Program 3: Container Orchestration with Kubernetes:

- **Tool**: Kubernetes
- **Program**:
    - Set up a Kubernetes cluster (use Minikube or a cloud provider).
    - Deploy a sample application using a Deployment and Service.
    - Scale the application using kubectl scale.

1. Set up a Kubernetes cluster useing Minikube:

Prerequisites:

- Docker Desktop installed and running.
- Windows 10/11 (PowerShell or CMD is fine)

Manual Install

- Download Minikube for Windows:
  https://github.com/kubernetes/minikube/releases/latest
- Download minikube-windows-amd64.exe
  Rename it to minikube.exe
- Add it to a folder in your system's PATH
  (e.g., C:\tools\minikube\ and add that to environment variables > PATH)

Start Minikube Using Docker:
Once installed, start it using Docker as the driver:
Open PowerShell as Administrator. Run the following command in powershell

- **minikube start --driver=docker**

See it download the base image and initialize the cluster.
Verify its working: Check the status:

- **minikube status**

Check cluster:

- **kubectl get nodes**

You should see a node named minikube in the Ready state.

What is Kubernetes?

Kubernetes ("K8s") is an open-source platform that helps you:

- Run, Manage, Scale, Update your containerized applications automatically.

Why do people use Kubernetes?

Python web app in a Docker container.

Without Kubernetes:

- manually start containers
- monitor them yourself
- If they crash, you restart them manually
- figure out how to load balance traffic
- handle deployments by hand

With Kubernetes:

- It runs multiple copies (pods) of your app
- It restarts them if they crash
- It scales up/down based on traffic
- It load balances requests
- It updates apps with zero downtime (rolling updates)
- It manages configs & secrets securely

Key Concepts

Term	What It Is
Pod	The smallest unit – runs one or more containers
Deployment	Defines how many pods to run and how to manage them
Service	A stable IP or name to access your app (load balancing)
ConfigMap	Stores non-sensitive config (env vars)
Secret	Stores sensitive data (passwords, API keys)
Node	A worker machine (VM or physical) that runs pods
Cluster	A group of nodes controlled by Kubernetes

Deploy a sample application using a Deployment and Service.

In terminal (PowerShell or CMD): type

- **minikube start**

Verify with:

- **minikube status**

Create a simple Pod YAML

Let's make a pod that runs a basic NGINX container.

Save this as pod.yaml:

```
apiVersion: v1
kind: Pod
metadata:
  name: my-nginx
spec:
  containers:
    - name: nginx
      image: nginx:latest
      ports:
        - containerPort: 80
```

Apply the pod YAML

- Run: **kubectl apply -f pod.yaml**

Check if it's running:

- **kubectl get pods**

You should see:

```
NAME       READY   STATUS    RESTARTS   AGE
my-nginx   1/1     Running   0          <time>
```

Access the **pod (for web apps).You can access it inside the cluster:**

- **kubectl get pods -o wide** (it displays complete information about the each running pods)

```
PS C:\Users\Admin\Desktop\p4\app1> kubectl get pods -o wide
NAME                          READY   STATUS    RESTARTS   AGE    IP           NODE       NOMINATED NODE   RE
ADINESS GATES
hw-deployment-9dcf4b4d6-4zwdb   1/1     Running   0          2m7s   10.244.0.88  minikube   <none>           <n
one>
hw-deployment-9dcf4b4d6-crl4m   1/1     Running   0          36m    10.244.0.86  minikube   <none>           <n
one>
hw-deployment-9dcf4b4d6-tpwkj   1/1     Running   0          36m    10.244.0.87  minikube   <none>           <n
one>
nginx                         1/1     Running   0          59m    10.244.0.81  minikube   <none>           <n
one>
PS C:\Users\Admin\Desktop\p4\app1>
```


- **minikube ssh** -□ it will login into the minikube cluster

Then use:

- **curl <nginx ip-address>** to See the NGINX welcome page inside the cluster.

Create a Kubernetes Deployment and Service for a simple Python web application (like Flask) running in Minikube.

