

# Scientific Calculator

*Mini Project Report*

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# 1 Project Overview

## 1.1 Introduction

This report documents the development and deployment pipeline of a **Scientific Calculator** application built in Java. The project demonstrates a complete software development lifecycle including continuous integration, automated testing, containerization, and infrastructure-as-code deployment strategies.

**Repository:** <https://github.com/rahul09123/SPE-Mini-Project>

```
rahulraman@Rahuls-MacBook-Air ~ % docker start calculator
calculator
rahulraman@Rahuls-MacBook-Air ~ % docker exec -it calculator sh
# java -jar app.jar
== Scientific Calculator ===
1. Addition (+)
2. Subtraction (-)
3. Multiplication (*)
4. Division (/)
5. Square Root (sqrt)
6. Factorial (x!)
7. Natural Logarithm (ln(x))
8. Power (x^y)
9. Exit
Enter your choice (1-9): 1
Enter first number: 12
Enter second number: 12
12.0000 * 12.0000 = 144.0000

== Scientific Calculator ===
1. Addition (+)
2. Subtraction (-)
3. Multiplication (*)
4. Division (/)
5. Square Root (sqrt)
6. Factorial (x!)
7. Natural Logarithm (ln(x))
8. Power (x^y)
9. Exit
Enter your choice (1-9): 8
Enter the base (x): 2
Enter the exponent (y): 4
2.0000^4.0000 = 16.0000
```

Figure 1: Scientific Calculator Application

## 1.2 Tech Stack & Objectives

**Stack:** Java 17, Maven 3, JUnit 5, Jenkins, Docker, Ansible

**Application:** Command-line scientific calculator with basic arithmetic (add, subtract, multiply, divide) and advanced functions (square root, factorial, logarithm, power) with comprehensive error handling.

# 2 Jenkins Pipeline Architecture

## 2.1 Pipeline Overview

The Jenkins pipeline automates the complete build, test, and deployment workflow. It follows a declarative pipeline approach, providing clarity and maintainability.

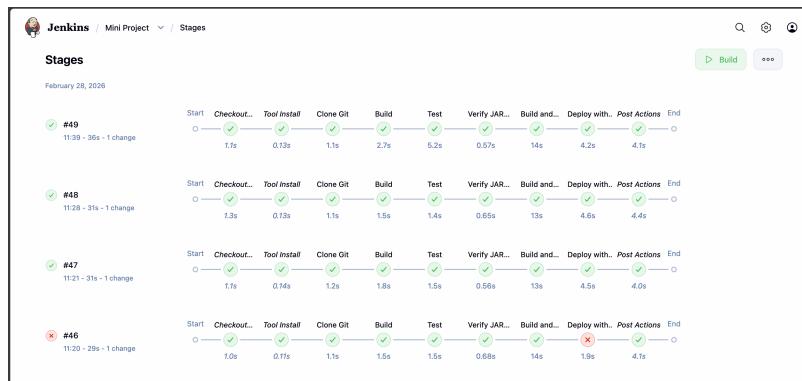


Figure 2: Jenkins Pipeline Architecture

## 2.2 Pipeline Stages

### 2.2.1 Stage 1: Clone Git

```

1 stage('Clone Git') {
2     steps {
3         script {
4             git branch: 'main',
5                 credentialsId: 'github_credentials',
6                 url: "${GITHUB_REPO_URL}"
7         }
8     }
9 }
```

Listing 1: Clone Git Stage

**Purpose:** Fetches latest source code from GitHub. Authenticates to repository and provides clean workspace for builds.

### 2.2.2 Stage 2: Build

```

1 stage('Build') {
2     steps {
3         sh 'mvn clean package -DskipTests'
4     }
5 }
```

Listing 2: Build Stage

**Purpose:** Compiles Java source and creates JAR artifact. Tests are skipped here and executed in the Test stage.

### 2.2.3 Stage 3: Test

```

1 stage('Test') {
2     steps {
3         sh 'mvn test'
4     }
5 }
```

Listing 3: Test Stage

**Purpose:** Executes 47 comprehensive unit tests using JUnit 5 and generates test reports.

### 2.2.4 Stage 4: Verify JAR Existence

```

1 stage('Verify JAR Existence') {
2     steps {
3         sh 'ls -lh target/'
4     }
5 }
```

Listing 4: Verify JAR Existence Stage

**Purpose:** Verifies successful JAR creation by listing target directory contents.

### 2.2.5 Stage 5: Build and Push Docker Image

```

1 stage('Build and Push Docker Image') {
2     steps {
3         script {
4             sh """
5                 docker buildx create --use || true
6                 docker buildx inspect --bootstrap
7
8                 docker buildx build \
9                     --platform linux/amd64,linux/arm64 \
10                    -t ${DOCKER_HUB_USERNAME}/${DOCKER_IMAGE_NAME}:latest \
11                    --push .
12             """
13         }
14     }
15 }
```

Listing 5: Docker Build Stage (Partial)

**Purpose:** Builds and pushes multi-platform Docker images (linux/amd64, linux/arm64) to Docker Hub registry.

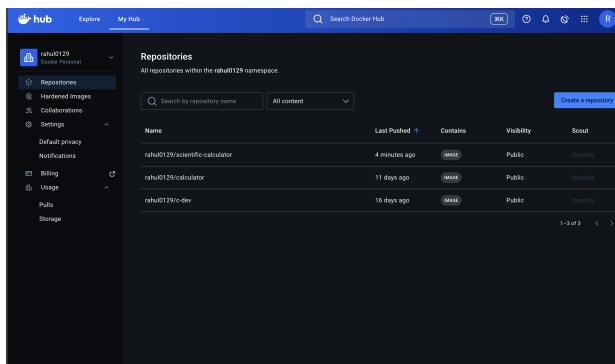


Figure 3: Docker Hub Multi-Platform Build

### 2.2.6 Stage 6: Deploy with Ansible

```

1 stage('Deploy with Ansible') {
2     steps {
3         sh 'ansible-playbook -i inventory.ini deploy.yml'
4     }
5 }
```

