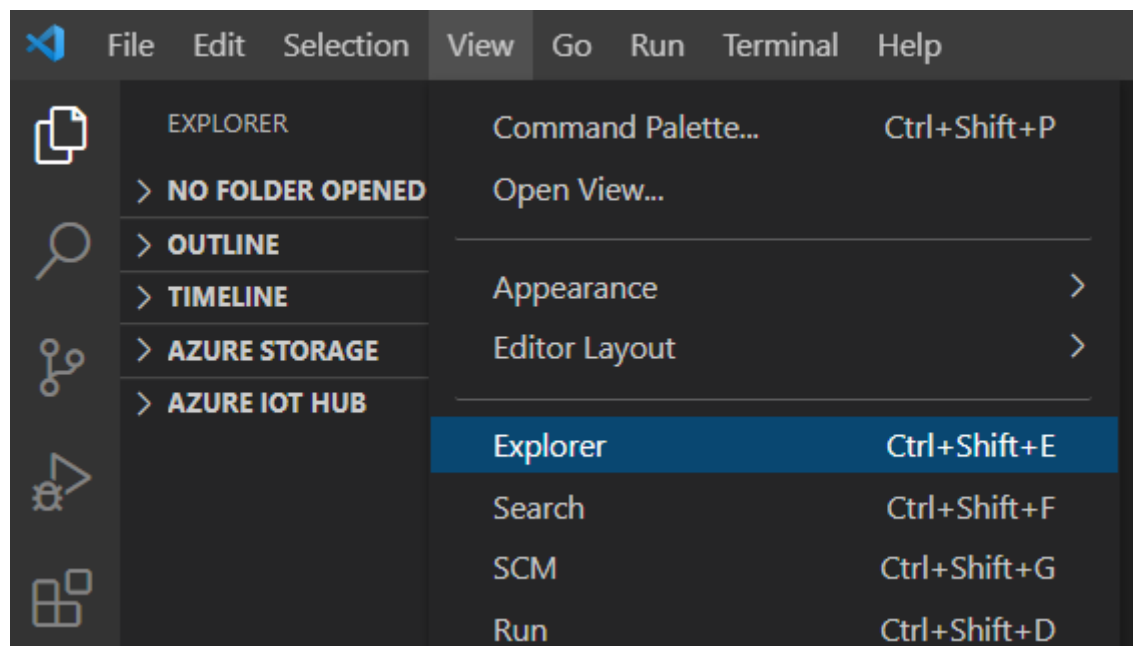
Our third way of creating an Azure resource, IoT Hub instance, is to use Visual Studio Code.

1. Install IoT Tools extension pack for VS Code in one of two ways:

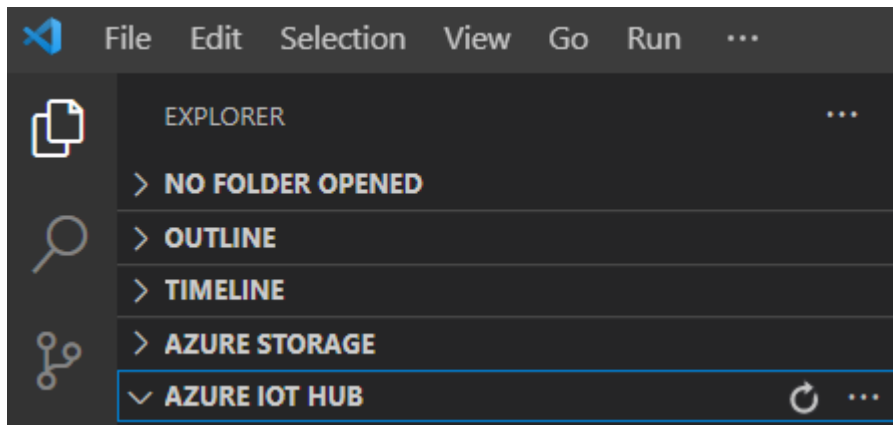
- Use the following URL <https://marketplace.visualstudio.com/items?itemName=vsciot-vscode.azure-iot-tools>
- Use the extension tab (highlighted in red) in VS Code, search for **iot tools**, select **Azure IoT Tools**, click **Install**



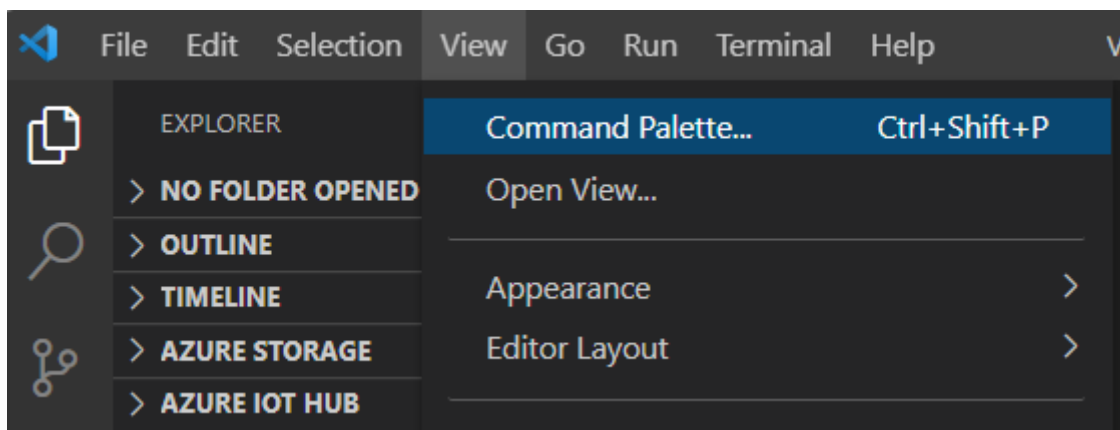
2. Click the View Menu and then Explorer



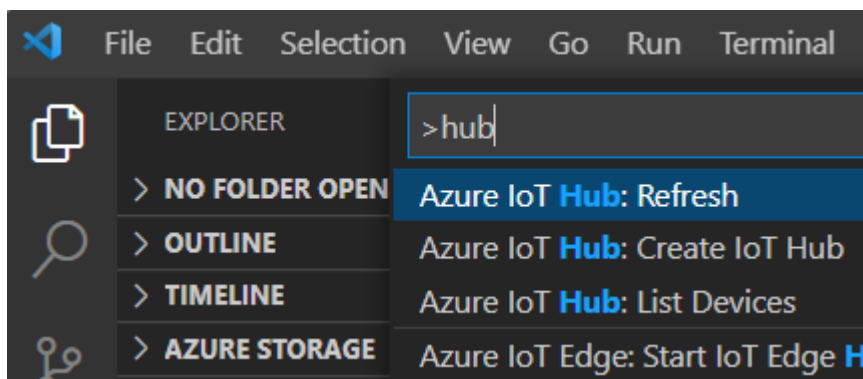
- Now you should be able to see the **Azure IoT Hub**



- To create a new IoT Hub Go to the menu **View** on the top toolbar then select **Command Palette**.

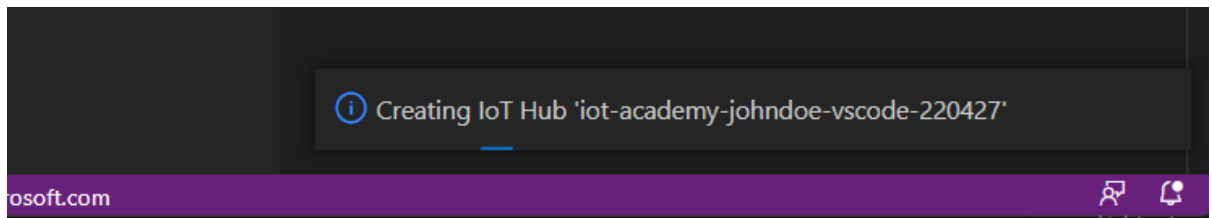


- Type **Azure IoT Hub** in the search bar, then you will see the list of commands available select **Azure IoT Hub: Create IoT Hub** and click Enter.

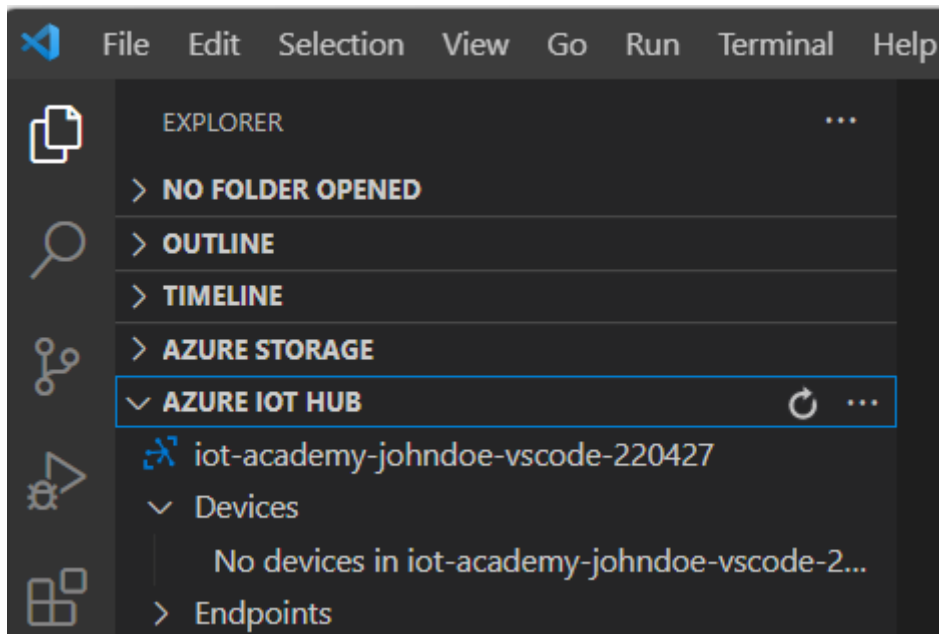


- Select the following parameters:
 - **Subscription:** Select your subscription.
 - **Resource group:** Use existing and select `rg-iot-academy`.
 - **Location:** Select the location you are using for resources in this hands-on lab.
 - **SKU:** Select **S1**.
 - **Name:** Assign a name to the IoT Hub `iot-academy-johndoe-vscode-220427` change `johndoe` and `220427` using your name and the date YYYYMMDD.

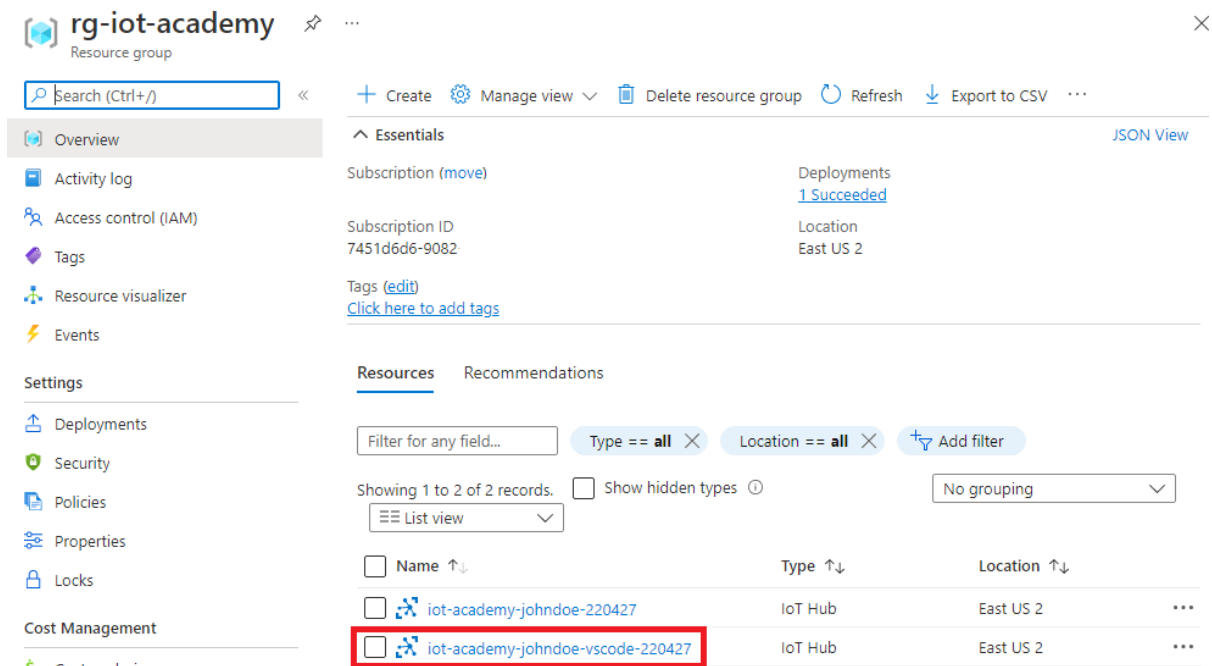
As the extension creates the IoT Hub instance you should see a status message as follows.



- After the creation process you should be able to see the new IoT Hub in VS Code and the Azure Portal.