Sample Python App (Flask)

```
from flask import Flask

app = Flask(__name__)

@app.route('/')
def hello():
    return "Hello from App 1!! Kubernetes, also known as K8s,is an open source system for automating deployment, scaling, and management of containerized applications"

if __name__ == '__main__':
    app.run(host='0.0.0.0', port=5000)
```

requirement.txt

flask==3.0.0

Dockerfile:

```
FROM python:3.12-slim
WORKDIR /app
COPY requirements.txt .
RUN pip install --no-cache-dir -r requirements.txt
COPY app.py .
EXPOSE 5000
CMD ["python", "app.py"]
```

Build and Push Docker Image

Make sure Docker is running.Then build:

- **docker build -t chethanaravi/app1-k8s:latest .**
- **docker push chethanaravi/app1-k8s:latest**

Now the image is locally available inside Minikube.

Kubernetes Deployment (deployment.yaml)

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: hw-deployment
spec:
  replicas: 2
  selector:
    matchLabels:
      app: hello-world
  template:
    metadata:
      labels:
        app: hello-world
    spec:
      containers:
      - name: hw-container
        image: chethanaravi/app1-k8s:latest
```

```
    ports:
    - containerPort: 5000
```

Kubernetes Service (service.yam0l)

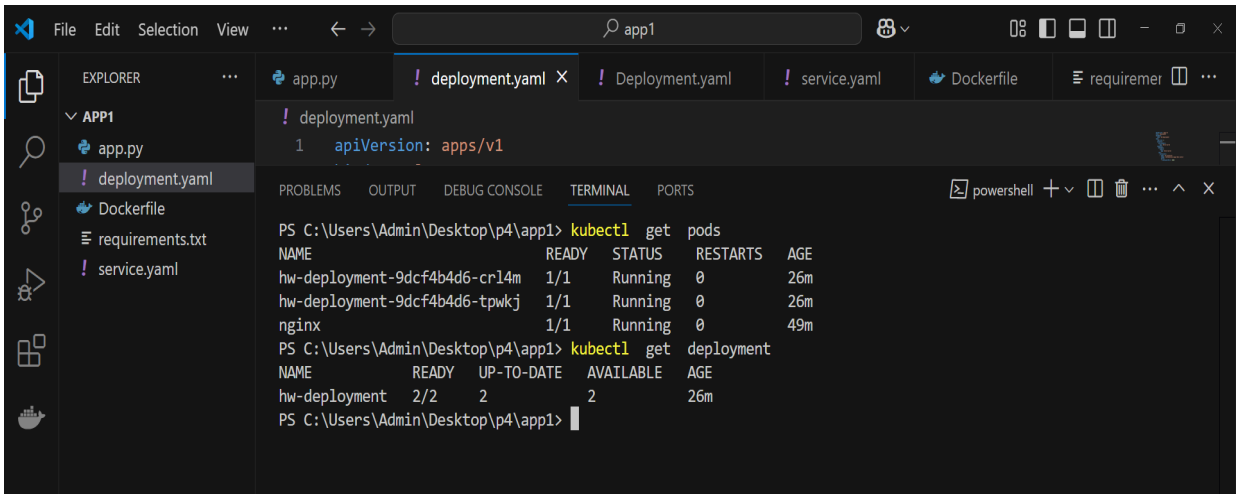
