International Institute of Information Technology Bangalore

CSE 816 - Software Production Engineering, 2025

Mini Project Report

Scientific Calculator with DevOps

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1 Introduction

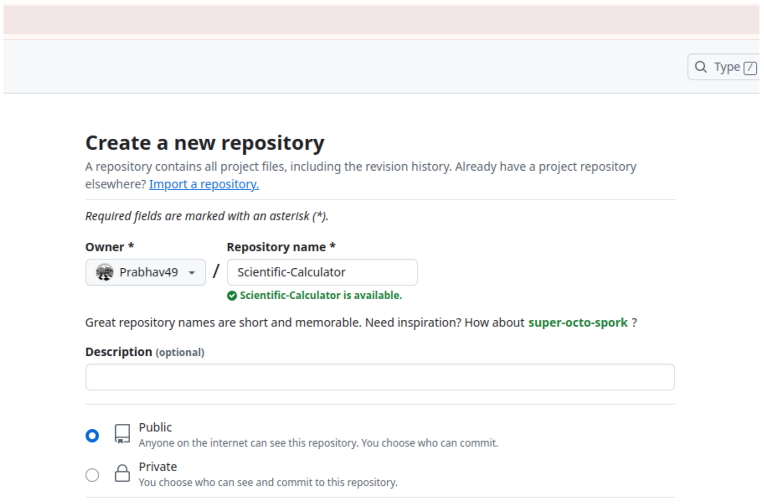
DevOps is a software engineering approach that bridges the gap between development and operations. It enables automation, collaboration, and continuous delivery, reducing manual effort and deployment failures.

2 Tools Used

- **Git and GitHub** - Git is a distributed version control system that tracks changes in source code during software development. GitHub is a web-based hosting service for Git repositories, providing collaboration features and a platform for managing and sharing code.
- **Maven** - Maven is a powerful build automation tool primarily used for Java projects. It simplifies the build process, manages dependencies, and provides a standard project structure. It handles compilation, packaging, testing, and deployment.
- **JUnit** - JUnit is a widely used unit testing framework for Java applications. It allows developers to write and run automated tests to verify the correctness of their code at the individual unit level.
- **Jenkins** - Jenkins is an open-source automation server that facilitates continuous integration and continuous delivery (CI/CD) pipelines. It automates build, test, and deployment processes, enabling frequent and reliable software releases.
- **Docker** - Docker is a platform for building, shipping, and running applications in containers. Containers allow developers to package an application and its dependencies into a standardized unit for software delivery, ensuring that the application runs consistently across different environments.
- **Docker Hub** - Docker Hub is a cloud-based registry service provided by Docker for storing and sharing Docker images. It acts as a central repository for developers to publish and retrieve pre-built images.
- **Ansible** - Ansible is an automation tool for configuration management, application deployment, and task automation. It uses a simple, agentless architecture to manage and configure systems, making it easy to automate repetitive tasks and deploy applications across multiple servers.

3 Project Setup

3.1 Creating the GitHub Repository



A repository contains all project files, including the revision history. Already have a project repository elsewhere? Import a repository.

Required fields are marked with an asterisk (*).

Owner *: Prabhav49 / Repository name *: Scientific-Calculator

Scientific-Calculator is available.

Great repository names are short and memorable. Need inspiration? How about **super-octo-spork** ?

Description (optional)

[✓ Public] Anyone on the internet can see this repository. You choose who can commit.

Private You choose who can see and commit to this repository.

Figure 1: GitHub Repository Setup

```
    git init
    git remote add origin
  https://github.com/Prabhav49/ScientificCalculator.git
    git add .
    git commit -m "Initial commit"
    git push -u origin master
```

3.2 Installing Dependencies

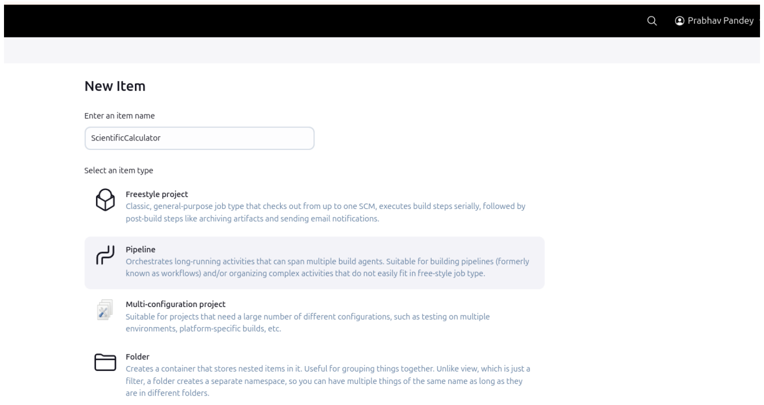
`sudo apt install git maven jenkins docker.io ansible -y`

3.3 Jenkins Setup

- Installed Jenkins and started the service.

```
    - sudo apt update
    - sudo apt install openjdk-17-jdk -y
    - wget -O-
  https://pkg.jenkins.io/debian-stable/jenkins.io.key |
  sudo tee /usr/share/keyrings/jenkins-keyring.asc >
  /dev/null
    - echo "deb
  [signed-by=/usr/share/keyrings/jenkins-keyring.asc]
  https://pkg.jenkins.io/debian-stable binary/" | sudo tee
  /etc/apt/sources.list.d/jenkins.list > /dev/null
    - sudo apt update
    - sudo apt install jenkins -y
    - sudo systemctl enable jenkins
    - sudo systemctl start jenkins
    - sudo systemctl status jenkins
```

- Created a pipeline job with a Jenkins Dashboard.