Azure Portal Resource Group View

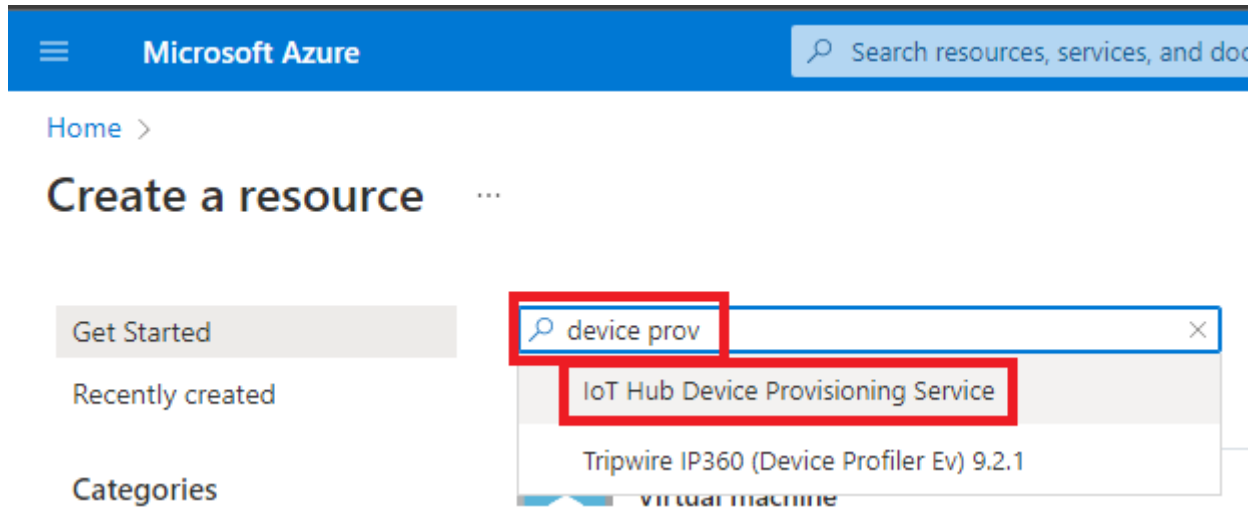


Exercise 2: Azure IoT Hub Device Provisioning Service (DPS)

Task 1: Deploy DPS

1. Create a DPS instance by:

- Go to the Azure Portal home page
- Click **Create a resource**
- Search for **device prov**
- Click **IoT Hub Device Provisioning Service**



2. Create Details

- Enter the following details
 - Resource group: **rg-iot-academy**
 - Name: **provs-iotacad-{SUFFIX}** e.g. **provs-iotacad-johndoe220427**
 - Region: **your region**

Microsoft Azure

Search resources, services, and docs (G+/)

Home > Create a resource > IoT Hub Device Provisioning Service >

Azure IoT Hub device provisioning service

Microsoft

Basics Networking Management Tags Review + create

The Azure IoT Hub device provisioning service is a helper service for IoT Hub that enables zero-touch, just-in-time provisioning to the right IoT hub without requiring human intervention, allowing customers to provision millions of devices in a secure and scalable manner. [Learn more](#)

Project details

Choose the subscription you'll use to manage deployments and costs. Use resource groups like folders to help you organize and manage resources.

Subscription *
 Visual Studio Enterprise Subscription

Resource group *
 rg-iot-academy

Instance details

Name *
 Name this device provisioning service

Region *
 East US 2

Review + create < Previous Next: Networking >

3. Click **Review and Create**, then click **Create**
4. When the deployment completes, click **Go to resource**
5. When the Overview page loads save the **ID Scope** to notepad

Task 2: Connect IoT Hub to DPS

1. Click **Linked IoT Hubs**, then click **Add**
2. Fill in the following details, then click **Save**
3. Click **Manage Allocation Policy**, review the options available

Task 3: Create an Individual Enrollment

1. Click **Add individual enrollment**
2. Fill in the following details
 - Mechanism: **Symmetric Key**
 - Auto-generate keys: **checked**
 - Registration ID: **iotacademy**
 - IoT Hub Device ID: **iot-academy-edge-device**
 - IoT Edge device: **True**
 - Select the IoT hubs this device can be assigned to: **select your hub** Leave all other values at default

3. Click **Save** at the top of the page

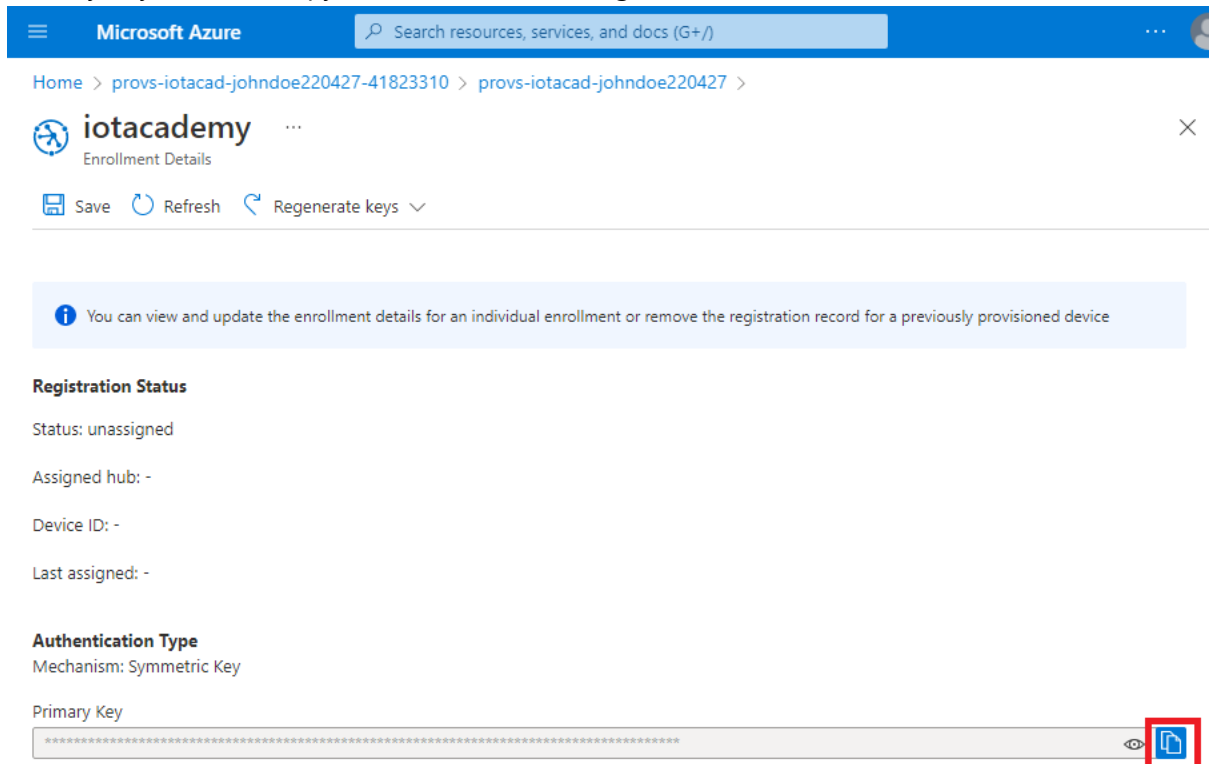
Task 4: Gather Individual Enrollment Details

1. Click **Manage enrollments**, then click **Individual Enrollments**, then click your enrollment **iotacademy**

The screenshot shows the Microsoft Azure portal interface for the IoT Hub Device Provisioning Service (DPS). The breadcrumb path is: Home > provs-iotacad-johndoe220427-41823310 > provs-iotacad-johndoe220427. The page title is 'provs-iotacad-johndoe220427 | Manage enrollments'. The left sidebar contains a navigation menu with the following items: Overview, Activity log, Access control (IAM), Tags, Diagnose and solve problems, Settings, Quick Start, Shared access policies, Linked IoT hubs, Certificates, **Manage enrollments** (highlighted with a red box), and Manage allocation policy. The main content area has a top bar with '+ Add enrollment group', '+ Add individual enrollment', 'Refresh', and 'Delete'. Below this is a message: 'You can add or remove individual device enrollments and/or enrollment groups from this page'. The 'Enrollment Groups' section shows a tab for 'Individual Enrollments' (highlighted with a red box). Below the tab is a search bar: 'Search individual enrollment by registration ID (ID has to be exact match)'. The 'REGISTRATION ID' section shows a table with one entry: 'iotacademy' (highlighted with a red box).

2. Take note of the following values in your notepad
 - Registration ID
 - IoT Hub Device ID

- Primary Key (click the copy icon shown in the image below)



Exercise 3: Create an Ubuntu-based Azure IoT Edge Device

During this exercise you will learn how to set up an Azure IoT Edge device and connect it to IoT Hub to start streaming data.

Task 1: Creating a VM to host an IoT Edge Device

In this exercise we'll set up an IoT Edge device using an Ubuntu based VM.

1. From Azure Portal select **Create resource** then from the most Popular list select **Ubuntu Server 18.04 LTS**. If you don't see it use the search box titled **Search services and marketplace** to search for **Ubuntu Server 18.04 LTS**.

Microsoft Azure Search resources, services, and docs (G+)

Home >

Create a resource

Get Started

Recently created

Categories

- AI + Machine Learning
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- Blockchain
- Compute
- Containers
- Databases
- Developer Tools
- DevOps
- Identity

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[Create](#) | [Docs](#)
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- Windows 10 Pro, version 20H2**
[Create](#) | [Learn more](#)
- Ubuntu Server 18.04 LTS**
[Create](#) | [Learn more](#)

2. Then you will need to complete the following parameters in the **Basics** tab:

- **Subscription:** Select the subscription you are using for this hands-on lab.
- **Resource group:** Use existing and select your resource group, `rg-iot-academy`.
- **Virtual Machine Name:** edgedevice+SUFFIX e.g. `edgedevice-johndoe-220427`
- **Region:** Select the location you are using for resources in this hands-on lab.
- **Availability Options:** Select **No Infrastructure redundancy required**.
- **Image:** Keep default
- **Size:** Keep default
- **Authentication Type:** Select **Password**
- **Username:** `iotacademy`
- **Password:** `MSFTacademy01!`
- **Public inbound ports:** None

3. Click the **Management** tab at the top of the pane.

 **Microsoft Azure**


[Home](#) > [Create a resource](#) >


Create a virtual machine ...

[Basics](#) [Disks](#) [Networking](#) **[Management](#)** [Advanced](#) [Tags](#) [Review + create](#)


Configure monitoring and management options for your VM.

Azure Security Center


Azure Security Center provides unified security management and advanced threat protection across hybrid [Learn more](#) 

 Your subscription is protected by Azure Security Center basic plan.


Monitoring

Boot diagnostics 

☒ **Enable with managed storage account (recommended)**
☐ Enable with custom storage account
☐ Disable

Enable OS guest diagnostics  ☐

Identity

System assigned managed identity  ☐

Notice the Auto-shutdown feature. This feature is a helpful to control costs for development or infrequently used virtual machines. When the VM is shutdown you do not incur compute costs.

Auto-shutdown

Enable auto-shutdown ⓘ

☒

Shutdown time ⓘ

7:00:00 PM

Time zone ⓘ

(UTC) Coordinated Universal Time

Notification before shutdown ⓘ

☒

Email * ⓘ

alanblythe@microsoft.com

Backup

Enable backup ⓘ

☐

Guest OS updates

Patch orchestration options ⓘ

Image default

Some patch orchestration options are not available for this image. [Learn more](#)

4. Click the Tags tab Add the following two tags

- environment: development
- product: iot-academy-training

Diagram showing the tags tab while creating a VM

Microsoft Azure

Search resources, services, and docs (G+)

Home > Create a resource >

Create a virtual machine

Basics

Disks

Networking

Management

Advanced

Tags

Review + create

Tags are name/value pairs that enable you to categorize resources and view consolidated billing by applying the same tag to multiple resources and resource groups. [Learn more about tags](#)

Note that if you create tags and then change resource settings on other tabs, your tags will be automatically updated.

Name ⓘ	Value ⓘ	Resource	
environment	: development	All resources	<div></div>
<div>product</div>	: iot-academy-training	12 selected	<div></div>
		12 selected	<div></div>

Tags are an important aspect for management, governance, and hygiene of Azure resources. It's not uncommon to have thousands of resources in mature organizations. The tags can be used for search,

reporting, and automation tools to ease management of large deployments. You can read more at [Azure Tagging Strategy](#)

5. Last select **Review + Create** after successful validation you should be able to click **Create**
6. Once the resource is available click **Go to resource** to view the newly created Virtual Machine. You should see in the Overview section the Public IP to connect, copy the IP to your notepad.

The screenshot shows the Microsoft Azure portal interface. At the top, there's a search bar and navigation menu. Below, the breadcrumb trail indicates the path: Home > CreateVm-Canonical.UbuntuServer-18_04-lts-gen2-20220413184623 >. The main heading is 'edgedevice-johndoe-220427' with a 'Virtual machine' subtitle. A search bar and action buttons (Connect, Start, Restart, Stop, Capture, Delete) are visible. On the left, a sidebar lists navigation options: Overview (selected), Activity log, Access control (IAM), Tags, Diagnose and solve problems, Settings, Networking, Connect, Disks, Size, and Security. The main content area, titled 'Essentials', displays key VM details in a table:

Property	Value
Resource group	rg-iot-academy
Status	Running
Location	East US 2
Subscription	Visual Studio Enterprise Subscrip...
Subscription ID	7451d6d6-9082-46d9-9373-ccd5...
Operating system	Linux (ubuntu 18.04)
Size	Standard DS1 v2 (1 vcpu, 3.5 GiB...
Public IP address	20.122.3.1
Virtual network/subnet	rg-iot-academy-vnet/default
DNS name	Not configured
Tags	More (2)

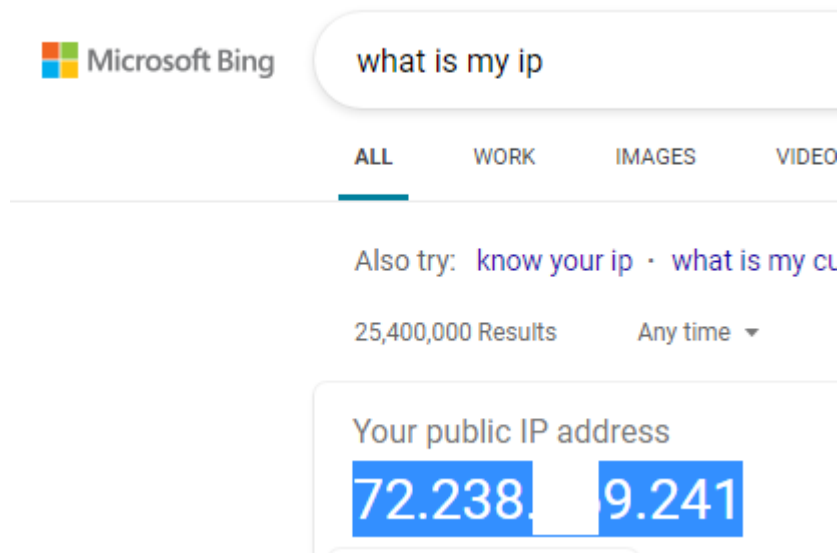
Task 2: Connecting to your Ubuntu Virtual Machine

An important aspect of building cloud infrastructure is doing it in a secure manner. As part of this exercise port 22 could be opened, for SSH, to allow quick connection to the VM. However, this could allow an attacker to attempt to breach this port. Two safer approaches could be used

- A safer approach would be to use an important feature of Azure Virtual Machines, Just-in-time (JIT) VM access. This feature allows enabling access to the VM for a specified amount of time. More information can found at [Just-in-time VM Access](#)
- Enabling SSH, port 22, access for just your IP address