```
apiVersion: v1
kind: Service
metadata:
 name: hello-world
spec:
 type: NodePort
 selector:
  app: hello-world
 ports:
  - port: 5000
    targetPort: 5000
```

This makes your app accessible via NodePort on port 30005. Apply the Manifests

- **kubectl apply -f deployment.yaml**
- **kubectl apply -f service.yaml**

Verify:

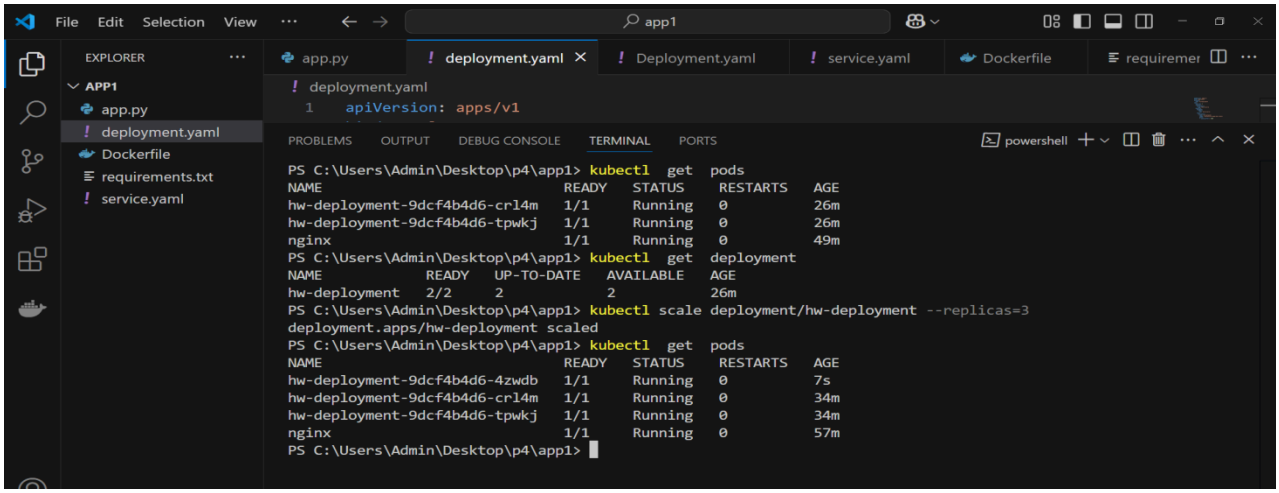
- **kubectl get pods**
- **kubectl get svc**



Replicating pods in Kubernetes is easy using **Deployments**. This is to tell Kubernetes how many **replicas** (copies) of your pod you want.

Syntax:

- **kubectl scale deployment <deployment-name> --replicas=<number>**
- **Example: kubectl scale deployment/hw-deployment --replicas=3**

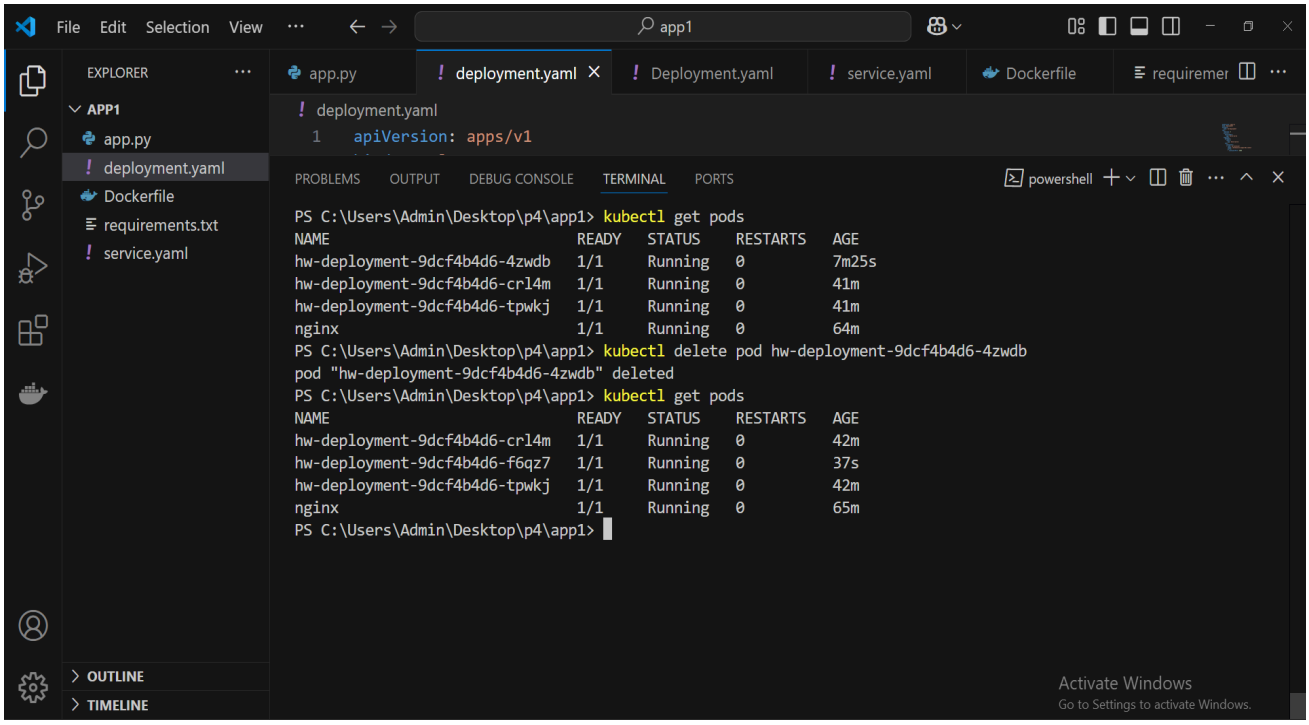


To see how many replicas are running:

- **kubectl get deployment**
- **kubectl get pods**

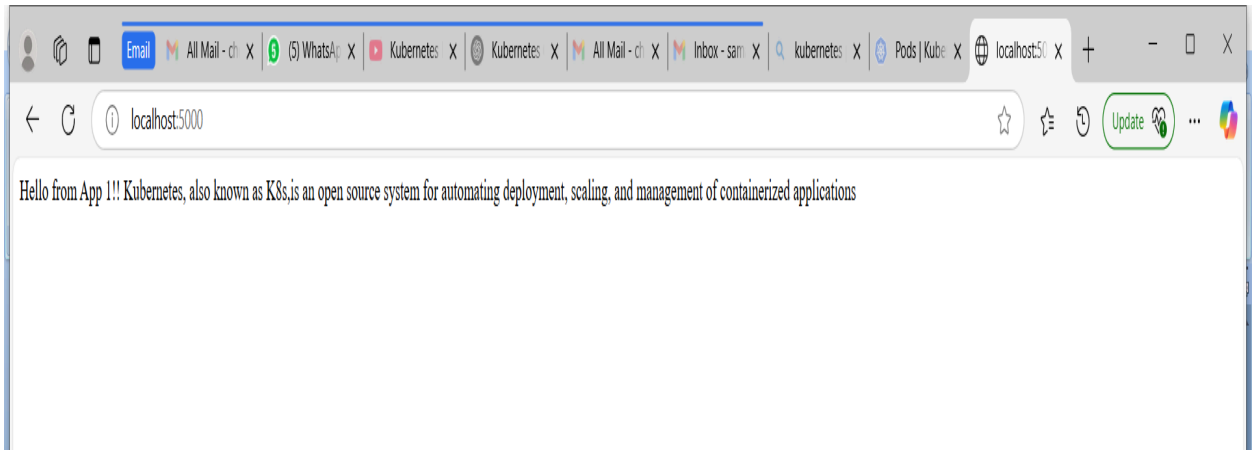
Output:

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
hw-deployment	3/3	3	3	5m



Forwards container port 5000 to host port 5000

- **kubectl port-forward svc/hello-world 5000:5000**
- **Goto browser and type http://localhost:5000**



Simple Python application in Kubernetes using **ConfigMap** and **Secret**.

- Python App (app.py)

