# SPE Miniproject Report

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## Quick links

- Github Repo
- Docker image on Dockerhub

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## Problem statement

**Problem Statement**

Create a scientific calculator program with the following user menu driven operations:

- Square root function - $\sqrt{x}$
- Factorial function - x!
- Natural logarithm (base e) - ln(x)
- Power function - $x^b$

More details about the problem statement can be found in this document.

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## What is DevOps?

DevOps is a **software development and IT operations methodology** that aims to improve **collaboration, automation, and efficiency** in the software delivery process. It integrates **development (Dev)** and **operations (Ops)** teams to enable **continuous integration, continuous delivery (CI/CD), faster releases, and better reliability**.

### Key Principles of DevOps:

1. **Collaboration** – Breaking silos between development and operations.
2. **Automation** – Automating testing, deployment, and infrastructure management.
3. **Continuous Integration & Deployment (CI/CD)** – Frequent code integration and automated deployment.
4. **Monitoring & Feedback** – Real-time tracking of system health and user feedback.
5. **Security (DevSecOps)** – Integrating security practices throughout the pipeline.

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### Why DevOps?

Traditional software development models (like **Waterfall**) often suffer from **slow deployments, miscommunication, and inefficient workflows**. DevOps addresses these issues by:

1. **Faster Time-to-Market** – Automated pipelines enable quick releases.
2. **Improved Software Quality** – Continuous testing ensures fewer bugs in production.
3. **Greater Scalability & Reliability** – Cloud-native DevOps practices enhance performance.
4. **Better Collaboration** – Developers and IT teams work together seamlessly.

5. **Cost Efficiency** – Reduces manual efforts, downtime, and operational costs.

DevOps is **crucial** in modern **cloud computing, microservices, and AI-driven applications**, ensuring agility and efficiency in software delivery.

**DevOps = Speed + Quality + Reliability!**

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## Tools used

- **Git**
    - This is a distributed VCS; we used GitHub issues and commits to track the progress of changes made to files.
- **Docker**
    - This is a containerization platform that packages projects into lightweight containers.
- **Ansible**
    - This is a configuration management tool that automates deployment and infrastructure management.
- **Jenkins**
    - This is a CI/CD automation tool that helps automate build, test, and deployment pipelines.
- **Python**
    - The primary programming language used to build the scientific calculator application.
- **FastAPI**
    - A high-performance web framework for building APIs, used to serve the calculator functionalities.
- **Shell Scripting**
    - Used for automating routine deployment and system configuration tasks.
- **Homebrew**
    - A package manager for macOS, used to install dependencies like Docker.

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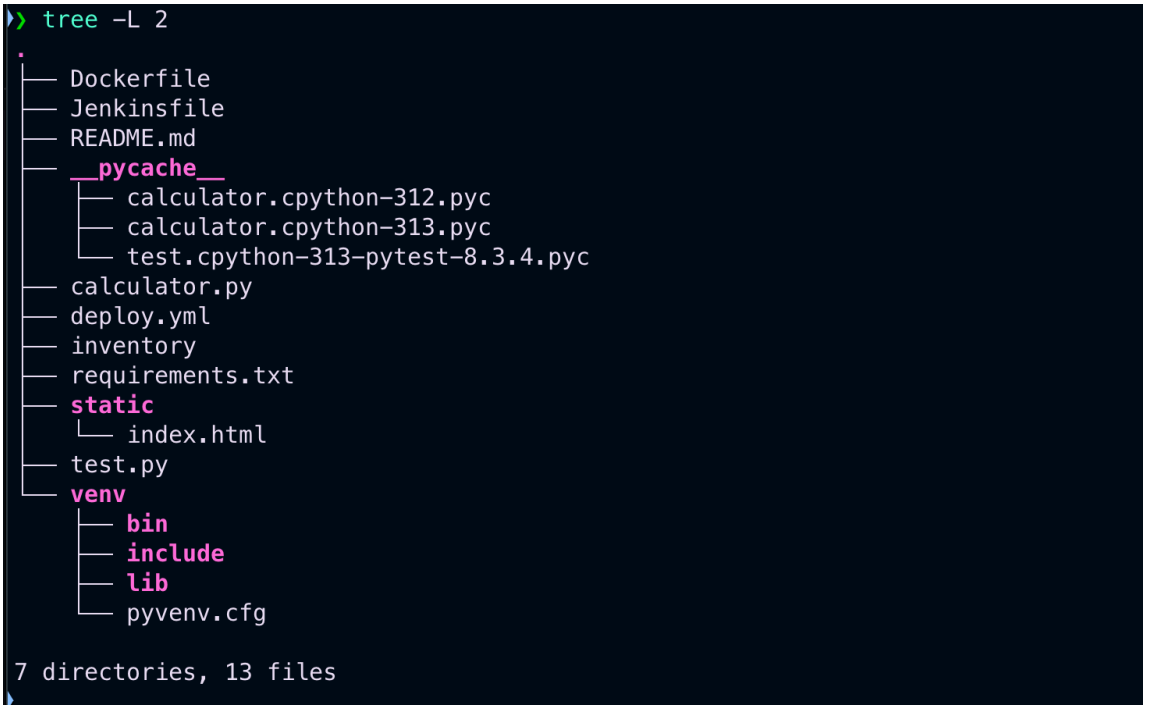
## Project structure