New Item

Enter an item name: ScientificCalculator

Select an item type

Freestyle project
Classic, general-purpose job type that checks out from up to one SCM, executes build steps serially, followed by post-build steps like archiving artifacts and sending email notifications.

Pipeline
Orchestrates long-running activities that can span multiple build agents. Suitable for building pipelines (formerly known as workflows) and/or organizing complex activities that do not easily fit in free-style job type.

Multi-configuration project
Suitable for projects that need a large number of different configurations, such as testing on multiple environments, platform-specific builds, etc.

Folder
Creates a container that stores nested items in it. Useful for grouping things together. Unlike view, which is just a filter, a folder creates a separate namespace, so you can have multiple things of the same name as long as they are in different folders.

Figure 2: Created Pipeline Job through Jenkins

3.4 Email Notification Configuration

- First go to manage jenkins

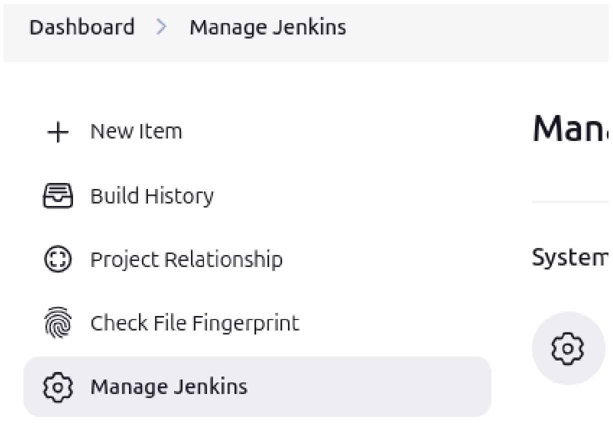


Figure 3: Go to Manage Jenkins

- Then go to "System"

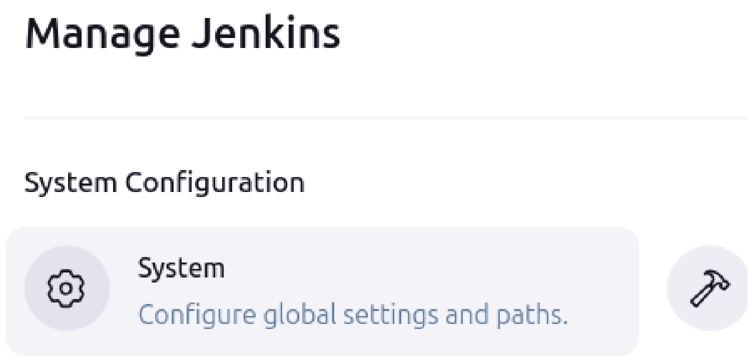
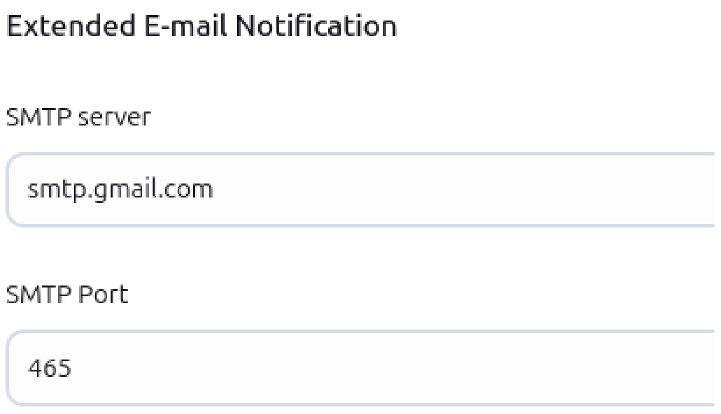


Figure 4: Go to Systems

- Then go to Extended Email-Notification section and configured as per image given below.


