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Experiment 8

AIM: To learn Dockerfile instructions, build an image for a sample web application using DOCKERFILE.

Theory :

Dockerfiles are the cornerstone of creating Docker images. They contain a set of instructions that automate the process of building a Docker image, specifying everything from the base operating system to the application code, dependencies, and configuration settings.

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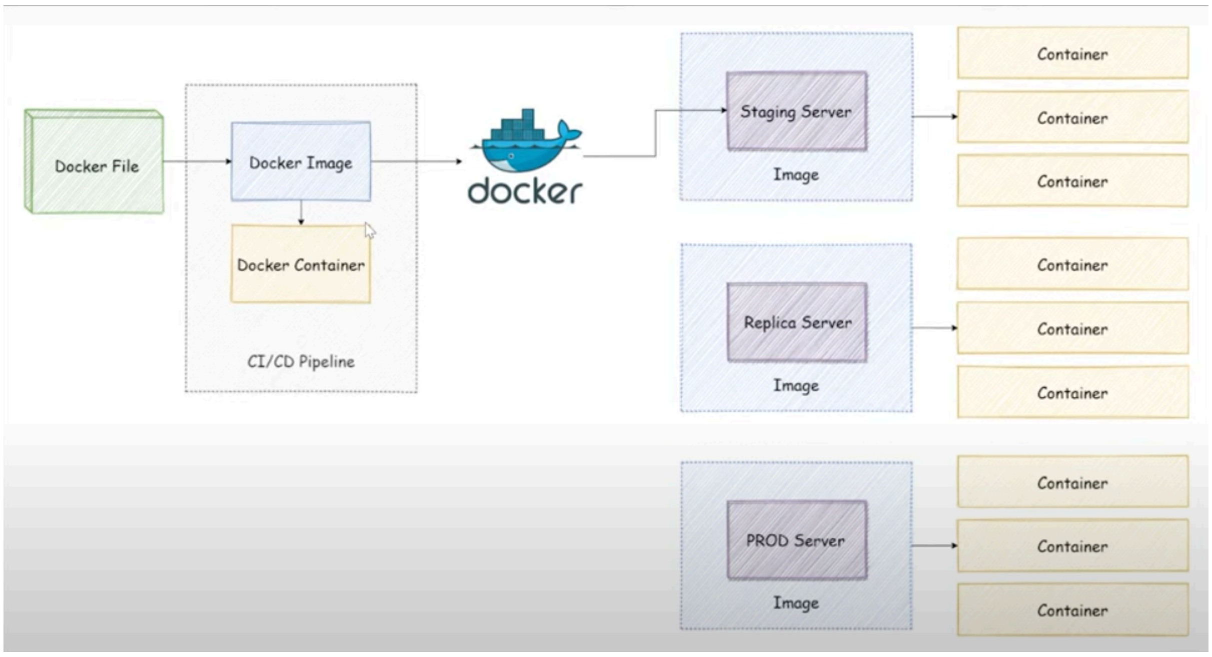
1. What is a Dockerfile?

A Dockerfile is a plain text file that defines the steps required to build a Docker image. It contains a series of commands (or instructions) that specify how the image should be constructed.

- **Purpose**: Automate the creation of Docker images for reproducibility, scalability, and consistency.
- **Format**: Written in a simple scripting language, using instructions like `FROM`, `RUN`, `COPY`, `CMD`, etc.



---

2. Basic Structure of a Dockerfile

```
# Use an official Python runtime as a parent image
FROM python:3.9-slim

# Set the working directory inside the container
WORKDIR /app

# Copy the current directory contents into the container at /app
COPY . /app

# Install any necessary dependencies
RUN pip install --no-cache-dir -r requirements.txt

# Make port 80 available to the world outside this container
EXPOSE 80

# Define environment variable
ENV NAME World

# Run app.py when the container launches
CMD ["python", "app.py"]
```

---

3. Common Dockerfile Instructions

1. FROM (Base Image)

- **Purpose**: Specifies the base image for your Docker image.