```
from flask import Flask
import os

app = Flask(__name__)

@app.route('/')
def index():
    app_env = os.getenv("APP_ENV", "not set")
    db_password = os.getenv("DB_PASSWORD", "not set")
    return f"APP_ENV: {app_env} <br> DB_PASSWORD: {db_password}"

if __name__ == '__main__':
    app.run(host='0.0.0.0', port=5000)
```

- Dockerfile

```
        FROM python:3.9-slim
```

```
WORKDIR /app
COPY app1.py .
RUN pip install flask
CMD ["python", "app1.py"]
```

- **Kubernetes Deployment (deployment.yaml)**

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: python-app
spec:
  replicas: 1
  selector:
    matchLabels:
      app: python-app
  template:
    metadata:
      labels:
        app: python-app
    spec:
      containers:
        - name: app-container
          image: chethanaravi/python-app:latest
          ports:
            - containerPort: 5000
          env:
            - name: APP_ENV
              valueFrom:
                configMapKeyRef:
                  name: my-config
                  key: APP_ENV
            - name: DB_PASSWORD
              valueFrom:
                secretKeyRef:
                  name: my-secret
                  key: DB_PASSWORD
```

- Service.yaml

```
apiVersion: v1
kind: Service
```

```
metadata:
  name: python-service
spec:
  type: NodePort
  selector:
    app: python-app
  ports:
    - protocol: TCP
      port: 80
      targetPort: 5000
      nodePort: 30005
```

- ConfigMap.yaml

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: my-config
data:
  APP_ENV: production
```

- Secret.yaml