**Root Files**

- **Dockerfile** - Defines instructions for building a Docker image.
- **Jenkinsfile** - Specifies CI/CD pipeline steps for Jenkins automation.
- **README.md** - Documentation file explaining the project setup and usage.

**Source Code & Logic**

- **calculator.py** - Main script containing the scientific calculator logic.
- **test.py** - Test script for verifying functionality (probably using `pytest`).

**Deployment & Automation**

- **deploy.yml** - Ansible playbook for automated deployment.
- **inventory** - Ansible inventory file listing target servers.

**Dependencies**

- **requirements.txt** - Lists Python dependencies required for the project.

**Frontend Files**

- **static/** - Contains static web files for the frontend.
  - **index.html** - The HTML file for the web-based calculator UI.

**Virtual Environment**

- **venv/** - Virtual environment for managing Python dependencies.
  - **bin/** - Contains executables and scripts for the virtual environment.
  - **include/** - C header files for compiling Python packages.
  - **lib/** - Installed Python libraries.
  - **pyvenv.cfg** - Configuration file for the virtual environment.

**Compiled Files (Ignored in Version Control)**

- **pycache/** - Stores compiled Python bytecode files for faster execution.

- `calculator.cpython-312.pyc`
- `calculator.cpython-313.pyc`
- `test.cpython-313-pytest-8.3.4.pyc`

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## Project Overview

This project follows a well-structured approach to **development, deployment, and automation**:

#### Development & Testing

- The core logic is in `calculator.py`, and `test.py` ensures correctness.
- A virtual environment (`venv/`) isolates dependencies.

#### Automation & Deployment

- **Jenkins** automates CI/CD pipelines via `Jenkinsfile`.
- **Ansible** manages deployment with `deploy.yml` and `inventory`.

#### Containerization

- The `Dockerfile` ensures a portable and reproducible environment.

#### User Interface

- The **web-based frontend** is in `static/index.html`.

This structured approach ensures **scalability, efficiency, and automation** in software development.

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## Code snippets

```python
@app.get("/")
def home():
    return
FileResponse("static/index.html")

@app.get("/sqrt/{x}")
def square_root(x: float):
    return {"result": math.sqrt(x)}


@app.get("/factorial/{x}")
def factorial(x: int):
    return {"result": math.factorial(x)}


@app.get("/ln/{x}")
def natural_log(x: float):
    return {"result": math.log(x)}


@app.get("/power/{x}/{b}")
def power(x: float, b: float):
    return {"result": math.pow(x, b)}
```

This Python code defines a simple **FastAPI-based scientific calculator** that provides various mathematical operations as API endpoints. The `@app.get` decorators define routes for different calculations:

- `/` → Serves the `index.html` file for the frontend.
- `/sqrt/{x}` → Returns the square root of `x`.
- `/factorial/{x}` → Returns the factorial of `x`.
- `/ln/{x}` → Returns the natural logarithm of `x`.
- `/power/{x}/{b}` → Computes `x` raised to the power of `b`.

Each function extracts parameters from the URL, performs the operation using Python's `math` module, and returns the result as JSON.

```python
def test_square_root():
    response = client.get("/sqrt/9")
    assert response.status_code == 200
    assert response.json()["result"] ==
3.0

def test_factorial():
    response = client.get("/factorial/5")
    assert response.status_code == 200
    assert response.json()["result"] ==
120

def test_natural_log():
    response = client.get("/ln/1")
    assert response.status_code == 200
    assert response.json()["result"] ==
0.0

def test_power():
    response = client.get("/power/2/3")
    assert response.status_code == 200
    assert response.json()["result"] ==
8.0
```

This Python code contains unit tests for a FastAPI-based scientific calculator using a test client. Each function sends a GET request to an API endpoint and verifies the response:

- **`test_square_root()`** : Checks if `/sqrt/9` returns `3.0` .
- **`test_factorial()`** : Ensures `/factorial/5` returns `120` .
- **`test_natural_log()`** : Tests if `/ln/1` returns `0.0` .
- **`test_power()`** : Verifies `/power/2/3` returns `8.0` .