Extended E-mail Notification

SMTP server

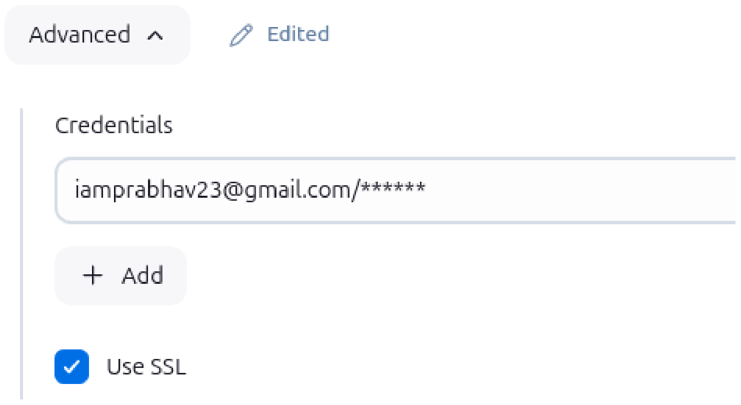
smtp.gmail.com

SMTP Port

465

Figure 5: Extended Email-Notification section

- Then click on "Advanced" and follow configuration as per image, while adding credentials, add your google email id in place of username and in place of password generate a passcode using "Google App Passwords and paste it here".



Credentials

iamprabhav23@gmail.com/******

✓ Use SSL

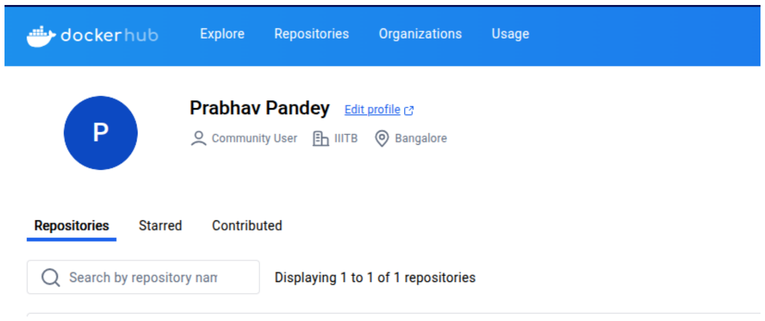
Figure 6: Advanced Email Notification setup

3.5 Install Plugin in Jenkins

- Email Notification
- Pipeline Stage View Plugin.
- Docker plugin.
- Docker pipeline.
- Docker-build-step
- Ansible plugin
- Ansible Tower plugin
- SSH Agent plugin
- SSH pipeline Steps
- SSH plugin

4 Docker Hub Account

Go to **Docker Hub site** and create an account.



Prabhav Pandey

Community User IIITB Bangalore

Displaying 1 to 1 of 1 repositories

Figure 7: Docker Hub Profile

5 Install Docker, Ansible

- Docker.

```
        sudo apt install -y docker.io
```

- Ansible

```
        sudo apt install -y ansible
```

6 Adding credentials in jenkins

- Go to Dashboard and click on "Manage Jenkins"

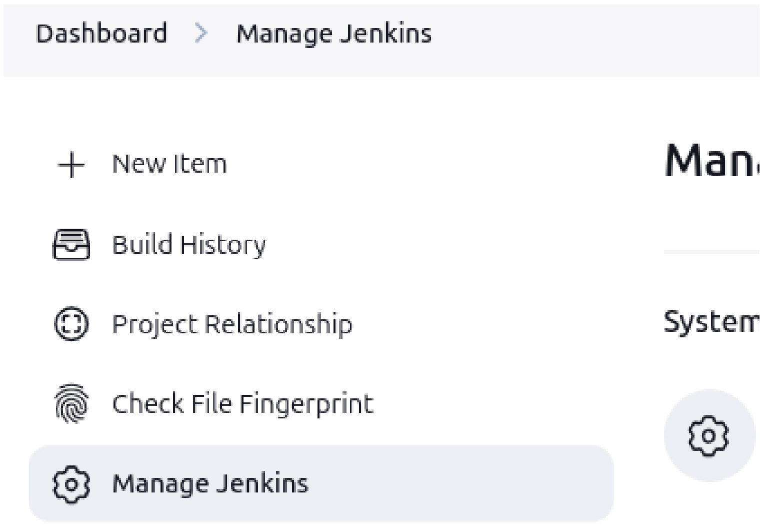


Figure 8: Manage Jenkins

- Go to "Security and click on "Credentials"

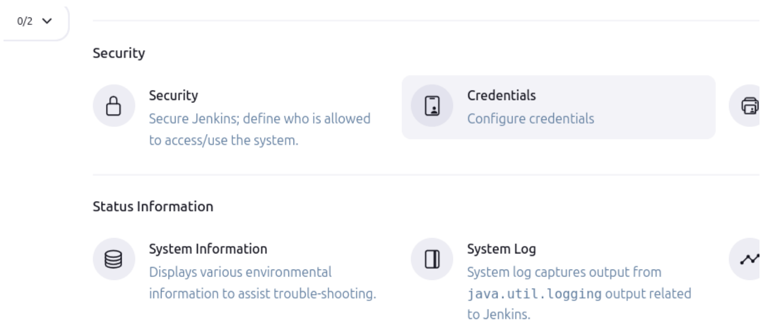
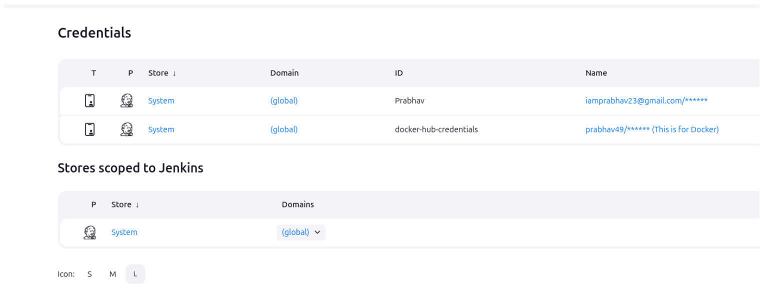