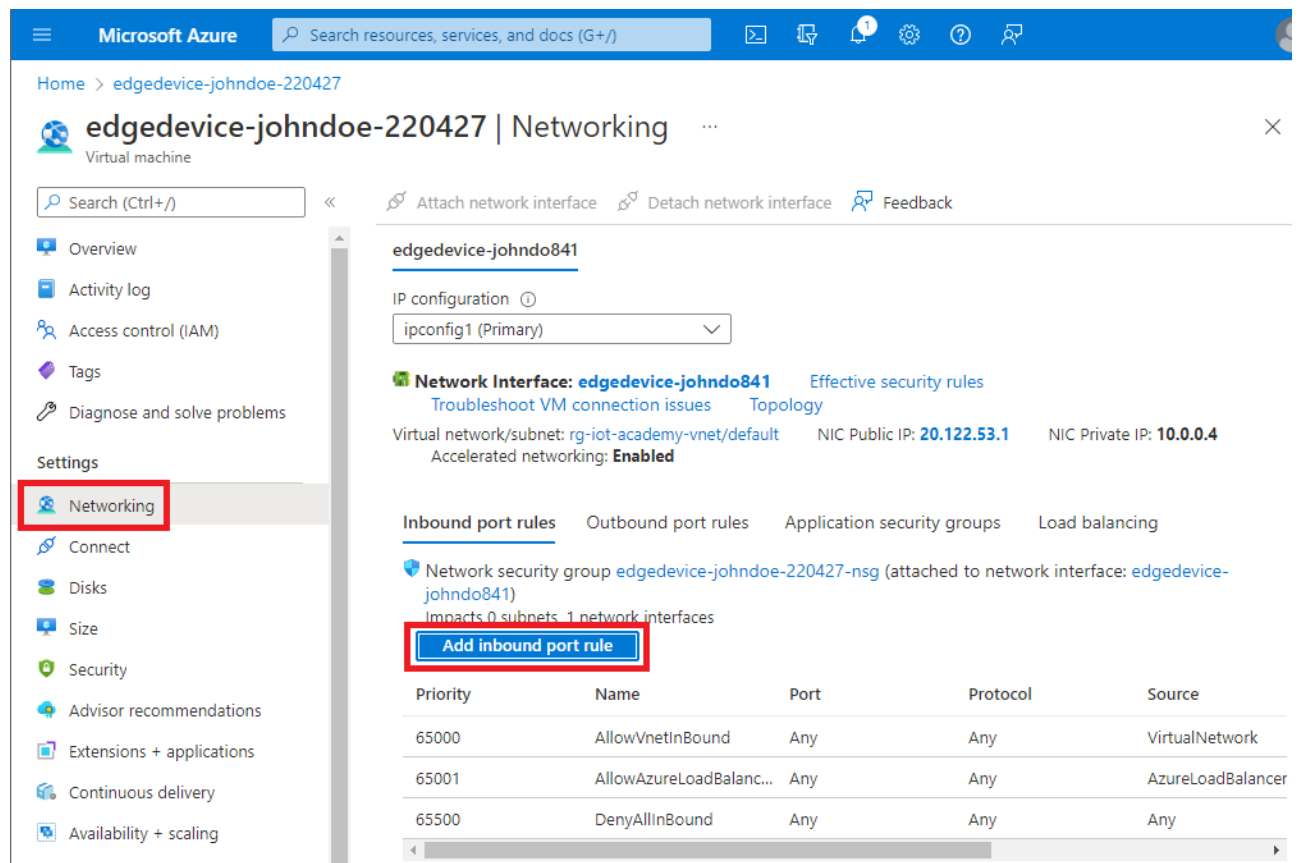
For simplicity the 2nd option will be used.

1. Go to www.bing.com in your browser and search for **what is my ip**



Copy your IP address to your notepad.


2. On your VM resource click the **Networking** tab. Click the **Add inbound port rule**



3. Set the details for the new inbound port rule, click Add.

- Source: **IP Addresses**
- Source IP addresses/CIDR ranges: **Your IP address you saved in notepad**
- Source port ranges: *****
- Service: **SSH**
- Action: **Allow**
- Priority: **100**

- Name: **Port_22**

 **Add inbound security rule** ✕
edgedevice-johndoe-220427-nsg

Source ⓘ

IP Addresses ✓

Source IP addresses/CIDR ranges * ⓘ

72.238. 9.241 ✓

Source port ranges * ⓘ

*

Destination ⓘ

Any ✓

Service ⓘ

SSH ✓

Destination port ranges ⓘ

22

Protocol

☐ Any

☒ TCP

☐ UDP

☐ ICMP

Action

☒ Allow

☐ Deny

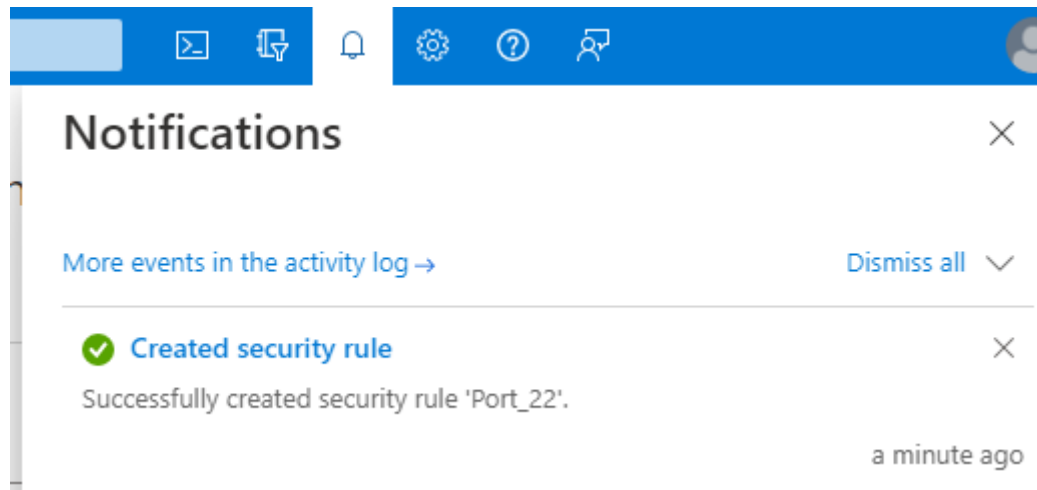
Priority * ⓘ

100

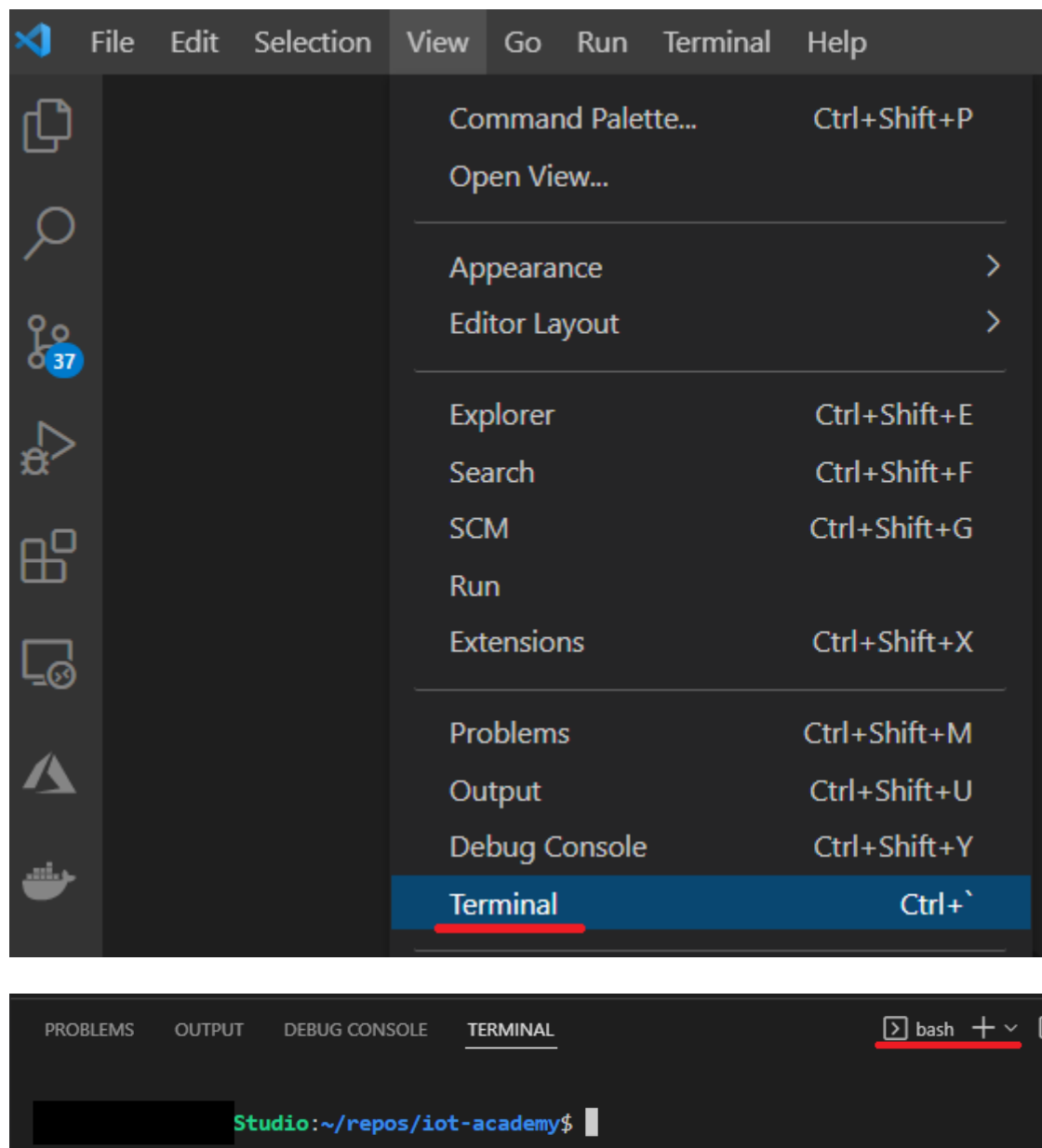
Name *

Port_22 ✓

4. Watch for the notification that the security rule created successfully



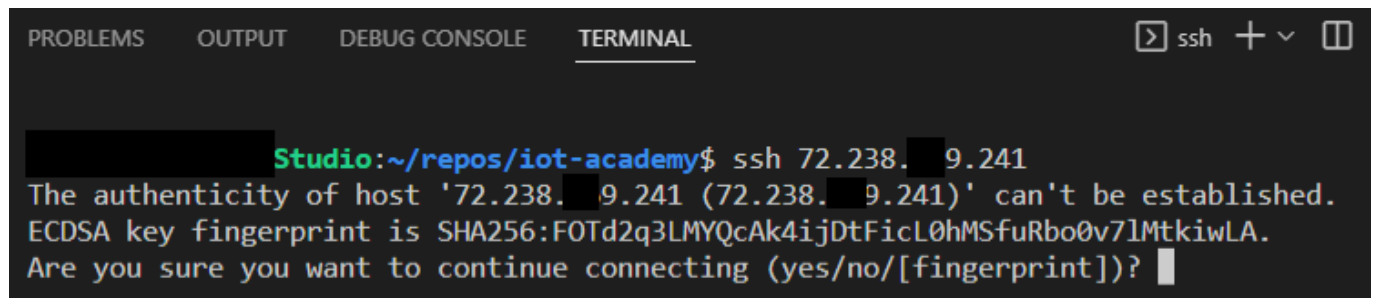
5. Switch to VS Code, use the **View** menu and click **Terminal**



If you don't see a `bash` terminal at the top, click the `+` and click `bash`

6. Enter `ssh iotacademy@{the public IP address of your VM}` and press enter. You saved the VMs public IP address earlier in your notepad. Be sure to not confuse your public IP address with the IP address of the VM. e.g. `ssh iotacademy@20.122.53.2`

If this is your first time connecting you'll see a prompt asking `Are you sure you want to continue connecting?`. Enter `yes` and press enter.

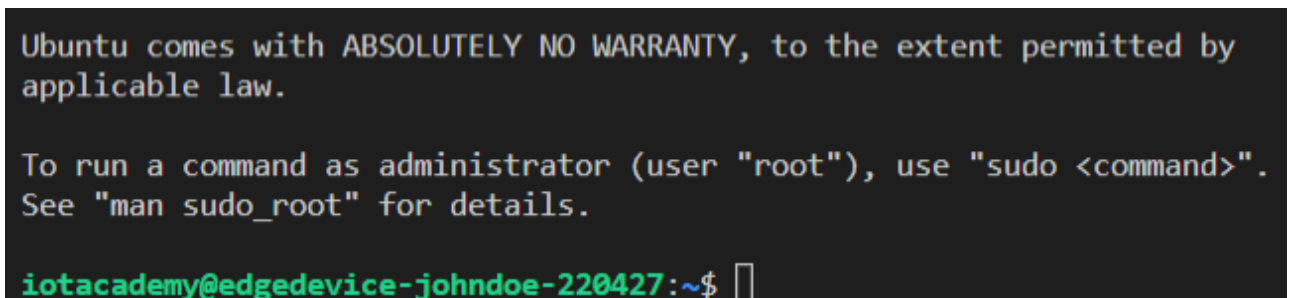


```
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL [ssh] + - [ ]
Studio:~/repos/iot-academy$ ssh 72.238.19.241
The authenticity of host '72.238.19.241 (72.238.19.241)' can't be established.
ECDSA key fingerprint is SHA256:FOTd2q3LMYQcAk4ijDtFicL0hMSfuRbo0v7lMtkiwLA.
Are you sure you want to continue connecting (yes/no/[fingerprint])?
```

7. Enter your password you defined earlier `MSFTacademy01!` and press enter. The password can be copied to your clipboard and pasted into the terminal by:

- left clicking on the terminal window once, to focus the window
- right clicking on the terminal window once, this pastes the clipboard contents

After successfully connecting you'll see the following in your terminal



```
Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

iotacademy@edgedevice-johndoe-220427:~$
```

Task 3: Install the Azure IoT Edge Runtime and Connect the Device

1. Now logged into the VM, Install the Edge Runtime

Install the repository configuration that matches your device operating system.

```
curl https://packages.microsoft.com/config/ubuntu/18.04/multiarch/prod.list
> ./microsoft-prod.list
```

Copy the generated list to the sources.list.d directory.

```
sudo cp ./microsoft-prod.list /etc/apt/sources.list.d/
```

Install the Microsoft GPG public key.

```
curl https://packages.microsoft.com/keys/microsoft.asc | gpg --dearmor >
microsoft.gpg
sudo cp ./microsoft.gpg /etc/apt/trusted.gpg.d/
```

Azure IoT Edge software packages are subject to the license terms located in each package (usr/share/doc/{package-name} or the LICENSE directory). Read the license terms prior to using a package. Your installation and use of a package constitutes your acceptance of these terms. If you do not agree with the license terms, do not use that package.