Example:

```
 FROM ubuntu:20.04
FROM node:14
FROM python:3.9-slim
```

-
- **Note**: This is the first instruction and is mandatory in most cases.

2. WORKDIR (Set Working Directory)

- **Purpose**: Defines the directory inside the container where subsequent instructions will be executed.

Example:

WORKDIR /app

-

3. COPY (Copy Files)

- **Purpose**: Copies files or directories from the host system into the container.

Example:

COPY . /app

-
- **Variants**:
  - `COPY <src> <dest>`
  - `ADD` is similar but supports remote URLs and tar file extraction.

4. RUN (Execute Commands)

- **Purpose**: Executes commands inside the container during the image build process.

Example:

RUN apt-get update && apt-get install -y curl

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

-
- **Tip**: Each `RUN` creates a new layer in the image. Combine commands with `&&` to reduce image size.

5. EXPOSE (Expose Ports)

- **Purpose**: Informs Docker that the container will listen on the specified network ports at runtime.

Example:

```
EXPOSE 80
```

-
- **Note**: This does not publish the port; it's just for documentation.

6. ENV (Set Environment Variables)

- **Purpose**: Sets environment variables inside the container.

Example:

```
ENV APP_ENV=production
```

-

7. CMD (Default Command)

- **Purpose**: Specifies the default command to run when the container starts.

Example:

```
CMD ["python", "app.py"]
```

-
- **Key Points**:
    - Only one `CMD` is allowed.
    - It can be overridden by passing a command with `docker run`.

8. ENTRYPOINT (Set Entry Point)

- **Purpose**: Defines a command that will always be executed when the container starts.

Example:

```
ENTRYPOINT ["python"]
CMD ["app.py"]
```

-
- **Difference from CMD**: `ENTRYPOINT` is not overridden unless explicitly done with `--entrypoint`.

---

4. Building Images from a Dockerfile

To build an image:

```
docker build -t myapp:latest .
```

- `-t myapp:latest`: Tags the image.
- `.`: Refers to the current directory as build context.

Build Options:

- `-f <file>`: Specify a custom Dockerfile.
- `--no-cache`: Build without using the cache.
- `--build-arg <arg>`: Pass build-time arguments.

---

5. Managing Docker Images

List Images:

```
docker images
```

Remove an Image:

```
docker rmi myapp:latest
```

Run a Container:

```
docker run -p 8080:80 myapp:latest
```

---

6. Multi-Stage Builds (Advanced)

Multi-stage builds help reduce image size by separating the build environment from runtime:

```
# Stage 1: Build stage
FROM node:14 AS build
WORKDIR /app
COPY package.json ./
RUN npm install
COPY . .

# Stage 2: Production stage
FROM node:14-slim
WORKDIR /app
COPY --from=build /app /app
CMD ["node", "server.js"]
```

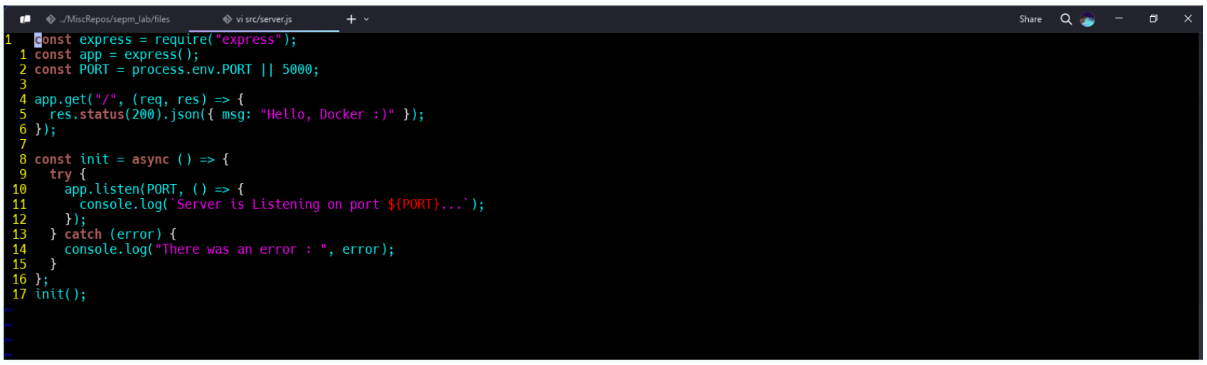
This keeps the final image small and excludes unnecessary build tools.