0/2
Security
Security
Secure Jenkins; define who is allowed to access/use the system.
Credentials
Configure credentials
Status Information
System Information
Displays various environmental information to assist trouble-shooting.
System Log
System log captures output from java.util.logging output related to Jenkins.

Figure 9: Click on Credentials

- Go to Stores scoped to Jenkins and click on global



Credentials

T	P	Store ↓	Domain	ID	Name
		System	(global)	Prabhav	iamprabhav23@gmail.com/******
		System	(global)	docker-hub-credentials	prabhav49/****** (This is for Docker)

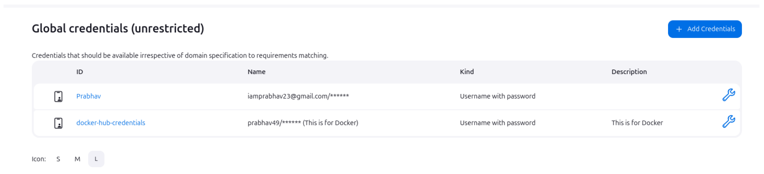
Stores scoped to Jenkins

P	Store ↓	Domains
	System	(global)

Icon: S M L

Figure 10: Click on global

- Click on "Add Credentials"



Global credentials (unrestricted)

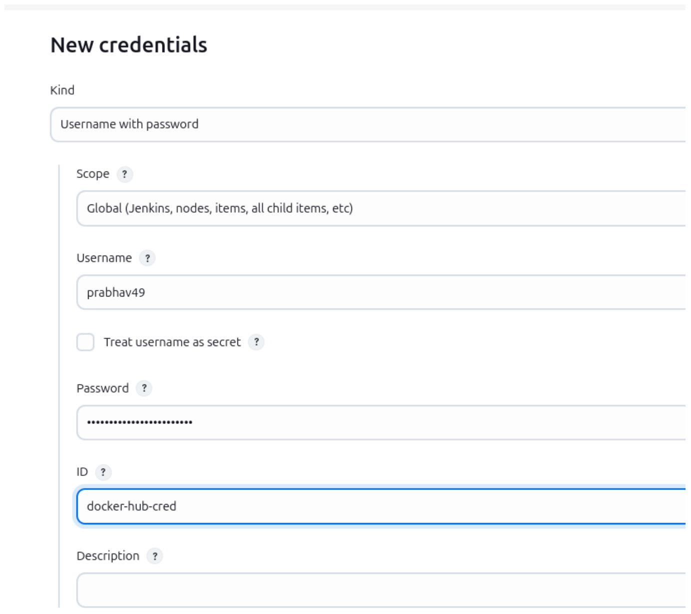
Credentials that should be available irrespective of domain specification to requirements matching.

	ID	Name	Kind	Description
	Prabhav	iamprabhav23@gmail.com/******	Username with password	
	docker-hub-credentials	prabhav49/****** (This is for Docker)	Username with password	This is for Docker

Icon: S M L

Figure 11: Add Credentials

- Now you can see your added Credentials



New credentials

Kind: Username with password

Scope: Global (Jenkins, nodes, items, all child items, etc)

Username: prabhav49

☐ Treat username as secret

Password: ••••••••••••••••••••••••

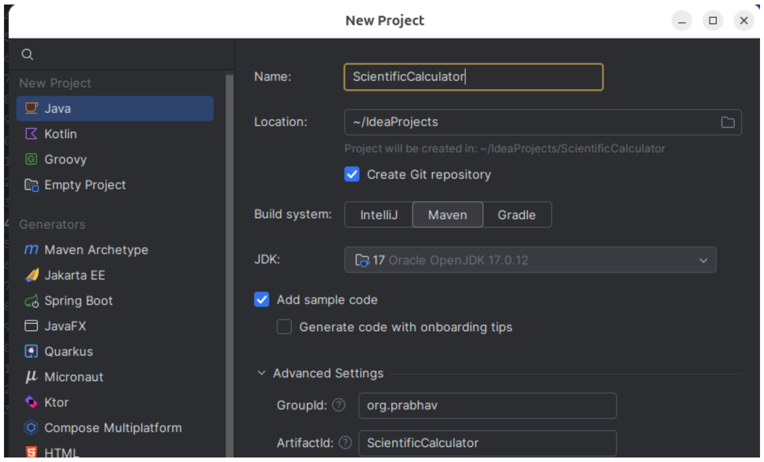
ID: docker-hub-cred

Description:

Figure 12: Check your added credentials

7 Create Calculator console Application using Java

- First Create New Project
- Choose Maven for build system



Name: ScientificCalculator
Location: ~/IdeaProjects
Project will be created in: ~/IdeaProjects/ScientificCalculator
☑ Create Git repository
Build system: IntelliJ [✓ Maven] Gradle
JDK: 17 Oracle OpenJDK 17.0.12
☑ Add sample code
☐ Generate code with onboarding tips
Advanced Settings
GroupId: org.prabhav
ArtifactId: ScientificCalculator

Figure 13: Maven Build System

- Then go to: src → main → java → org → example → Main.java

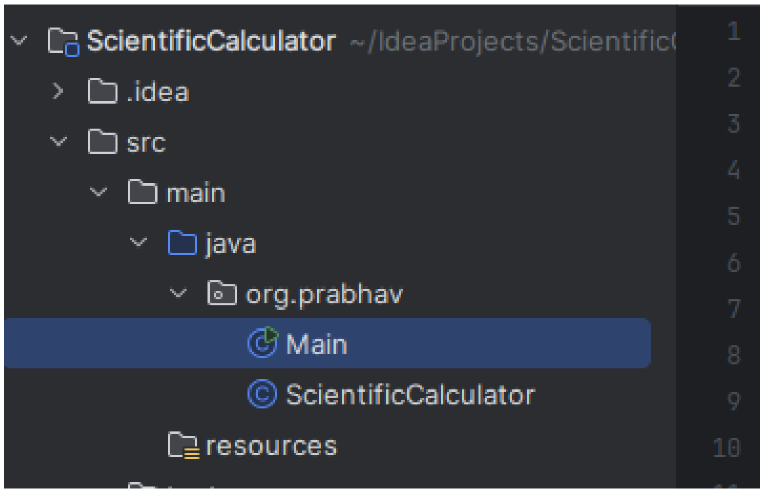
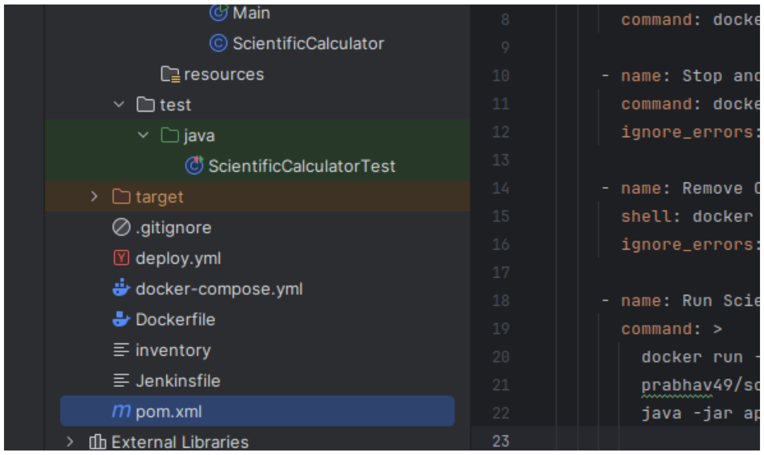


Figure 14: Main Java class

- Then write your calculator logic code
- Then go to pom.xml file



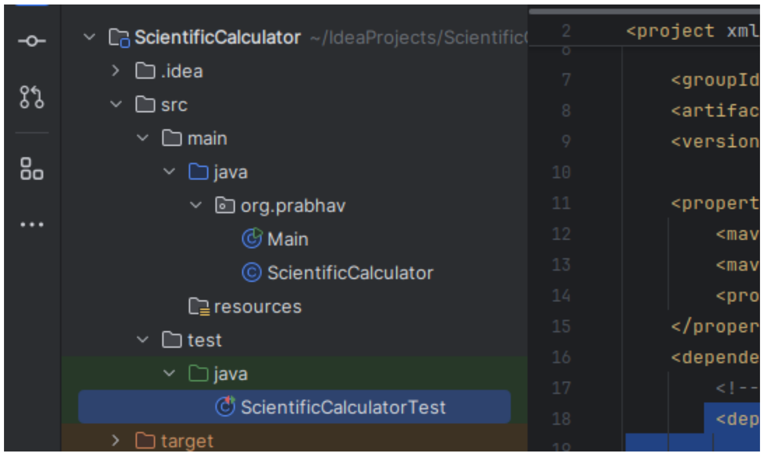
```
    command: docke

  - name: Stop and
    command: docke
    ignore_errors:

  - name: Remove C
    shell: docker
    ignore_errors:

  - name: Run Scie
    command: >
      docker run -
      prabhav49/sc
      java -jar ap
```

Figure 15: pom.xml file

- Paste JUnit dependency under dependencies

```
         <dependency>
            <groupId>junit</groupId>
            <artifactId>junit</artifactId>
            <version>4.13.2</version>
            <scope>test</scope>
        </dependency>
```

- Then go to test folder then write testing logic for your main code



```
<project xml

    <groupId
    <artifac
    <version

    <propert
        <mav
        <mav
        <pro
    </proper
    <depende
        <!--
        <dep
```