After successfully running the previous commands you'll see the following results depicted in the diagram.

```
iotacademy@edgedevice-johndoe-220427:~$ curl https://packages.microsoft.com/config/ubuntu
/18.04/multiarch/prod.list > ./microsoft-prod.list
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left   Speed
100  101  100    101    0     0  1463      0  --:--:-- --:--:-- --:--:--  1463
iotacademy@edgedevice-johndoe-220427:~$ sudo cp ./microsoft-prod.list /etc/apt/sources.li
st.d/
iotacademy@edgedevice-johndoe-220427:~$ curl https://packages.microsoft.com/keys/microsof
t.asc | gpg --dearmor > microsoft.gpg
microsoft.gpg /etc/apt/trusted.gpg.d/  % Total    % Received % Xferd  Average Speed   Time
Time    Time  Current
                                 Dload  Upload   Total   Spent    Left   Speed
100  983  100    983    0     0 20061      0  --:--:-- --:--:-- --:--:-- 20061
iotacademy@edgedevice-johndoe-220427:~$ sudo cp ./microsoft.gpg /etc/apt/trusted.gpg.d/
```

2. Install a Container Engine

Update package lists on your device.

```
sudo apt-get update
```

Install the Moby engine.

```
sudo apt-get install moby-engine
```

3. Install the IoT Edge runtime package

```
sudo apt-get install iotedge
```

4. Edit the IoT Edge config.yaml, updating the provisioning information

- Configure the provisioning section with the information that we saved during the setup of DPS.

```
sudo nano /etc/iotedge/config.yaml
```

- Scroll down to **Manual Provisioning with an IoT Hub connection string** then comment out all the uncommented lines using the # symbol.

```
#                                     about the re-provisioning event before shutting down
#
#####

# Manual provisioning with an IoT Hub connection string (SharedAccessKey authentication)
# provisioning:
#   source: "manual"
#   device_connection_string: "<ADD DEVICE CONNECTION STRING HERE>"
#   dynamic_reprovisioning: false

# Manual provisioning with X.509 identity certificate authentication
# provisioning:
#   source: "x509"
```

- Scroll down further to locate the **DPS provisioning with symmetric key attestation** section. Uncomment the section and set the following values
 - scope_id: saved in notepad
 - registration_id: saved in notepad
 - symmetric_key: the primary key saved in notepad

```
# DPS provisioning with symmetric key attestation
provisioning:
  source: "dps"
  global_endpoint: "https://global.azure-devices-provisioning.net"
  scope_id: "0ne005AB0F7"
  attestation:
    method: "symmetric_key"
    registration_id: "iot-academy-edge-device"
    symmetric_key: "XJxLQ..."
  always_reprovision_on_startup: true
  dynamic_reprovisioning: false
```

After making the edits:

- press **CrtL+X** to close the file
- select **Y** to save the changes
- press enter to accept the file name

Now restart your edge daemon

```
sudo systemctl restart iotedge
```

In a few minutes you should receive a **Running** status after executing the following command. You may need to run the command several times if enough time has not passed since restarting the IoT Edge runtime.

```
sudo iotedge list
```

Another command that is useful is **check** that is shown below. The **check** command:

- checks the validity of the config.yaml file
- the container engine is functional
- time is correct
- connections to DPS and IoT Hub can be established

```
sudo iotedge check
```

Task 4: Observe the Enrollment and Device Status

1. Navigate to your DPS instance by searching for **provs** and clicking your instance.
2. Click **Manage Enrollments**
3. Click **Individual Enrollments**
4. Click **iotacademy**

Registration Status

Status: assigned

Assigned hub: iot-academy-johndoe-vscode-220427.azure-devices.net

Device ID: iot-academy-edge-device

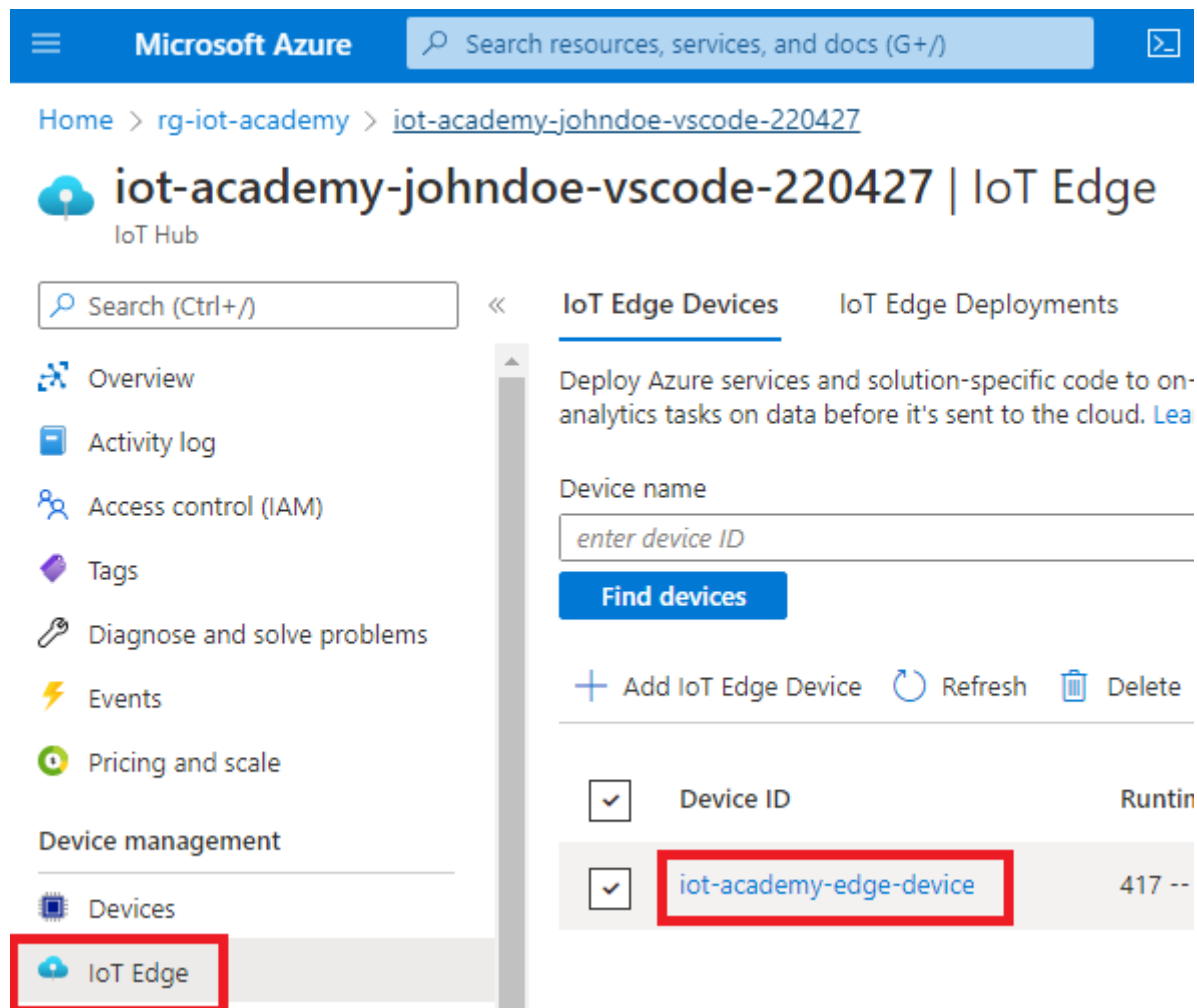
Last assigned: Tue Apr 19 2022 00:41:57 GMT-0400 (Eastern Daylight Time)

Delete Registration

Exercise 4: Deploy and IoT Edge Module to Simulate Device Telemetry

Task 1: Use the IoT Edge Module Marketplace to Provision the Simulated Temperature Sensor Module

1. In Azure Portal, navigate to your IoT Hub created in previous steps, under **Device Management** click **IoT Edge**, then click your Edge Device



Microsoft Azure

Search resources, services, and docs (G+)

Home > rg-iot-academy > iot-academy-johndoe-vscode-220427

iot-academy-johndoe-vscode-220427 | IoT Edge

IoT Hub

Search (Ctrl+/)

- Overview
- Activity log
- Access control (IAM)
- Tags
- Diagnose and solve problems
- Events
- Pricing and scale

Device management

- Devices
- IoT Edge**

IoT Edge Devices

Deploy Azure services and solution-specific code to on-analytics tasks on data before it's sent to the cloud. [Lea](#)

Device name

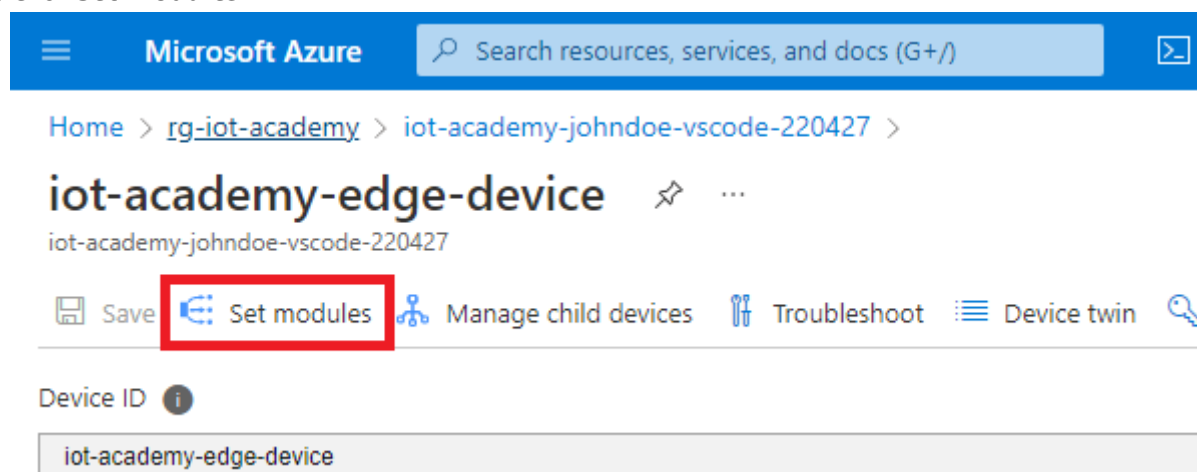
enter device ID

Find devices

+ Add IoT Edge Device Refresh Delete

<input checked="" type="checkbox"/>	Device ID	Runtim
<input checked="" type="checkbox"/>	iot-academy-edge-device	417 --

2. Click **Set Modules**



Microsoft Azure

Search resources, services, and docs (G+)

Home > rg-iot-academy > iot-academy-johndoe-vscode-220427 >

iot-academy-edge-device

iot-academy-johndoe-vscode-220427

Save **Set modules** Manage child devices Troubleshoot Device twin

Device ID ⓘ

iot-academy-edge-device

3. Click **Add**. Then click **Marketplace Module**

Microsoft Azure Search resources, services, and docs (G+/)

Home > rg-iot-academy > iot-academy-johndoe-vscode-220427 > iot-academy-edge-device >

Set modules on device: iot-academy-edge-device

iot-academy-johndoe-vscode-220427

Modules Routes Review + create

Container Registry Credentials

You can specify credentials to container registries hosting module images. Listed credentials are used to retrieve modules with a matching URL. The Edge Agent will report error code 500 if it can't find a container registry setting for a module.

NAME	ADDRESS	USER NAME	PASSWORD
<input type="text" value="Name"/>	<input type="text" value="Address"/>	<input type="text" value="User name"/>	<input type="password" value="Password"/>

IoT Edge Modules

IoT Edge modules are Docker containers deployed to IoT Edge devices. They can communicate with other modules or send data to the IoT Edge runtime. Modules on devices count toward IoT Hub quota limits based on tier and units. For example, for S1 tier, modules can be set 10 times per second if no other updates are happening in the IoT Hub. [Learn more](#)

+ Add Runtime Settings

- + IoT Edge Module
- + Marketplace Module**
- + Azure Stream Analytics Module

Send usage data to Microsoft to help improve our products and services. Read our [privacy statement](#) to learn more. See [details](#) of what data is collected.

4. The search box will appear, type **Simulated Temperature Sensor**, Then click the module to add it

Microsoft Azure Search resources, services, and docs (G+/)

IoT Edge Module Marketplace

Marketplace

Simulated Temperature Sensor
Microsoft
IoT Edge module that simulates a temperature sensor

5. Review the presentation section **Routes** to learn about IoT Edge routing

6. Click **Review + create** at the bottom of the pane. Review the available settings for the Deployment

7. After validation passes click **Create** at the bottom of the pane

Task 2: Ensure the Module is Running

Review the running modules on your Edge device

It may take a few minutes for the module to deploy and come to a running state. Running modules can be verified in a few ways:

- On device details review the **Modules** section at the bottom of the pane.