Each test asserts that:

1. The API response has a **status code of `200`** .

2. The computed result matches the expected value.

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## 🛠️ Setup and Installation for local machine

**1 Clone Repository**

```
git clone https://github.com/AryanRastogi7767/Scientific_Calculator.git
```

**2 Install Dependencies**

Before running the application, install the required dependencies:

```
pip install -r requirements.txt
```

**3 Running the FastAPI Server**

Start the application using Uvicorn:

```
uvicorn calculator:app --host 0.0.0.0 --port 8000
```

The API will be available at `http://localhost:8000`.

**4 Running Tests**

To verify the API functionality, run the test suite using **pytest**:

```
pytest test.py
```

Test results will be logged in `pytest.log`.

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## Docker build and run

```
# Dockerfile
FROM python:3.9-alpine

WORKDIR /app

COPY requirements.txt ./
RUN pip install --no-cache-dir -r requirements.txt

COPY . .

CMD ["uvicorn", "calculator:app", "--host", "0.0.0.0", "--port",
"8000"]
```

This is the dockerfile that is used to generate a container with the python file. We can build the image as follows:

```
docker build -t aryan7767/scientific-calculator .
```

This will use the Dockerfile in our directory to create a docker image

It can then be run with

```
❯ docker run -d --name calculator-container -p 8000:8000 aryan7767/scientific-
calculator
```

Expose the port 8000 of the container to port 8000 of the local machine. The API will be available at `http://localhost:8000` .

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## Docker Image to DockerHub

Once the Image is built, we can push it to DockerHub to make it publically accessible.

#### 1 Docker Login

Login into docker.

```
docker login
```

#### 2 Tag the Image

```
docker tag aryan7767/scientific-calculator aryan7767/scientific-calculator:latest
```

#### 3 Push Image to DockerHub

```
docker push aryan7767/scientific-calculator:latest
```

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## Deploy Using Ansible

**Prerequisites**

- Ansible installed on your local machine
- Docker installed on the target machine
- SSH access to the target machine
- Required Ansible collections installed ( `community.docker` )

### Steps to Deploy the Container

#### 1. Set Up Ansible Environment

Ensure Ansible is using the correct Python interpreter:

```
vars:
  ansible_python_interpreter: /Users/aryanrastogi/.ansible-env/bin/python3
```

#### 2. Ensure Docker is Installed

Check if Docker is installed, and install it using Homebrew if necessary:

```
- name: Ensure Docker is installed
  command: docker --version
  register: docker_installed
  ignore_errors: yes

- name: Install Docker if not installed
  when: docker_installed.rc != 0
  block:
    - name: Install Homebrew (if needed)
      command: /bin/bash -c "$(curl -fsSL
https://raw.githubusercontent.com/Homebrew/install/HEAD/install.sh)"
      args:
        creates: /opt/homebrew/bin/brew

    - name: Install Docker using Homebrew
      command: brew install --cask docker
```

#### 3. Start Docker (if Not Running)

Ensure Docker is running before proceeding:

```
- name: Start Docker (if not running)
  shell: open -a Docker
  ignore_errors: yes

- name: Wait for Docker to be available
  command: docker info
  register: docker_status
  until: docker_status.rc == 0
```

```
  retries: 10
  delay: 5
```

#### 4. Install Required Ansible Collections

Install the `community.docker` collection:

```
- name: Install required Ansible collections
  ansible.builtin.command: ansible-galaxy collection install community.docker
```

#### 5. Pull the Latest Docker Image

Download the latest version of the scientific calculator Docker image:

```
- name: Pull the latest Docker image
  community.docker.docker_image:
    name: "aryan7767/scientific-calculator"
    source: pull
```

#### 6. Remove Existing Container (if Running)

Ensure no previous instance of the container is running:

```
- name: Remove existing container (if running)
  community.docker.docker_container:
    name: calculator-container
    state: absent
```

#### 7. Deploy the Scientific Calculator Container

Start a new container with the latest image:

```
- name: Run the container
  community.docker.docker_container:
    name: calculator-container
    image: "aryan7767/scientific-calculator:latest"
    state: started
    restart_policy: always
    ports:
      - "8000:8000" # Corrected port mapping for FastAPI
```