Figure 16: Test file

- Then run below command to build your code, this will create .jar file under target folder.

```
        mvn clean package
```

- Then run below command to test your code

```
        mvn test
```

8 Continuous Integration and Deployment (CI/CD) Pipeline

8.1 Jenkins Pipeline Configuration: Jenkinsfile

```
pipeline {
    agent any
    environment {
        DOCKER_IMAGE = 'prabhav49/scientific-calculator:latest'
        ANSIBLE_PLAYBOOK = 'deploy.yml'
    }
    stages {
        stage('Clone Repository') {
            steps {
                git
   'https://github.com/Prabhav49/ScientificCalculator.git'
            }
        }

        stage('Build') {
            steps {
                sh 'mvn clean package'
            }
        }

        stage('Test') {
            steps {
                sh 'mvn test'
            }
            post {
                always {
                    junit 'target/surefire-reports/*.xml'
                }
            }
        }

        stage('Build Docker Image') {
            steps {
                sh 'docker build -t $DOCKER_IMAGE .'
            }
        }

        stage('Push Docker Image') {
            steps {

   withCredentials([usernamePassword(credentialsId:
   'docker-hub-credentials', usernameVariable: 'DOCKER_USER',
   passwordVariable: 'DOCKER_PASS')]) {
                    sh 'echo "$DOCKER_PASS" | docker login -u
   "$DOCKER_USER" --password-stdin'
                    sh 'docker push $DOCKER_IMAGE'
                }
            }
        }

//          stage('Deploy with Ansible') {
//                      steps {
//                          script {
//                              def deployStatus = sh(script:
   'ansible-playbook --connection=local --become deploy.yml',
   returnStatus: true)
//                              if (deployStatus != 0) {
//                                  error "Deployment failed!"
//                              }
//                          }
//                      }
//                  }

        stage('Run Ansible Playbook') {
                    steps {
                        script {
                            ansiblePlaybook(
                                playbook: 'deploy.yml',
                                inventory: 'inventory'
                            )
                        }
                    }
                }
```

```
    }
    post {
        success {
            emailext(
                to: 'iam49smith@gmail.com',
                subject: "SUCCESS: ${env.JOB_NAME}
   #${env.BUILD_NUMBER}",
                body: """<p>The build and deployment were
   <b>successful!</b></p>
                        <p>Check the build details: <a
   href="${env.BUILD_URL}">${env.BUILD_URL}</a></p>"""
            )
        }
        failure {
            emailext(
                to: 'iam49smith@gmail.com',
                subject: "FAILURE: ${env.JOB_NAME}
   #${env.BUILD_NUMBER}",
                body: """<p>The build or deployment
   <b>failed!</b></p>
                        <p>Check the build details: <a
   href="${env.BUILD_URL}">${env.BUILD_URL}</a></p>"""
            )
        }
        always {
            cleanWs()
        }
    }
}
```

8.2 Containerization Setup: Dockerfile

```
FROM openjdk:17-jdk-slim

# Set the working directory inside the container
WORKDIR /app

COPY
   target/ScientificCalculator-1.0-SNAPSHOT-jar-with-dependencies.jar
   app.jar

ENTRYPOINT ["sh", "-c", "sleep infinity"]
CMD ["java", "-jar", "app.jar"]
```

8.3 Service Orchestration: docker-compose.yml

```
version: '3.8'

services:
  calculator:
    image: scientific-calculator
    container_name: scientific_calculator
    stdin_open: true  # Keep STDIN open for interactive input
   (useful if needed later)
    tty: true
    entrypoint: ["java", "-jar", "app.jar"]
```

8.4 Configuration Management: Ansible Playbook

```
- name: Deploy Scientific Calculator
  hosts: localhost
  remote_user: prabhav
  become: false
  tasks:

    - name: Pull Latest Docker Image
      command: docker pull
   prabhav49/scientific-calculator:latest

    - name: Stop and Remove Existing Container
      command: docker rm -f scientific_calculator
      ignore_errors: yes

    - name: Remove Old Docker Images (Optional)
      shell: docker images -q prabhav49/scientific-calculator |
   xargs -r docker rmi -f
      ignore_errors: yes

    - name: Run Scientific Calculator Container
      command: >
        docker run -d --name scientific_calculator
        prabhav49/scientific-calculator:latest
        java -jar app.jar 1 4 2
```

8.5 Inventory Configuration: inventory

```
ansible_host=localhost
ansible_user=<name of your server>
ansible_ssh_pass=<password of your system>
ansible_ssh_common_args='-o StrictHostKeyChecking=no'
```

9 Creating Pipeline Job and configuration

- Go to Jenkins and go to the project that you created while setuping the project.
- Go to "configure"
- Go to "Pipeline" section then "Definition" then select "Pipeline script from SCM"