Modules IoT Edge hub connections Deployments and Configurations				
Name	Type	Specified in Deployment	Reported by Device	Runti...
SedgeAgent	IoT Edge System Module	✓ Yes	✓ Yes	running
SedgeHub	IoT Edge System Module	✓ Yes	✓ Yes	running
SimulatedTemperatureSensor	IoT Edge Custom Module	✓ Yes	✓ Yes	running

- Using SSH, connect to your VM and run the `iotedge list` command as shown below

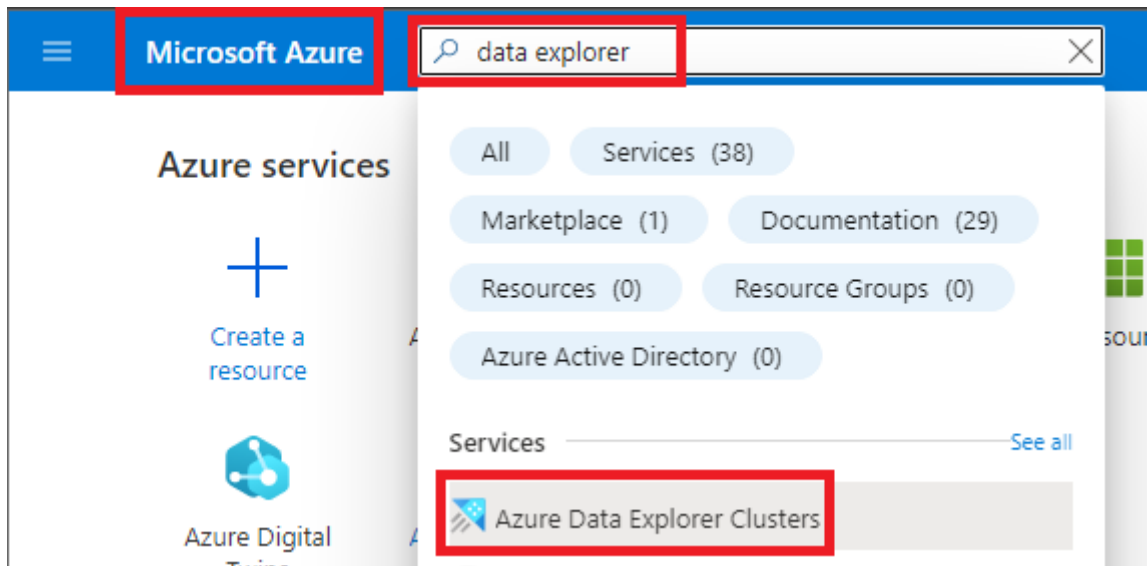
```
sudo iotedge list
```

```
iotacademy@edgedevice-johndoe-220427:~$ sudo iotedge list
NAME                                STATUS      DESCRIPTION      CONFIG
SimulatedTemperatureSensor          running    Up 6 minutes     mcr.mic
edgeAgent                           running    Up 9 hours       mcr.mic
edgeHub                             running    Up 5 minutes     mcr.mic
iotacademy@edgedevice-johndoe-220427:~$
```

Exercise 5: Ingesting Telemetry Data with IoT Hub and Azure Data Explorer (ADX)

Task 1: Creating the ADX Cluster

- Find the Azure Data Explorer service to create a new cluster
 - Go to the Azure Portal home page by selecting **Microsoft Azure** at the top of the window. Then click **Azure Data Explorer Clusters**



- Click **Create**
2. Enter the details for the new ADX cluster then click **Review + create**
- Details
 - Resource group: `rg-iot-academy`
 - Cluster name: `{prefix|iot|acad|johnd|220427}` e.g. `deciotacadjohnd220427`. This name must be globally unique, alphanumeric only, limited to 22 characters.
 - Region: `{Your region}` e.g. `East US 2`
 - Workload: `Dev/test`
 - Compute specifications: `Dev(No SLA)_Standard_E2a_v4`

Microsoft Azure

Search resources, services, and docs (G+)

Home > Azure Data Explorer Clusters >

Create an Azure Data Explorer Cluster ...

* Basics

Scale

Configurations

Security

Network

Diagnostic settings

Tags

Review + create

PROJECT DETAILS

Select the subscription to manage deployed resources and costs. Use resource groups like folders to organize and manage all your resources.

Subscription *

Visual Studio Enterprise Subscription

Resource group * ⓘ

rg-iot-academy

[Create new](#)

CLUSTER DETAILS

Cluster name * ⓘ

deciotacadjohnd220427

Region * ⓘ

East US 2

COMPUTE SPECIFICATION

Workload *

Dev/test

Size

Compute specifications *

Dev(No SLA)_Standard_E2a_v4

[Select from all options](#)

Availability zones ⓘ

Zones 1, 2, 3

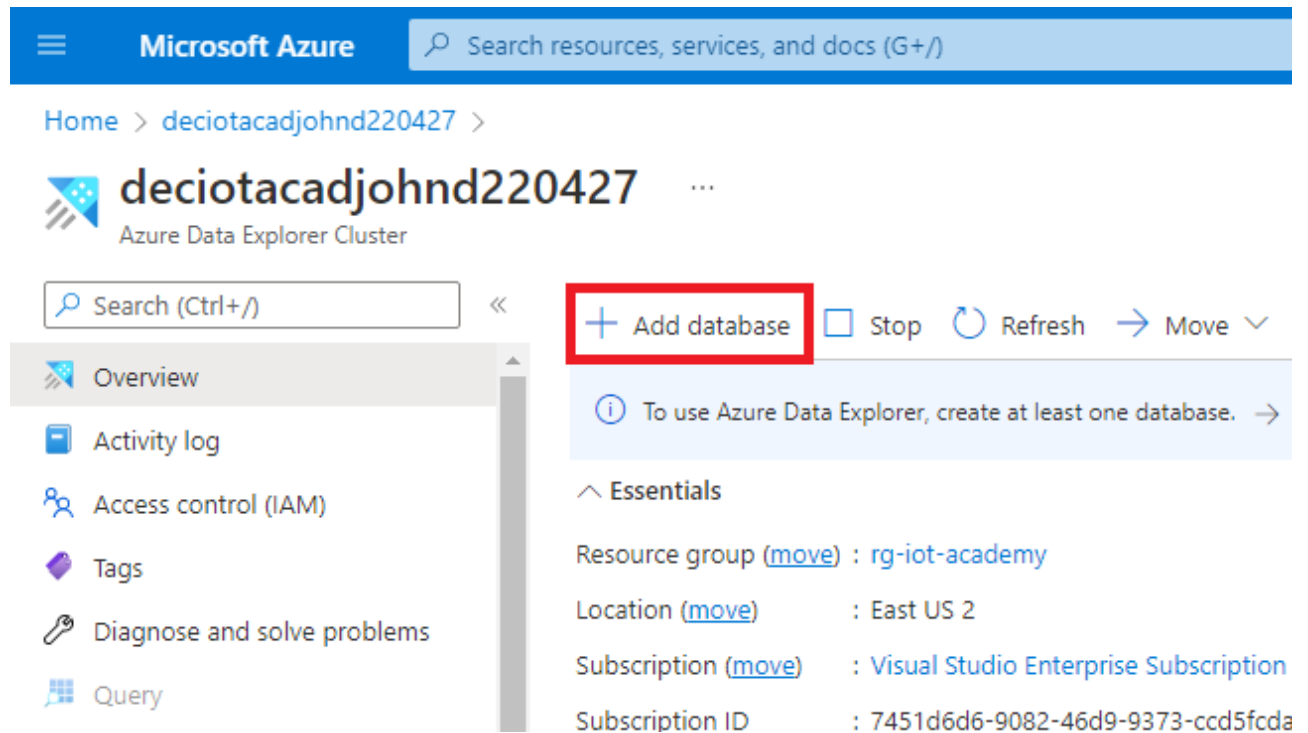
Review + create

Next : Scale >

- After validation passes click **Create**
- Wait until the cluster is created and click **Go to resource**

Task 2: Adding an ADX Database

1. Now on the Overview tab for your new ADX cluster click **Add database**



Microsoft Azure Search resources, services, and docs (G+)

Home > deciotacadjohnd220427 >

deciotacadjohnd220427 ...
Azure Data Explorer Cluster

Search (Ctrl+/) <<

+ Add database ☐ Stop Refresh → Move ▾

To use Azure Data Explorer, create at least one database. →

^ Essentials

Resource group ([move](#)) : [rg-iot-academy](#)

Location ([move](#)) : East US 2

Subscription ([move](#)) : [Visual Studio Enterprise Subscription](#)

Subscription ID : 7451d6d6-9082-46d9-9373-ccd5fcda

Overview

Activity log

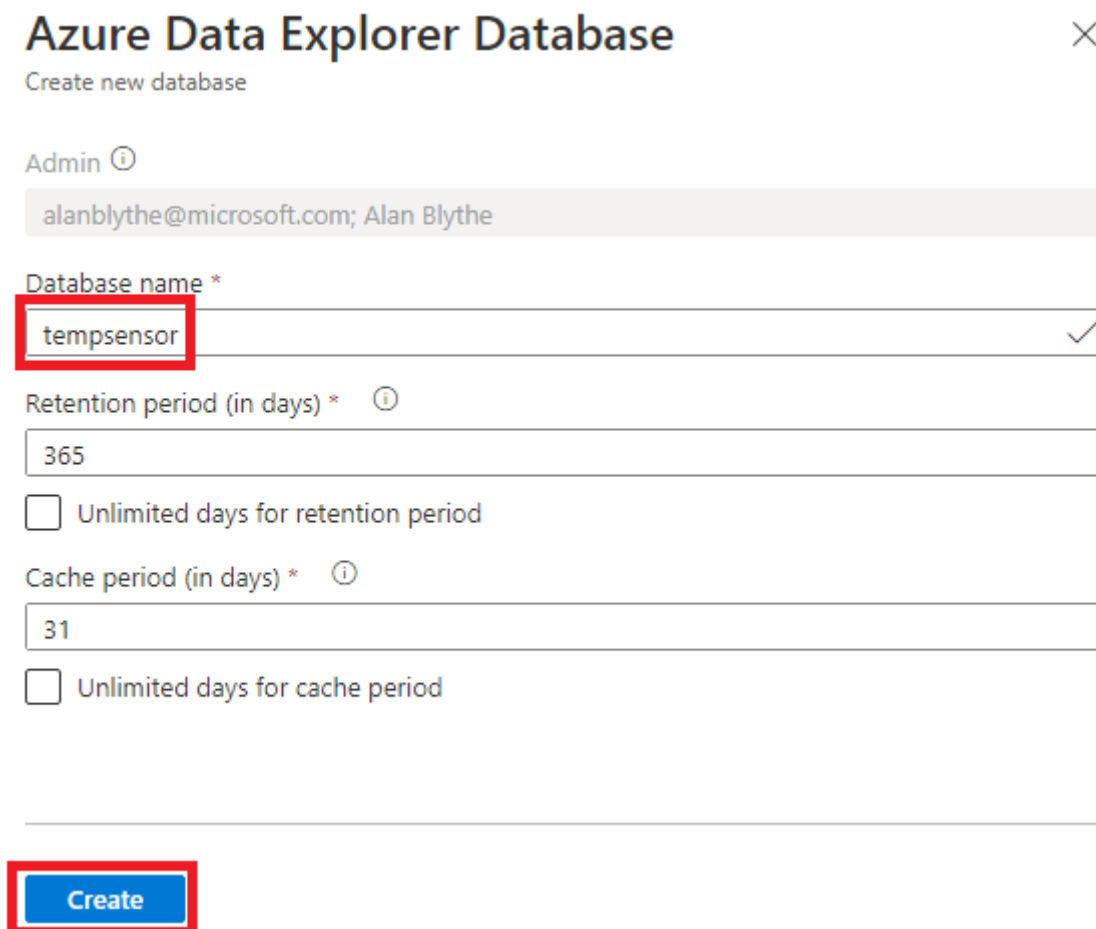
Access control (IAM)

Tags

Diagnose and solve problems

Query

2. Click **Create**



Azure Data Explorer Database

Create new database

Admin ⓘ

alanblythe@microsoft.com; Alan Blythe

Database name *

tempsensor ✓

Retention period (in days) * ⓘ

365

☐ Unlimited days for retention period

Cache period (in days) * ⓘ

31

☐ Unlimited days for cache period

Create

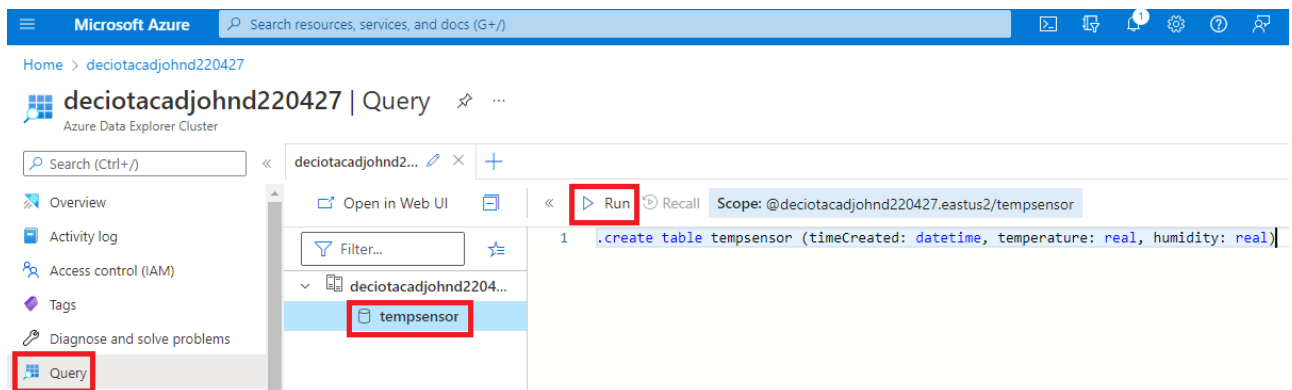
- After a few moments you'll be back at the overview page.

Task 3: Creating the tempsensor table

Create the tempsensor table with schema and mapping

- Click Query. Click your **tempsensor** database. Paste the create table code from below into the windows. Then click **Run**.

```
.create table tempsensor (timeCreated: datetime, temperature: real,
humidity: real)
```



- A message as follows will be received when successful.