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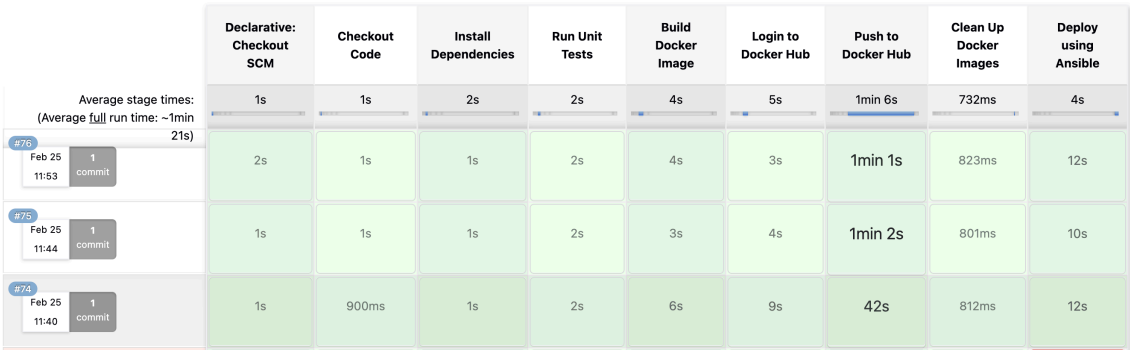
## Automated Build, Test and Deployment using Jenkins

**Stage View**



| | Declarative: Checkout SCM | Checkout Code | Install Dependencies | Run Unit Tests | Build Docker Image | Login to Docker Hub | Push to Docker Hub | Clean Up Docker Images | Deploy using Ansible |
|---|---|---|---|---|---|---|---|---|---|
| Average stage times: (Average full run time: ~1min 21s) | 1s | 1s | 2s | 2s | 4s | 5s | 1min 6s | 732ms | 4s |
| #76 Feb 25 11:53 1 commit | 2s | 1s | 1s | 2s | 4s | 3s | 1min 1s | 823ms | 12s |
| #75 Feb 25 11:44 1 commit | 1s | 1s | 1s | 2s | 3s | 4s | 1min 2s | 801ms | 10s |
| #74 Feb 25 11:40 1 commit | 1s | 900ms | 1s | 2s | 6s | 9s | 42s | 812ms | 12s |

## 1. Checkout Code

Clones the latest code from the GitHub repository.

```
stage('Checkout Code') {
    steps {
        script {
            git branch: 'main', url: "${GITHUB_REPO_URL}"
        }
    }
}
```

## 2. Install Dependencies

Sets up a Python virtual environment and installs required packages.

```
stage('Install Dependencies') {
    steps {
        sh '''
            python3 -m venv venv
            source venv/bin/activate
            python3 -m pip install --upgrade pip
            python3 -m pip install -r requirements.txt
        '''
    }
}
```

## 3. Run Unit Tests

Executes unit tests using `pytest`.

```
stage('Run Unit Tests') {
    steps {
        sh '''
            python3 -m venv venv
            source venv/bin/activate
            python3 -m pip install --upgrade pip
```

```
            python3 -m pip install -r requirements.txt
            pytest test.py --tb=short --disable-warnings
        '''
    }
}
```

### 4. Build Docker Image

Builds a Docker image for the project.

```
stage('Build Docker Image') {
    steps {
        script {
            sh 'docker --version'  // Verify Docker installation
            sh "docker build -t ${DOCKER_IMAGE_NAME} ."
        }
   }
}
```

### 5. Login to Docker Hub

Authenticates with Docker Hub using Jenkins credentials.

```
stage('Login to Docker Hub') {
    steps {
        withCredentials([usernamePassword(credentialsId: env.DOCKER_CREDENTIALS_ID,
usernameVariable: 'DOCKER_USERNAME', passwordVariable: 'DOCKER_PASSWORD')]) {
            sh '''
                echo "$DOCKER_PASSWORD" | docker login -u "$DOCKER_USERNAME" --
password-stdin
            '''
        }
    }
}
```

### 6. Push Docker Image to Docker Hub

Tags and pushes the Docker image to the repository.

```
stage('Push to Docker Hub') {
    steps {
        script {
            sh "docker tag ${DOCKER_IMAGE_NAME} ${DOCKER_TAG}"
            sh "docker push ${DOCKER_TAG}"
        }
    }
}
```

### 7. Clean Up Docker Images

Removes old Docker images to free space.

```
stage('Clean Up Docker Images') {
    steps {
        sh "docker rmi ${DOCKER_TAG} || true"  // Remove old images
        sh "docker rmi ${DOCKER_IMAGE_NAME} || true"
    }
}
```

### 8. Deploy Using Ansible

Deploys the containerized application using Ansible.

```
stage('Deploy using Ansible') {
    steps {
        sh 'ansible-playbook -i inventory deploy.yml'
    }
}
```

## Deployment Complete 🎉

The scientific calculator container is now up and running! We can access it at `http://localhost:8000`.