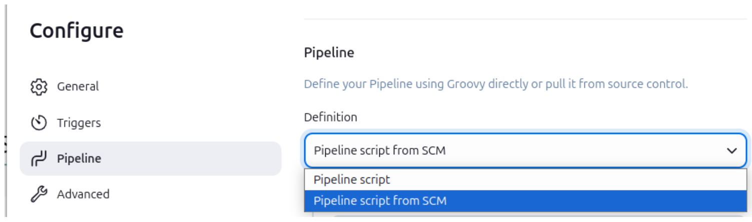
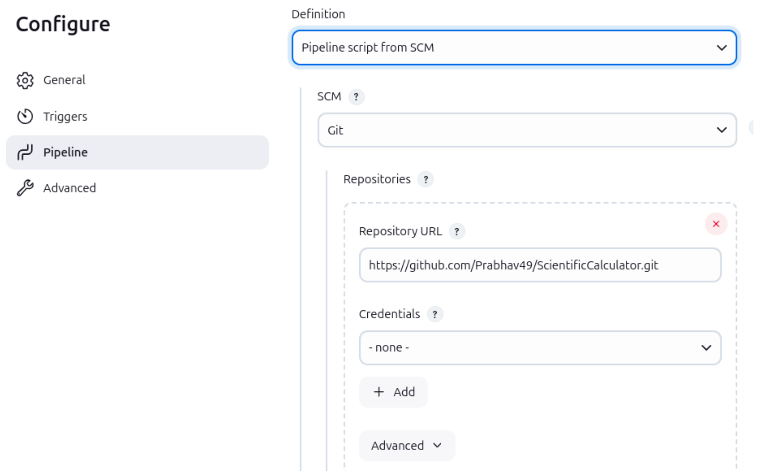


Figure 17: Select Pipeline script from SCM

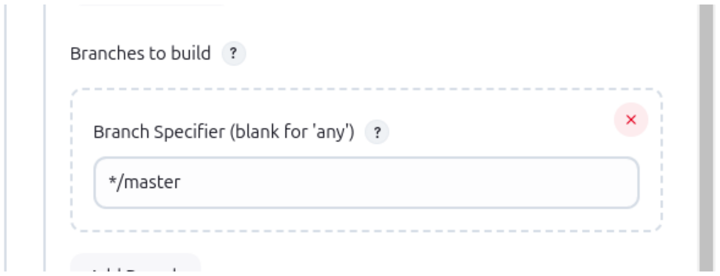
- Select GIT in SCM and enter the repository URL in "Repository URL"



Definition: Pipeline script from SCM
SCM: Git
Repositories
Repository URL: https://github.com/Prabhav49/ScientificCalculator.git
Credentials: - none -

Figure 18: Add Repository URL in SCM

- Change branch according to your repository, default branch



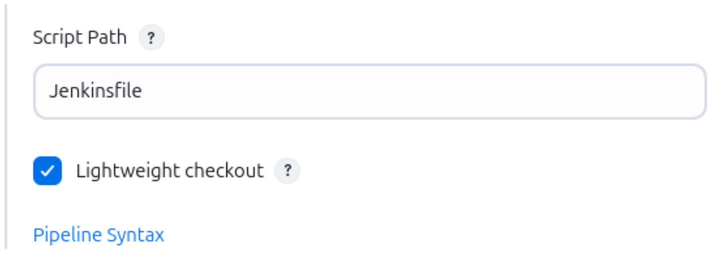
Branches to build

Branch Specifier (blank for 'any')

```
*/master
```

Figure 19: Change Branch of your repository

- In script path enter "Jenkinsfile" (file name of your pipeline script created earlier).



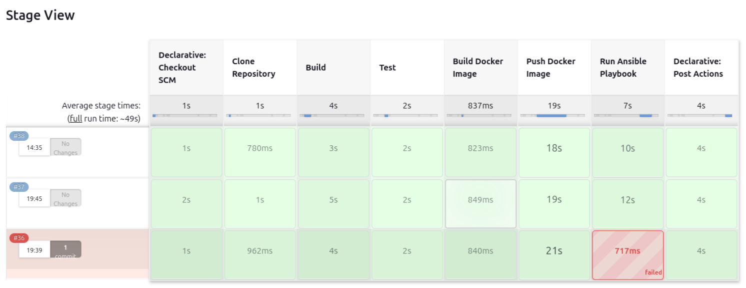
Script Path

```
Jenkinsfile
```

✓ Lightweight checkout

Figure 20: Add script file in path

- Click on save
- Go back and click on "Build Now then you can see your pipeline stage view"



Stage View

	Declarative: Checkout SCM	Clone Repository	Build	Test	Build Docker Image	Push Docker Image	Run Ansible Playbook	Declarative: Post Actions
Average stage times: (full run time: ~49s)	1s	1s	4s	2s	837ms	19s	7s	4s
#38 14:35 No Changes	1s	780ms	3s	2s	823ms	18s	10s	4s
#37 19:45 No Changes	2s	1s	5s	2s	849ms	19s	12s	4s
#36 19:39 1 commit	1s	962ms	4s	2s	840ms	21s	717ms failed	4s

Figure 21: Stage view of pipeline

- If any error occurs, then you can see that error on console output.