Table 1				
	Search	Done (0.293 s)	123	1 records
TableName	Schema	DatabaseName	Folder	
tempsensor	{ "Name": "tempsensor", "OrderedColumns": [{ "Name": "timeCreated", "Type": "System.DateTime", "CslType": "datetime" }, { "Name": "temperature", "Type": "System.Double", "CslType": "real" }, { "Name": "humidity", "Type": "System.Double", "CslType": "real" }] }	tempsensor		
1	"TableName": tempsensor,			
2	"Schema": { "Name": "tempsensor", "OrderedColumns": [{ "Name": "timeCreated", "Type": "System.DateTime", "CslType": "datetime" }, { "Name": "temperature", "Type": "System.Double", "CslType": "real" }, { "Name": "humidity", "Type": "System.Double", "CslType": "real" }] },			
3	"DatabaseName": tempsensor,			
4	"Folder": ,			
5	"DocString": ,			
6				

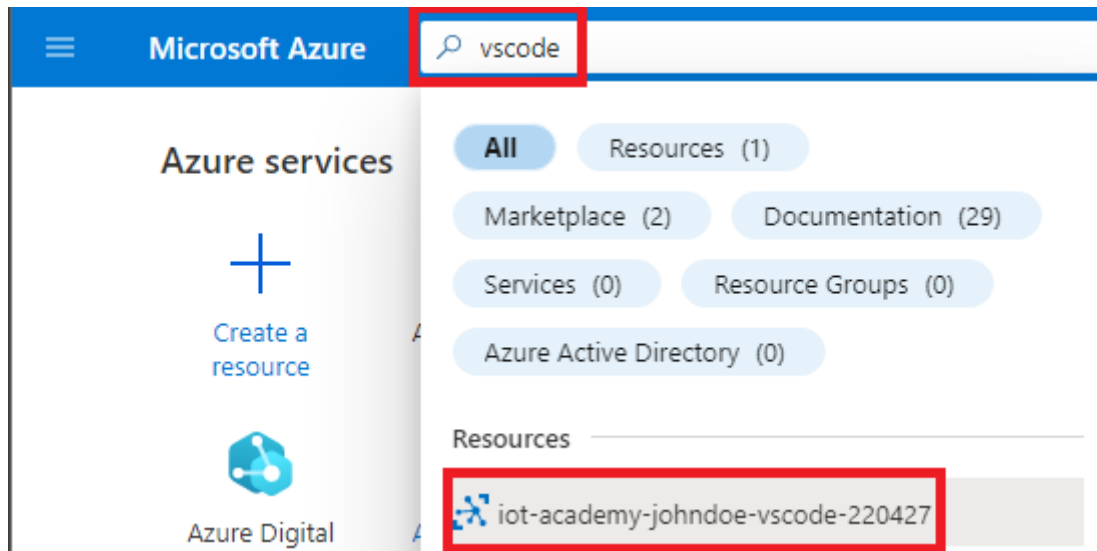
- Next, create the tempsensor ingestion mapping. Replace the command in the window with the command from the following code block. Then, click **Run**. When successful a similar result from the last command will be observed.

```
.create table tempsensor ingestion json mapping 'tempsensorMapping'
'[{ "column": "timeCreated", "path": "$.timeCreated", "datatype": "datetime" },
{ "column": "humidity", "path": "$.ambient.humidity", "datatype": "real" },
{ "column": "temperature", "path": "$.ambient.temperature", "datatype": "real" } ]'
```

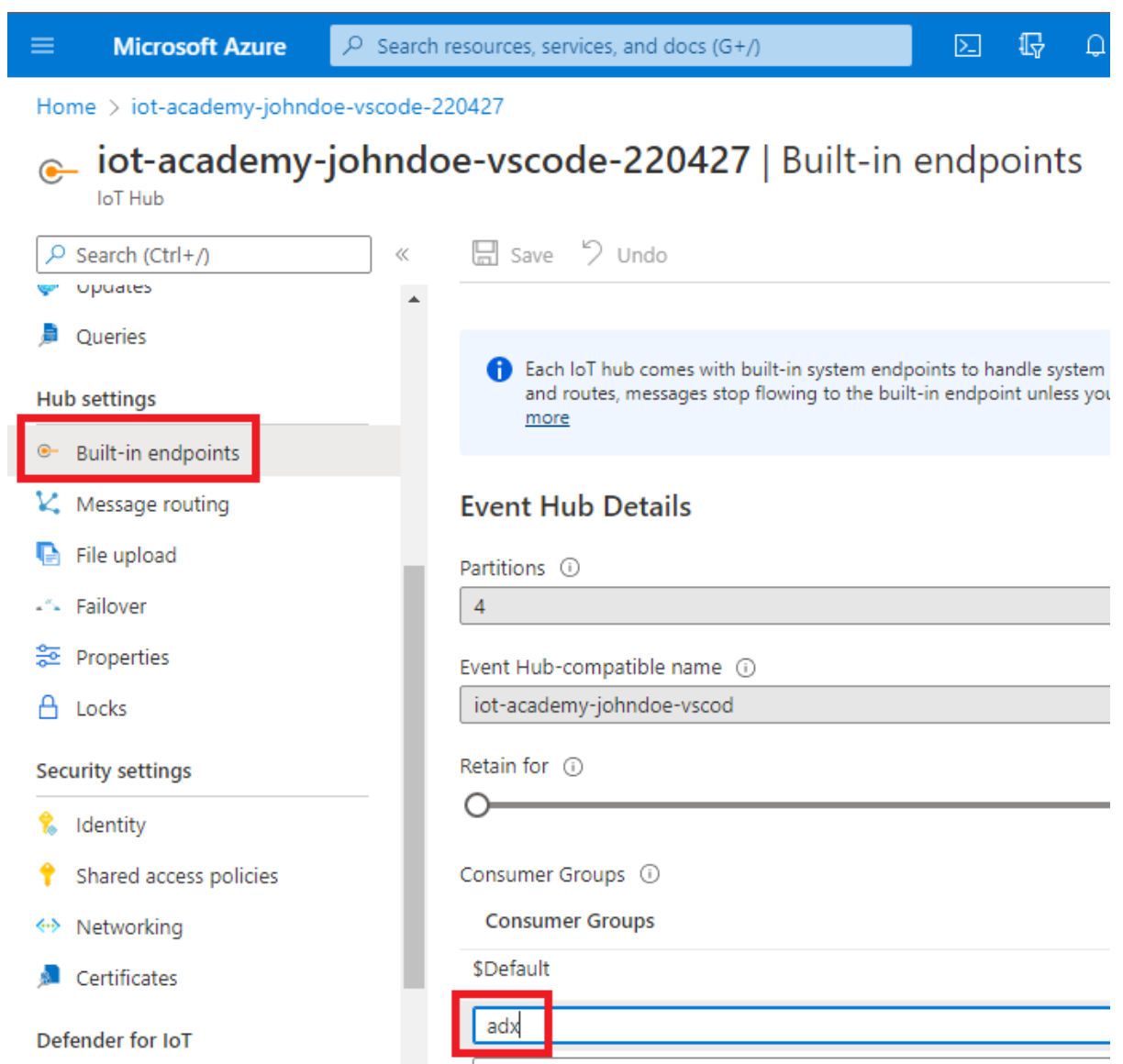
Task 4: Connecting ADX to IoT Hub to Ingest Telemetry

1. Add a new Consumer Group to your IoT Hub

- Use the Azure Portal search bar, type **vscode**. Your IoT Hub instance will be shown. Click your IoT Hub name to navigate to the resource.




- Click **Built-in endpoints**. Add a new consumer group under the **Consumer Groups** section. Type **adx** in the box and press tab. When you press tab your entry will be saved.

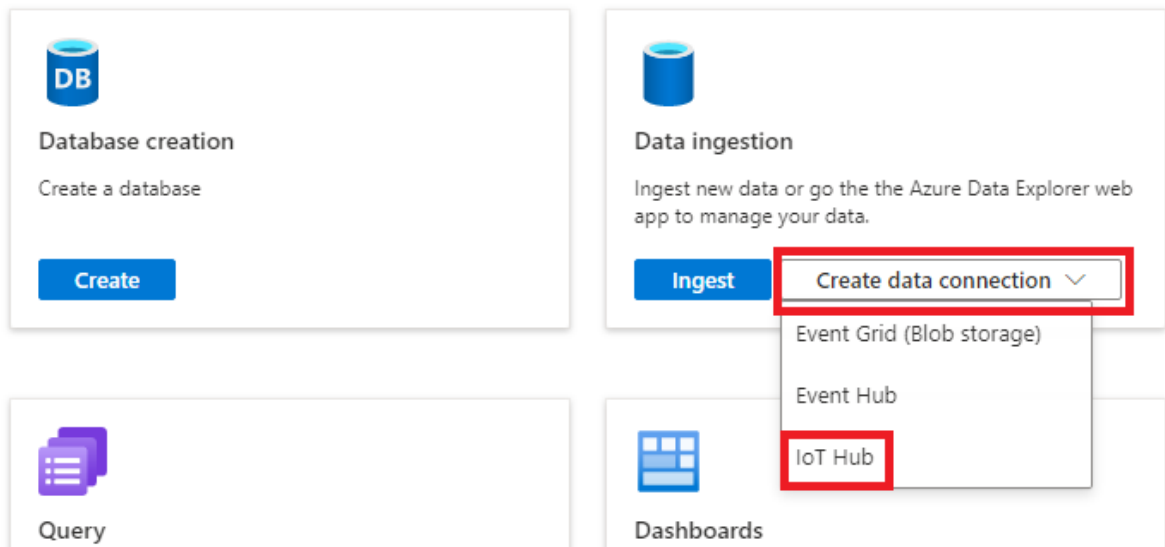


2. Create a data connection to ingest your tempsensor telemetry data

- Use the Azure Portal search bar to search for `dec`, the standard prefix for Azure Data Explorer resources. Then, click your instance to load the resource.
- Click **Create data connection** and select IoT Hub.

Get started with Azure Data Explorer

Use the Azure Data Explorer web app to manage your data easily. [Learn more](#) 



- Fill in all the fields as follows:
 - Data connection name: `tempsensor`
 - Subscription: {Your subscription}
 - IoT Hub: {Your IoT Hub that includes vscode in the name}
 - Shared Access Policy: {iothubowner}
 - Consumer Group: `adx`
 - Event system properties: Click the dropdown and select `iothub-connection-device-id`
 - Database Name: `tempsensor`
 - Table name: `tempsensor`
 - Data format: `JSON`
 - Mapping name: `tempsensorMapping`

- Click **Create**

IoT Hub



Data connection name *	<input type="text" value="tempsensor"/>
Subscription *	<input type="text" value="Visual Studio Enterprise Subscription"/>
IoT Hub *	<input type="text" value="iot-academy-johndoe-vscode-220427"/>
Shared Access Policy *	<input type="text" value="iothubowner"/>
Consumer group *	<input type="text" value="adx"/>
Event system properties	<input type="text" value="iothub-connection-device-id"/>
Database Name *	<input type="text" value="tempsensor"/>

Data routing settings

Allow routing the data to other databases (Multi database data connection) ☐ Don't allow

Target table

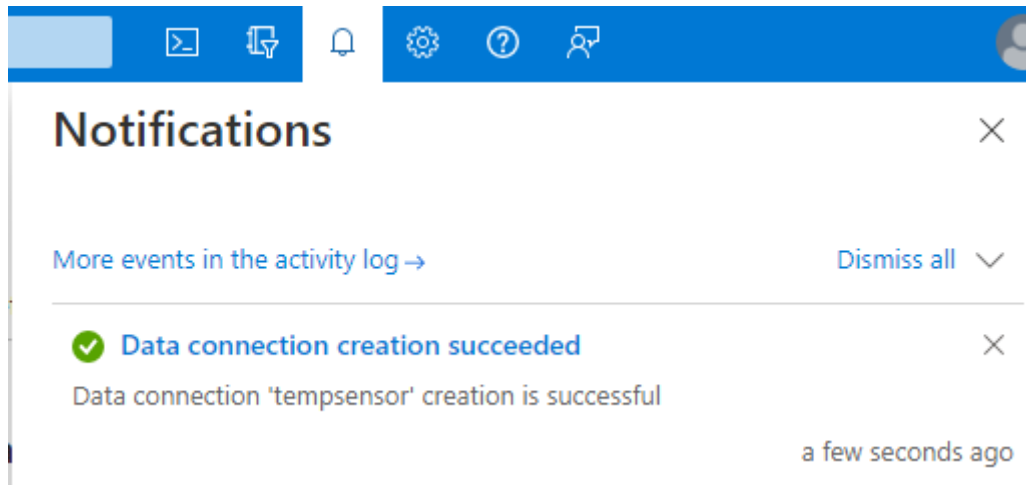
This is the default table routing setup. If you don't configure the table settings here, you'll need to configure them using Event Properties for the ingestion to succeed. The table Event Properties settings overrides the default table settings configured here. [Learn more](#)

Table name	<input type="text" value="tempsensor"/>
Data format	<input type="text" value="JSON"/>
Mapping name	<input type="text" value="tempsensorMapping"/>

This is a preview version of IoT Hub data connection. This version does not support IoT Hub manual-failover. In such cases, please recreate the data connection.

Create

- Watch for the notification for when the data connection creation is successful.



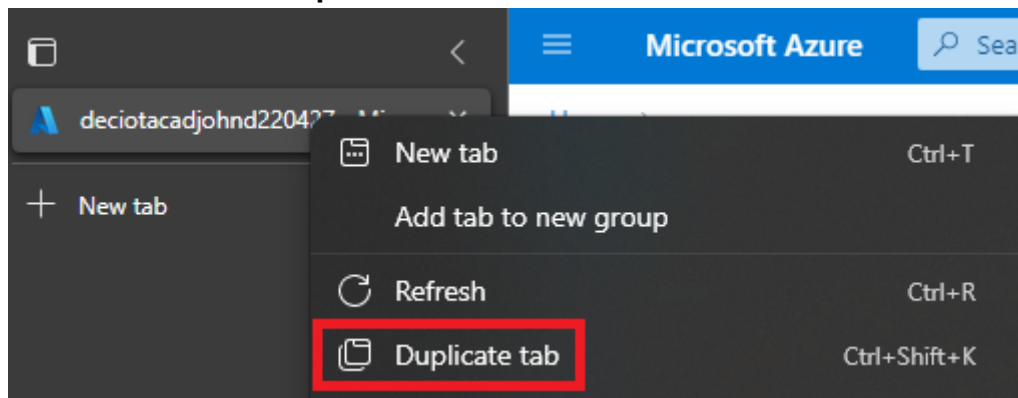
Exercise 6: Analyzing Data with Azure Data Explorer (ADX)

Task 1: Connecting ASA to IoT Hub

1. Restart the temperature sensor module to ensure fresh telemetry is flowing

The **Simulated Temperature Sensor** module sends 500 telemetry messages, once every 5 seconds. This means ~40 minutes worth of messages. As our lab takes some time to work through we'll restart the module to ensure we have plenty of data to analyze with ADX.

- Create a 2nd browser tab to have both ADX and IoT Hub open in the Azure Portal. Right click the browser tab and click **Duplicate tab**.