```
apiVersion: v1
kind: Secret
metadata:
  name: my-secret
type: Opaque
stringData:
  DB_PASSWORD: mypassword123
```

Build and Push Docker Image

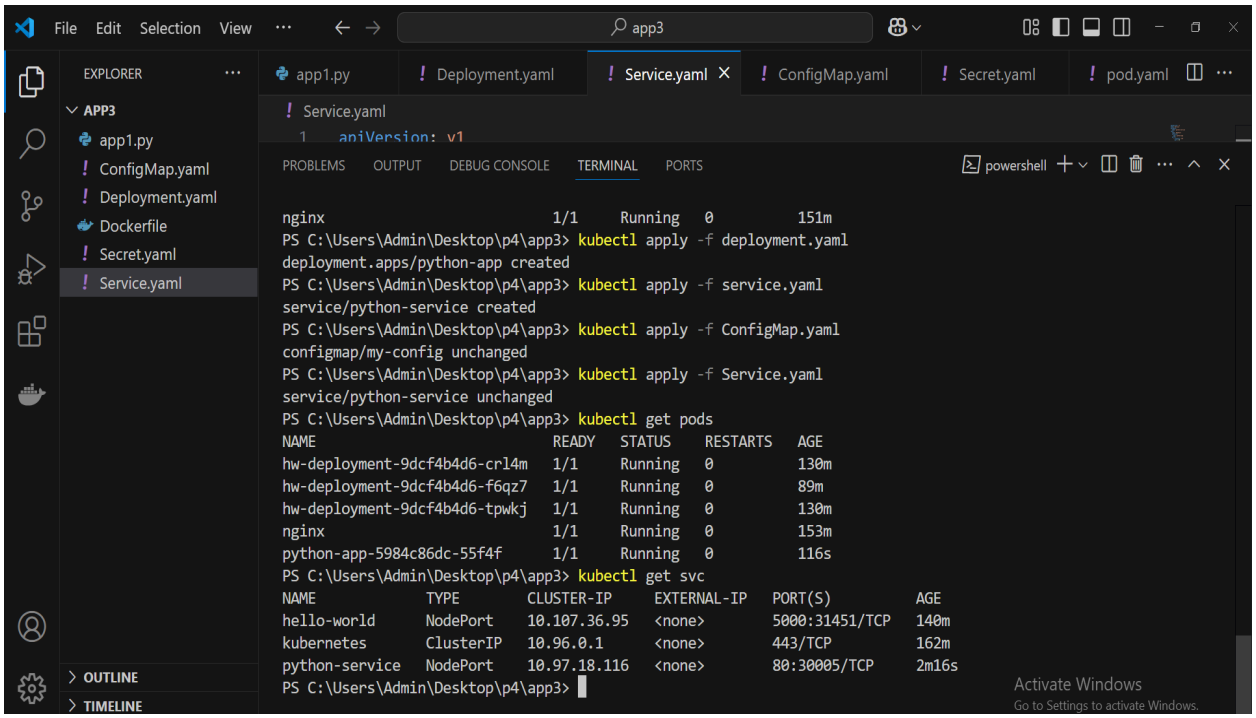
- **docker built -t python-app .**
- **docker built -t chethanaravi/python-app:latest**

Apply Everything

- **kubectl apply -f configmap.yaml**
- **kubectl apply -f secret.yaml**
- **kubectl apply -f deployment.yaml**
- **kubectl apply -f service.yaml**

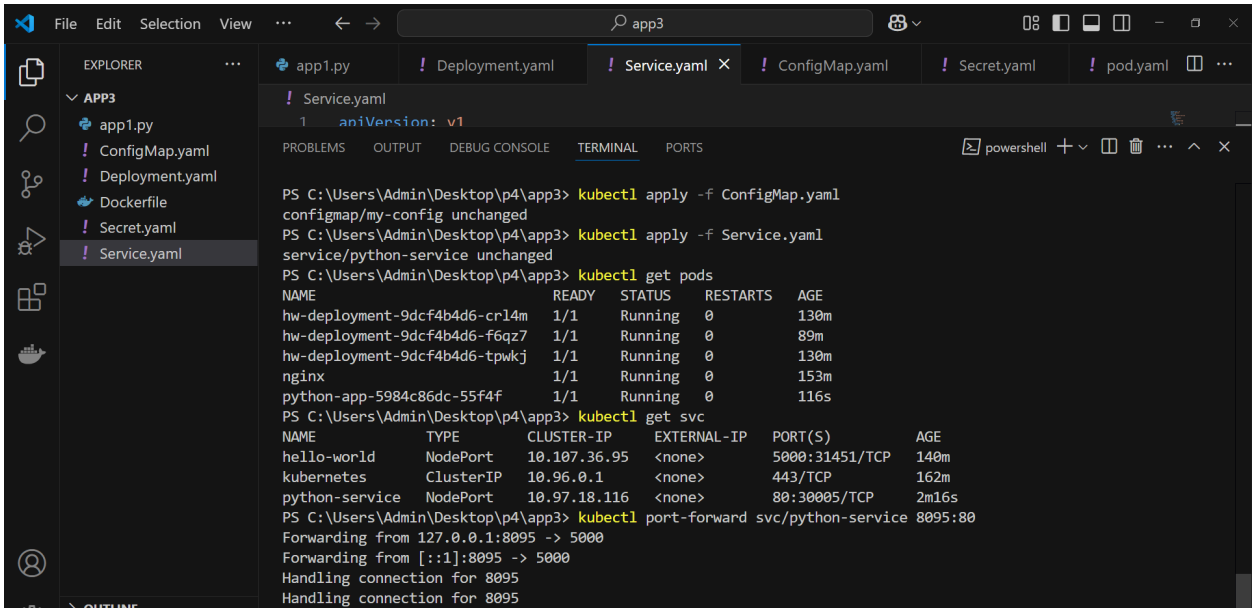
Check the Pod and Service Status

- **kubectl get pods**