10 Execution and Results

- After successful deployment, the application runs in a Docker container, also it is successfully pushed into your dockerhub profile.

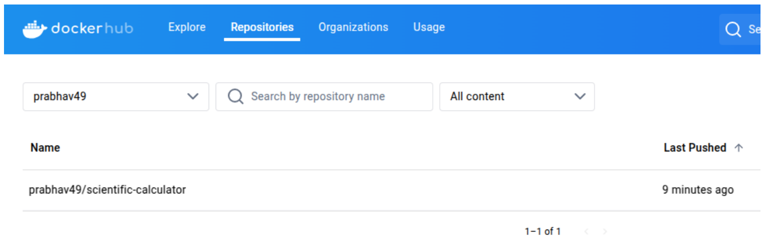


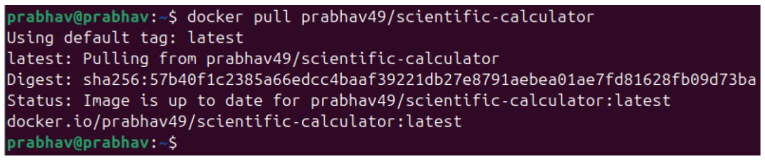
Figure 22: Image pushed to your dockerhub account

- To verify this on your terminal type below command:

```
        sudo docker images
```

- Pull the Image using the command: (prabhav49 is the username of the dockerhub profile and scientific-calculator is name of my image)

```
        sudo docker pull prabhav49/scientific-calculator
```



```
prabhav@prabhav:~$ docker pull prabhav49/scientific-calculator
Using default tag: latest
latest: Pulling from prabhav49/scientific-calculator
Digest: sha256:57b40f1c2385a66edcc4baaf39221db27e8791aebea01ae7fd81628fb09d73ba
Status: Image is up to date for prabhav49/scientific-calculator:latest
docker.io/prabhav49/scientific-calculator:latest
prabhav@prabhav:~$
```

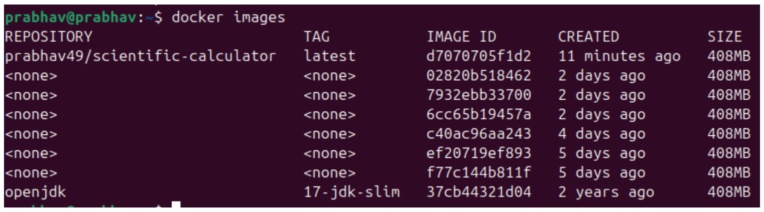
Figure 23: Pulling Docker image

- To see image is successfully pulled type below command

```
        sudo docker images
```

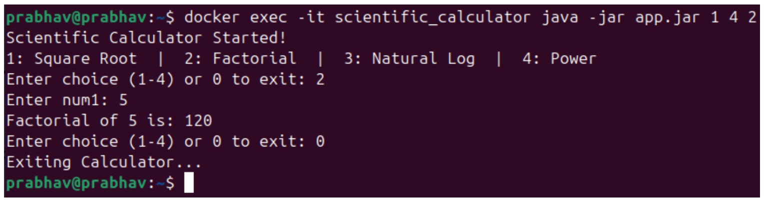
- To run the image type below command

```
        docker exec -it scientific_calculator java -jar
    app.jar 1 4 2
```



```
prabhav@prabhav:~$ docker images
REPOSITORY                          TAG           IMAGE ID       CREATED          SIZE
prabhav49/scientific-calculator     latest        d7070705f1d2   11 minutes ago   408MB
<none>                              <none>        02820b518462   2 days ago       408MB
<none>                              <none>        7932ebb33700   2 days ago       408MB
<none>                              <none>        6cc65b19457a   2 days ago       408MB
<none>                              <none>        c40ac96aa243   4 days ago       408MB
<none>                              <none>        ef20719ef893   5 days ago       408MB
<none>                              <none>        f77c144b811f   5 days ago       408MB
openjdk                             17-jdk-slim   37cb44321d04   2 years ago      408MB
```

Figure 24: Check images is pulled



```
prabhav@prabhav:~$ docker exec -it scientific_calculator java -jar app.jar 1 4 2
Scientific Calculator Started!
1: Square Root  |  2: Factorial  |  3: Natural Log  |  4: Power
Enter choice (1-4) or 0 to exit: 2
Enter num1: 5
Factorial of 5 is: 120
Enter choice (1-4) or 0 to exit: 0
Exiting Calculator...
prabhav@prabhav:~$
```

Figure 25: Running the Image

- To check whether the image is running and to check logs:

```
docker ps -a
docker logs calculator
```

11 Conclusion

The Scientific Calculator project successfully demonstrates DevOps principles, including automation, containerization, and continuous deployment.

12 References

References

[1] GitHub Repository, `https://github.com/Prabhav49/ScientificCalculator`

[2] Docker Hub Repository, `https://hub.docker.com/r/prabhav49/scientific-calculator`