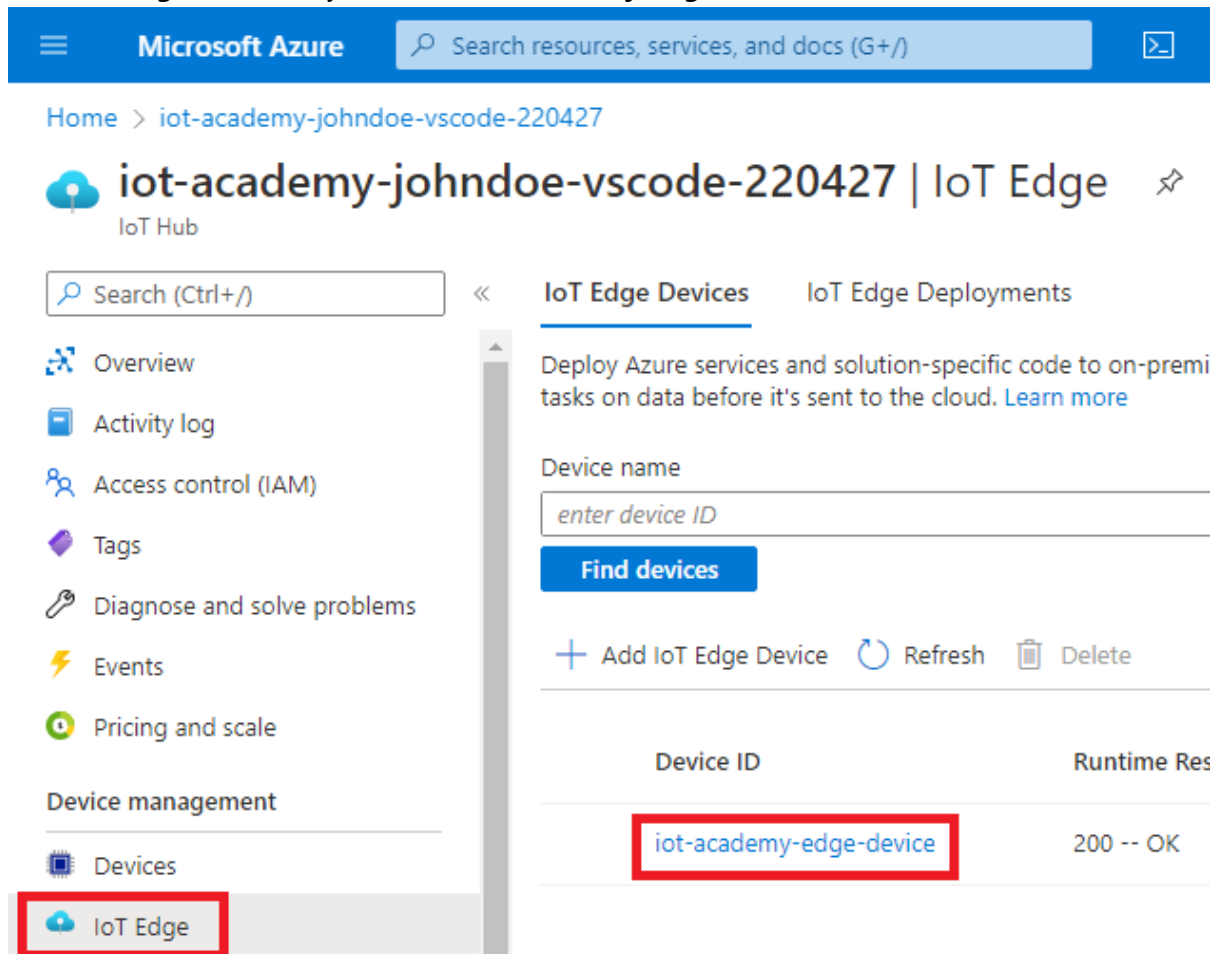


- Switch to your 2nd tab, then click Microsoft Azure at the top of window to take you to the home page.
- In your recent resources click your IoT Hub instance such as **iot-academy-johndoe-vscode-220427**

Recent resources

Name	Type
 tempsensor (deciotacadjohnd220427/tempsensor)	Azure Data Explorer Database
 deciotacadjohnd220427	Azure Data Explorer Cluster
 iot-academy-johndoe-vscode-220427	IoT Hub

- Click **IoT Edge**, then click your device **iot-academy-edge-device**



Microsoft Azure Search resources, services, and docs (G+)

Home > iot-academy-johndoe-vscode-220427

iot-academy-johndoe-vscode-220427 | IoT Edge

IoT Hub

Search (Ctrl+)

Overview
Activity log
Access control (IAM)
Tags
Diagnose and solve problems
Events
Pricing and scale
Device management
Devices
IoT Edge

IoT Edge Devices IoT Edge Deployments

Deploy Azure services and solution-specific code to on-premi tasks on data before it's sent to the cloud. [Learn more](#)

Device name

Find devices

+ Add IoT Edge Device Refresh Delete

Device ID	Runtime Res
iot-academy-edge-device	200 -- OK




- Click the **Simulated Temperature Sensor** module at the bottom of the window


Modules IoT Edge hub connections Deployments and Configurations		
Name	Type	Specified
SedgeAgent	IoT Edge System Module	✓ Yes
SedgeHub	IoT Edge System Module	✓ Yes
SimulatedTemperatureSensor	IoT Edge Custom Module	✓ Yes

- Click **Restart Simulated Temperature Sensor** Notice the status that's received **Initializing simulated temperature sensor to send 500 messages, at an interval of 5 seconds**

Troubleshoot ...

iot-academy-johndoe-vscode-220427

 Restart SimulatedTemperatureSensor  Refresh  Download

SimulatedTemperatureSensor 

Time range: Since 15 minutes Find: Not specified


SimulatedTemperatureSensor Main() finished.
[2022-04-15 03:14:45 : Starting Module
SimulatedTemperatureSensor Main() started.
Initializing simulated temperature sensor to send 500 messages, at an interval of 5 seconds.
To change this, set the environment variable MessageCount to the number of messages that should be sent (set it to -1
[Information]: Trying to initialize module client using transport type [Amqp_Tcp_Only].


Retrieved 6 line(s)

2. Review the data received by ADX


- Click your 1st browser tab where ADX is still loaded.
- Click **Query** and enter the following query. Also, click the **>>** and ensure the **tempsensor** database scope is selected.



```
tempsensor
| order by timeCreated desc
| limit 10
```

deciotacadjohnd220427 | Query  ...
Azure Data Explorer Cluster

Search (Ctrl+)

Overview
Activity log
Access control (IAM)
Tags
Diagnose and solve problems
Query

deciotacadjohnd2...  +

Open in Web UI   Run @deciotacadjohnd220427.eas...

Filter...

deciotacadjohnd2204...
▼ **tempsensor**
 > tempsensor

1 tempsensor
2 | order by timeCreated desc
3 | limit 10

- Click the **Run** button. If you're used to SQL don't press F5 as it will refresh your browser.

Table 1			
Stats			
Search			
Done (0.115 s)			
	timeCreated	temperature	humidity
>	2022-04-15 03:19:48.0580	21.218185964...	24
>	2022-04-15 03:19:43.0330	21.403753288...	26
>	2022-04-15 03:19:38.0110	20.953964428...	24
>	2022-04-15 03:19:32.9880	20.757084664...	24
>	2022-04-15 03:19:27.9650	20.723877524...	24

Exercise 7: Processing Telemetry with Azure Stream Analytics (ASA)

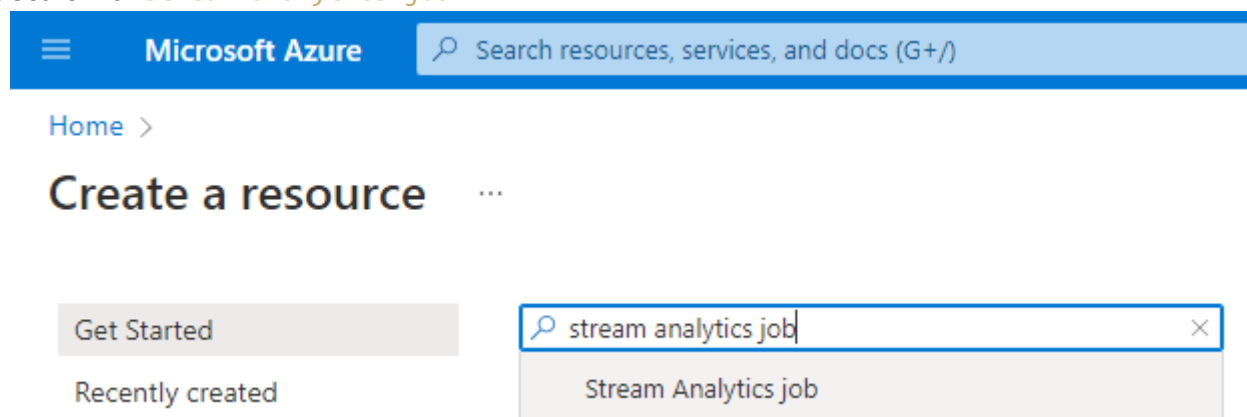
Task 1: Create a Table in ADX to Hold aggregated data

- In another Edge tab navigate to your ADX resource.
- Create a new table named `tempsensoragg` in the `tempsensor` database. Reference Exercise 5 - Task 3 if help is needed.

```
.create table tempsensoragg (WindowEnd: datetime, AverageTemperature: real)
```

Task 2: Create a new ASA Job

- Go to the Azure Portal home page
- Click **Create a resource**
- Search for `stream analytics job`




- Click **Stream Analytics job**
- Click **Create**
- Enter the details for the job:
 - Job name: `asajob-tempagg`

- Resource group: **rg-iot-academy**
- Location: **East US 2**
- Hosting environment: **Cloud**
- Streaming units: **1**

[Home](#) > [Create a resource](#) > [Stream Analytics job](#) >

New Stream Analytics job ...

 This will create a new Stream Analytics job. You will be charged according to Azure Stream

Job name *

asajob-tempagg ✓

Subscription *

Visual Studio Enterprise Subscription ▼

Resource group *

rg-iot-academy ▼

[Create new](#)

Location *

East US 2 ▼

Hosting environment ⓘ

Cloud

Edge

Streaming units (1 to 192) ⓘ



3



Secure all private data assets needed by this job in my Storage account. ⓘ

Create

7. When the deployment is complete click **Go to resource**

Task 3: Creating an ASA Input

- In another Edge tab navigate to your IoT Hub resource.
- Create a new consumer group named **asa**. Reference Exercise 5 - Task 4 if help is needed.
- Go back to your tab that has your ASA instance.

- Click **Inputs**, Click **Add stream input**, Click **IoT Hub**

The screenshot shows the Microsoft Azure portal interface for a Stream Analytics job named 'asa-abtest1'. The left-hand navigation pane includes sections for 'Overview', 'Activity log', 'Access control (IAM)', 'Tags', 'Diagnose and solve problems', 'Settings' (with sub-items 'Properties' and 'Locks'), and 'Job topology'. Under 'Job topology', the 'Inputs' option is selected and highlighted with a red rectangular box. The main content area displays the 'asa-abtest1 | Inputs' page. At the top of this area is a search bar and a '+ Add stream input' button. This button has been clicked, resulting in a dropdown menu that lists three input types: 'Blob storage/ADLS Gen2', 'Event Hub', and 'IoT Hub'. The 'IoT Hub' option is highlighted with a red rectangular box.

IoT Hub

New input

Input alias *

vscodeiothub

☐ Provide IoT Hub settings manually

☒ Select IoT Hub from your subscriptions

Subscription

Visual Studio Enterprise Subscription

IoT Hub * ⓘ

iot-academy-johndoe-vscode-220427

Consumer group * ⓘ

asa

Shared access policy name * ⓘ

iothubowner

Shared access policy key ⓘ

.....

Endpoint ⓘ

Messaging

Save

- Enter the input details:

Task 4: Creating an ASA Output

1. Click **Outputs**

2. Click **Add**, then click **Azure Data Explorer**

The screenshot shows the Microsoft Azure portal interface for configuring a Stream Analytics job named 'asajob-tempagg'. The left sidebar contains navigation options: Overview, Activity log, Access control (IAM), Tags, Diagnose and solve problems, Settings (Properties, Locks), Job topology (Inputs, Functions, Query, and Outputs, which is highlighted with a red box). The main area shows the 'Outputs' configuration for the job. At the top, there is a search bar and buttons for 'Add' (highlighted with a red box) and 'Refresh'. A dropdown menu is open from the 'Add' button, listing various sinks: Azure Data Explorer (Preview) (highlighted with a red box), Azure Function, Azure PostgreSQL (preview), Azure Synapse Analytics, Blob storage/ADLS Gen2, Cosmos DB, Data Lake Storage Gen1, Event Hub, Power BI, Service Bus queue, Service Bus topic, SQL Database, and Table storage. To the right of the dropdown, the word 'Sink' is visible.

3. Enter the details as shown below:

- Output alias: `adx`
- Cluster: your cluster created earlier
- Database: your database created earlier
- Table: `tempsensoragg`

Azure Data Explorer (Preview) ×

New output

Output alias *

adx

- ☐ Provide Azure Data Explorer settings manually
- ☒ Select Azure Data Explorer from your subscriptions

Subscription

Visual Studio Enterprise Subscription

Cluster *

deciotacadjohnd220427

Database *

deciotacadjohnd220427/tempsensor

Authentication mode

Create system assigned managed identity

The Monitor and Ingestor role will be granted to the Managed Identity for this Stream Analytics job when you click Save. If grant fails follow the manual grant steps [here](#).

Table *

tempsensoragg

Save

4. Click **Save**

Task 5: Writing an ASA Query

1. Click **Query**
2. Copy and paste the query below into the query window

```
SELECT System.Timestamp() AS WindowEnd, avg(ambient.temperature)
AverageTemperature
INTO adx
FROM vscodeiothub
GROUP BY TumblingWindow(Duration(minute, 1))
```

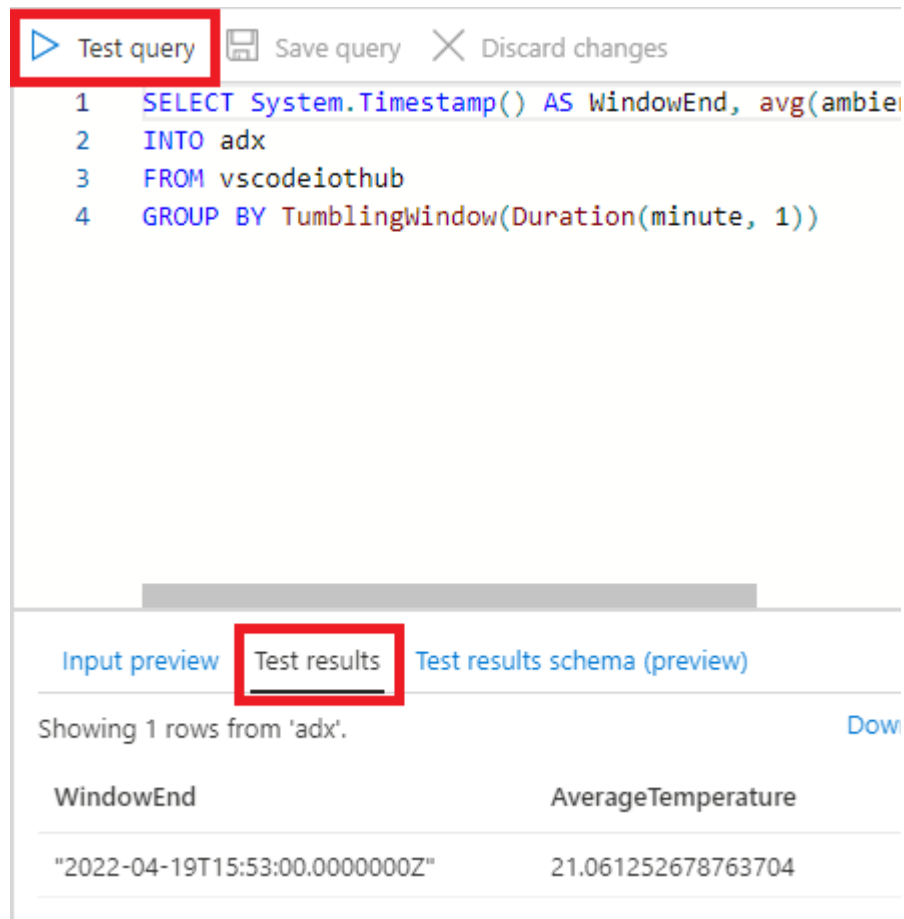
3. Click **Save query**

The screenshot shows the Azure Stream Analytics Query Editor interface. The breadcrumb navigation at the top reads 'Home > Stream Analytics jobs > asajob-tempagg'. The main title is '<> asajob-tempagg | Query' with a subtitle 'Stream Analytics job'. Below the title is a search bar and a row of links: 'Query language docs', 'Open in Visual Studio', and 'Share feedback'. The left sidebar contains a navigation menu with sections: 'Overview' (with links to Activity log, Access control (IAM), Tags, and Diagnose and solve problems), 'Settings' (with links to Properties and Locks), 'Job topology' (with links to Inputs, Functions, and Query), and 'Query' (which is currently selected). The main workspace is divided into three panes. The top pane shows the job topology with 'Inputs (1)' containing 'vscodeiothub' and 'Outputs (1)' containing 'adx'. The middle pane displays a SQL query:

```
1 SELECT System.Timestamp() AS WindowEnd, avg(am
2 INTO adx
3 FROM vscodeiothub
4 GROUP BY TumblingWindow(Duration(minute, 1))
```

 The bottom pane has tabs for 'Input preview', 'Test results', and 'Test results schema (preview)'. The 'Input preview' tab is active, showing a message: 'This input has not been created. Upload a sample file to preview data as'. Below this message are controls for 'Table', 'Raw', 'Upload sample input', and 'Download'.