- **kubectl get svc**

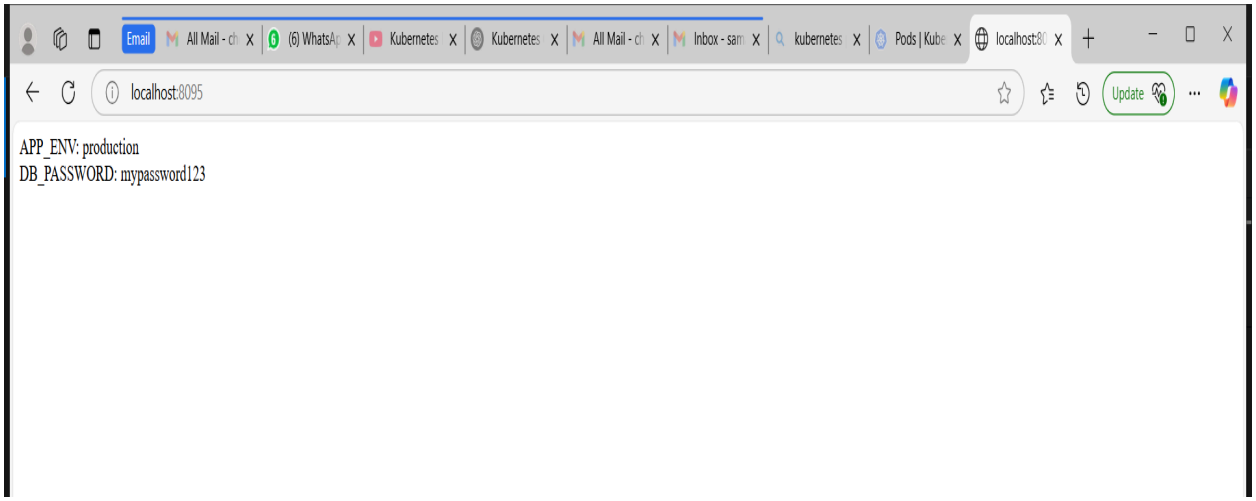


Port Forwarding

- **kubectl port-forward svc/python-service 8095:80**
- **http://localhost:8095**



This bypasses NodePort and goes directly to the service inside the cluster.



Note:

- Delete All Pods in the Current Namespace (usually default):

kubectl delete pods --all

- Delete Everything (Pods, Deployments, Services, etc.)

kubectl delete all --all

- Prevent Pods from Coming Back

kubectl delete deployment <deployment-name> / kubectl delete deployments --all