Listing 6: Ansible Deployment Stage

**Purpose:** Automates application deployment to target servers using Ansible playbooks.

Figure 4: Container Running and Deployed

## 2.3 Environment Variables

```

1 environment {
2     DOCKER_IMAGE_NAME = 'scientific-calculator',
3     GITHUB_REPO_URL = 'https://github.com/rahul09123/SPE-Mini-Project.git'
```

```
4     DOCKER_HUB_USERNAME = 'rahul0129'  
5     DOCKER_HOST = "unix:///Users/rahulraman/.docker/run/docker.sock"  
6 }
```

Listing 7: Environment Configuration

These variables configure: Docker image name, GitHub repository URL, Docker Hub credentials, and Docker daemon socket.

## 3 Testing and Validation

### 3.1 Test Suite Overview

The project includes 47 comprehensive unit tests covering all calculator operations. Tests are organized using JUnit 5's annotation-based approach.

### 3.2 Test Coverage

#### 3.2.1 Mathematical Operations Tested

- **Square Root:** Positive numbers, zero, decimals, negative numbers
- **Factorial:** Zero, one, positive integers (up to 20)
- **Natural Logarithm:** One, Euler's number, positive values, zero, negative values
- **Power Operations:** Base cases, decimal exponents, edge cases

#### 3.2.2 Test Sample

Tests validate: Square Root ( $\sqrt{16} = 4$ ,  $\sqrt{0} = 0$ ), Factorial ( $0! = 1$ ,  $5! = 120$ ,  $20! = 2.4 \times 10^{18}$ ), Natural Logarithm ( $\ln(1) = 0$ ,  $\ln(e) = 1$ ). Edge cases include NaN handling for negative numbers and infinity for  $\ln(0)$ . All 47 tests execute in 41 milliseconds with 100% pass rate.

## 4 Deployment Configuration

### 4.1 Ansible Deployment Playbook (deploy.yml)

The `deploy.yml` file automates container deployment to target servers using Ansible orchestration.

#### 4.1.1 Playbook Structure

```

1 - name: Pull the latest Docker image
2   shell: docker pull rahul0129/scientific-calculator:latest
3
4 - name: Stop and remove existing container
5   shell: docker rm -f calculator
6   ignore_errors: true
7
8 - name: Run calculator container (detached)
9   shell: docker run -dit --name calculator \
10    --restart unless-stopped \
11    rahul0129/scientific-calculator:latest
12
13 - name: Display container status
14   shell: docker ps -f "name=calculator"

```

Listing 8: deploy.yml Tasks

#### 4.1.2 Key Operations

- **Pull Image:** Downloads latest Docker image from Docker Hub
- **Cleanup:** Removes existing container (non-blocking with `ignore_errors`)
- **Deploy:** Launches container in detached mode with auto-restart policy
- **Verify:** Confirms successful container deployment and status

This playbook targets `webservers` host group defined in `inventory.ini`, enabling centralized deployment across multiple servers.

### 4.2 Pipeline Execution Flow

The Jenkins pipeline executes sequentially through all 6 stages: Clone (fetch code) → Build (Maven compile) → Test (JUnit 5, 47 tests) → Verify (JAR check) → Containerize (Docker multi-platform) → Deploy (Ansible).

### 4.3 Quality Assurance & Benefits

**QA Measures:** Automated testing with 47 test cases, build verification, multi-platform testing, and Infrastructure-as-Code deployment ensure reliability.

**Benefits:** Complete automation, consistency across environments, scalability to multiple servers, high portability across CPU architectures, and rapid feedback (41ms test execution time).

## 5 Conclusion

This project successfully demonstrates a complete CI/CD pipeline implementation with 100% test success (47/47 passing), fast execution (41ms), and multi-platform Docker containerization. The automated pipeline integrates Git-based version control, Maven-based Java builds, comprehensive JUnit 5 testing, multi-platform Docker image building and pushing, and Ansible-based infrastructure deployment. This comprehensive approach showcases modern DevOps practices combining continuous integration, automated testing, and infrastructure-as-code principles.

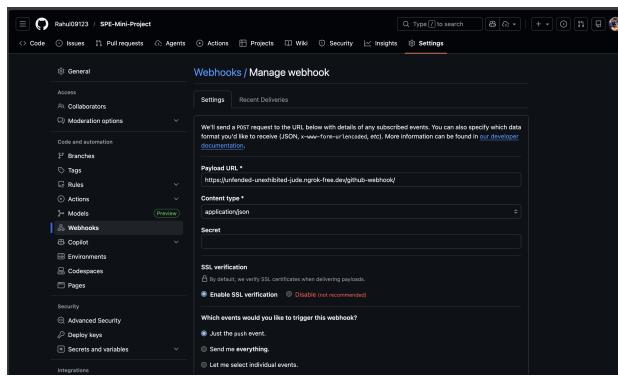


Figure 5: GitHub WebHook Configuration

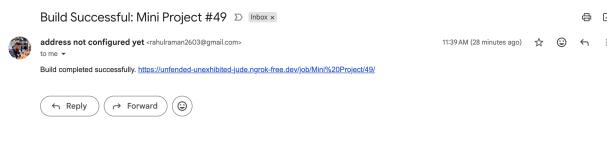


Figure 6: Email Notification on Build Status