4. In another Edge tab navigate to your IoT Hub Instance
5. Reset the **SimulatedTemperatureSensor** module as described in Exercise 6 Task 1 to ensure telemetry being sent
6. Now back to your asa job, in the other open Edge tab
7. Click **Test Query**
8. Review the results in the output under the **Test Results** tab



The screenshot shows the Azure Stream Analytics query editor. At the top, there is a toolbar with a play button labeled "Test query" (highlighted with a red box), a save icon labeled "Save query", and a close icon labeled "Discard changes". Below the toolbar, the SQL query is displayed:

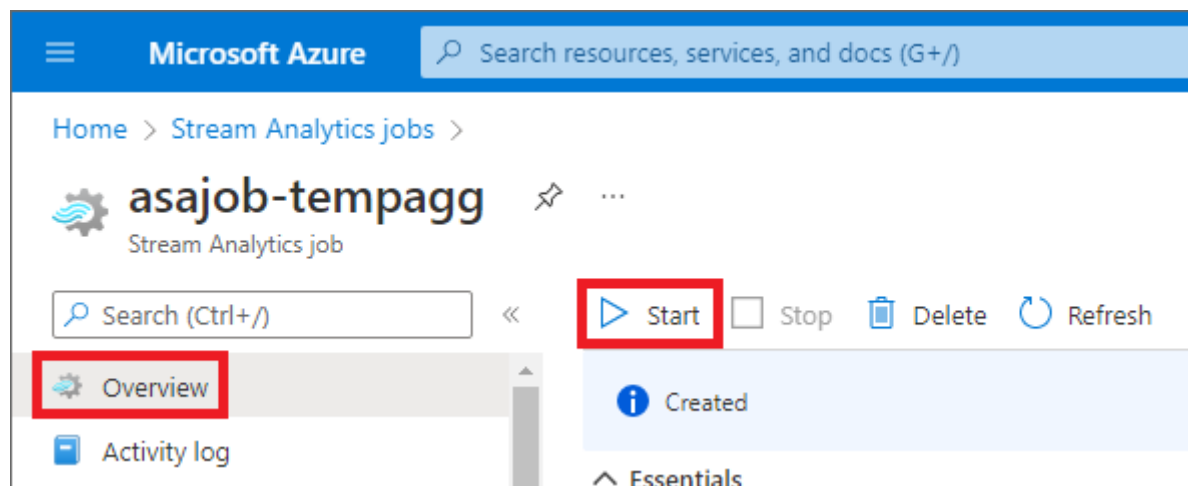
```
1 SELECT System.Timestamp() AS WindowEnd, avg(ambie
2 INTO adx
3 FROM vscodeiothub
4 GROUP BY TumblingWindow(Duration(minute, 1))
```

Below the query editor, there are three tabs: "Input preview", "Test results" (highlighted with a red box), and "Test results schema (preview)". The "Test results" tab shows "Showing 1 rows from 'adx'." and a "Download" link. Below this, a table displays the results:

WindowEnd	AverageTemperature
"2022-04-19T15:53:00.0000000Z"	21.061252678763704

Task 6: Start the ASA Job

1. Go to the **Overview** tab
2. Click **Start**



The screenshot shows the Microsoft Azure portal interface. At the top, there is a search bar labeled "Search resources, services, and docs (G+/)". Below the search bar, the breadcrumb navigation shows "Home > Stream Analytics jobs >". The main heading is "asajob-tempagg" with a gear icon and a dropdown menu. Below the heading, there is a search bar labeled "Search (Ctrl+ /)" and a set of action buttons: "Start" (highlighted with a red box), "Stop", "Delete", and "Refresh". On the left side, there is a sidebar with two tabs: "Overview" (highlighted with a red box) and "Activity log". The "Overview" tab is selected, and the "Start" button is highlighted with a red box.

Start job

asajob-tempagg

Streaming units ⓘ
1







Environment ⓘ
Standard

Job output start time ⓘ
Now Custom

Start


3. Click **Start** once more

4. Watch the notification to ensure that the ASA job starts successfully.




Notifications

[More events in the activity log →](#) [Dismiss all](#) ▼



Streaming job started successfully.
Started Streaming job 'asajob-tempagg' successfully.
a few seconds ago



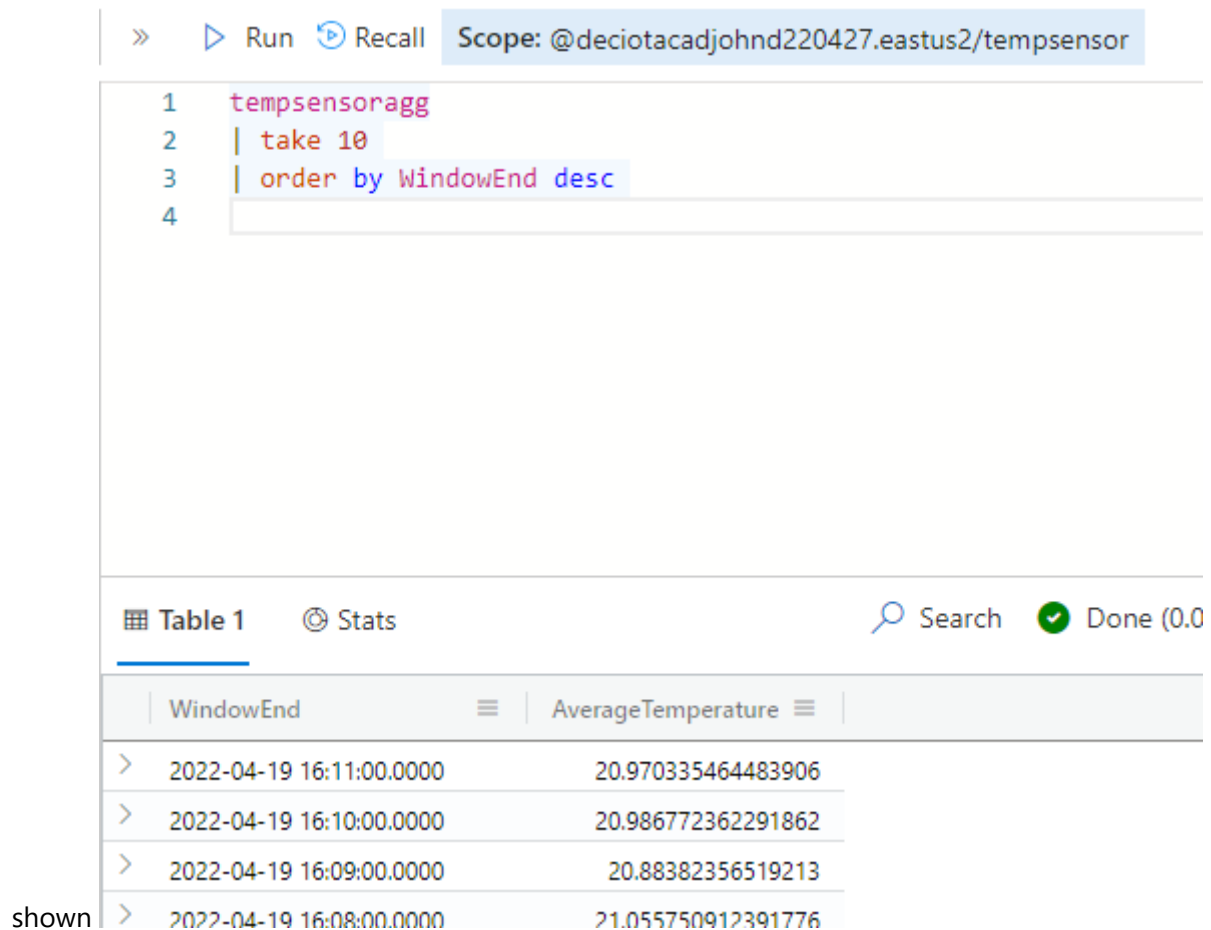
Task 7: Review Collected Aggregated in ADX

1. Navigate to your ADX resource in another Edge tab
2. Click **Query**
3. Enter the query below

```
tempsensoragg  
| take 10  
| order by WindowEnd desc
```

4. Click **Run**

5. Continue clicking **Run** occasionally for 10 - 15 minutes until you see your data appear in the results as



The screenshot shows the Azure Data Explorer interface. At the top, there are buttons for 'Run' and 'Recall', and a 'Scope' dropdown set to '@deciotacadjohnd220427.eastus2/tempsensor'. Below this is a query editor with the following SQL query:

```
1 tempsensoragg
2 | take 10
3 | order by WindowEnd desc
4
```

Below the query editor, there is a table view labeled 'Table 1' with a 'Stats' icon. The table has two columns: 'WindowEnd' and 'AverageTemperature'. The results are as follows:

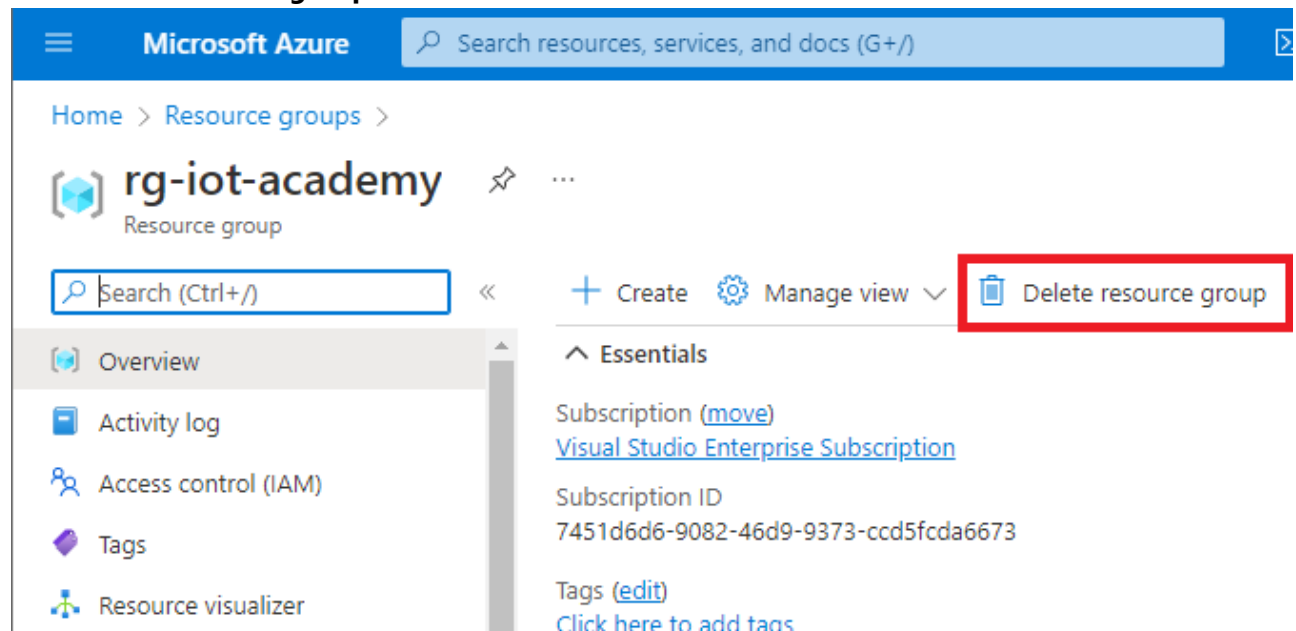
WindowEnd	AverageTemperature
2022-04-19 16:11:00.0000	20.970335464483906
2022-04-19 16:10:00.0000	20.986772362291862
2022-04-19 16:09:00.0000	20.88382356519213
2022-04-19 16:08:00.0000	21.055750912391776

The word 'shown' is written to the left of the last row of the table.

Exercise 8: Cleanup

It's important to not leave your Azure resources provisioned until the next Azure IoT Academy session as there may not be enough Azure credit for the next sessions.

1. Navigate to the Azure Portal home page
2. Click **Resource groups**
3. Click **rg-iot-academy**
4. Click **Delete resource group**



The screenshot shows the Azure Portal interface. The top navigation bar includes the 'Microsoft Azure' logo and a search bar. The breadcrumb trail shows 'Home > Resource groups >'. The main content area displays the 'rg-iot-academy' resource group. On the right side, there is a 'Delete resource group' button, which is highlighted with a red rectangle. Below this button, there is a section titled 'Essentials' containing information about the subscription, including the 'Subscription ID' (7451d6d6-9082-46d9-9373-ccd5fcda6673) and a link to 'Click here to add tags'.