---

7. Best Practices for Dockerfiles

1. Use minimal base images (e.g., alpine).
2. Order instructions from least to most frequently changing to leverage caching.
3. Combine RUN commands with `&&`.
4. Avoid root – use non-root users.
5. Clean up unnecessary files to reduce image size.

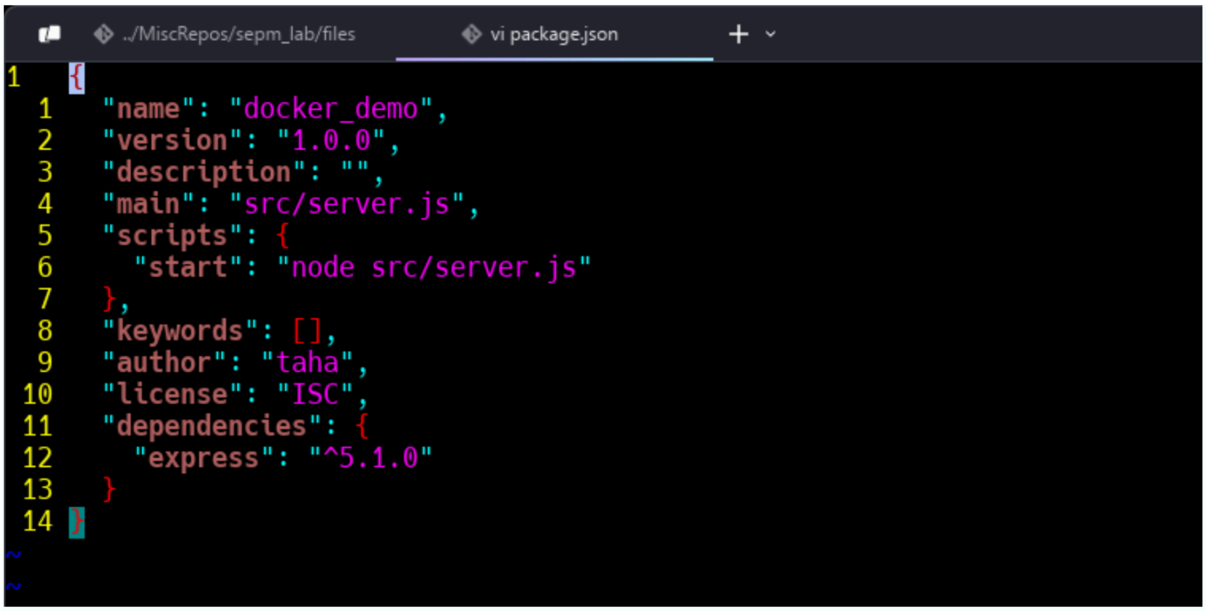
OUTPUT:



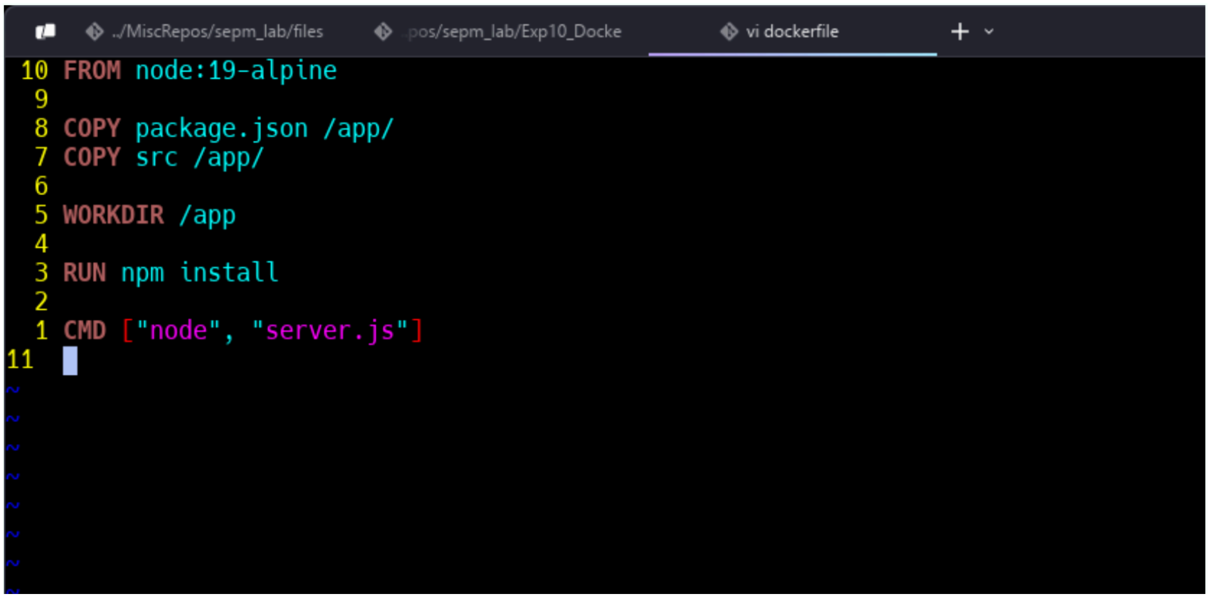
```
const express = require("express");
const app = express();
const PORT = process.env.PORT || 5000;

app.get("/", (req, res) => {
  res.status(200).json({ msg: "Hello, Docker :)" });
});

const init = async () => {
  try {
    app.listen(PORT, () => {
      console.log(`Server is Listening on port ${PORT}...`);
    });
  } catch (error) {
    console.log("There was an error : ", error);
  }
};
init();
```



```
{
  "name": "docker_demo",
  "version": "1.0.0",
  "description": "",
  "main": "src/server.js",
  "scripts": {
    "start": "node src/server.js"
  },
  "keywords": [],
  "author": "taha",
  "license": "ISC",
  "dependencies": {
    "express": "^5.1.0"
  }
}
```



```
FROM node:19-alpine

COPY package.json /app/
COPY src /app/

WORKDIR /app

RUN npm install

CMD ["node", "server.js"]
```

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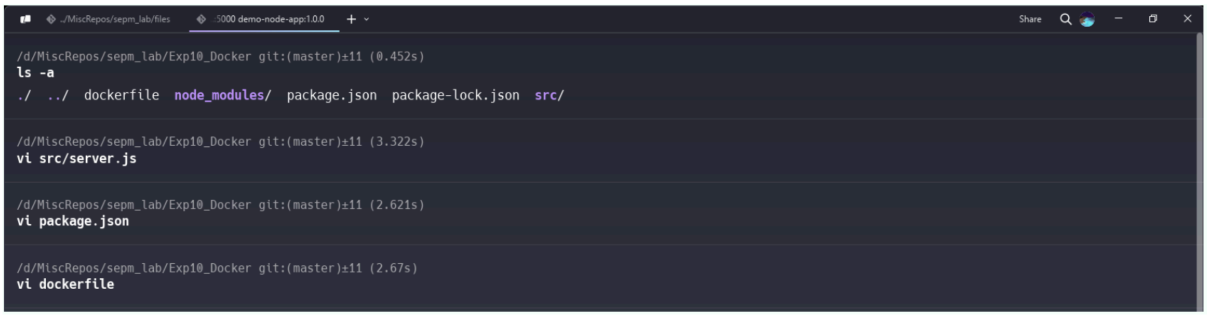
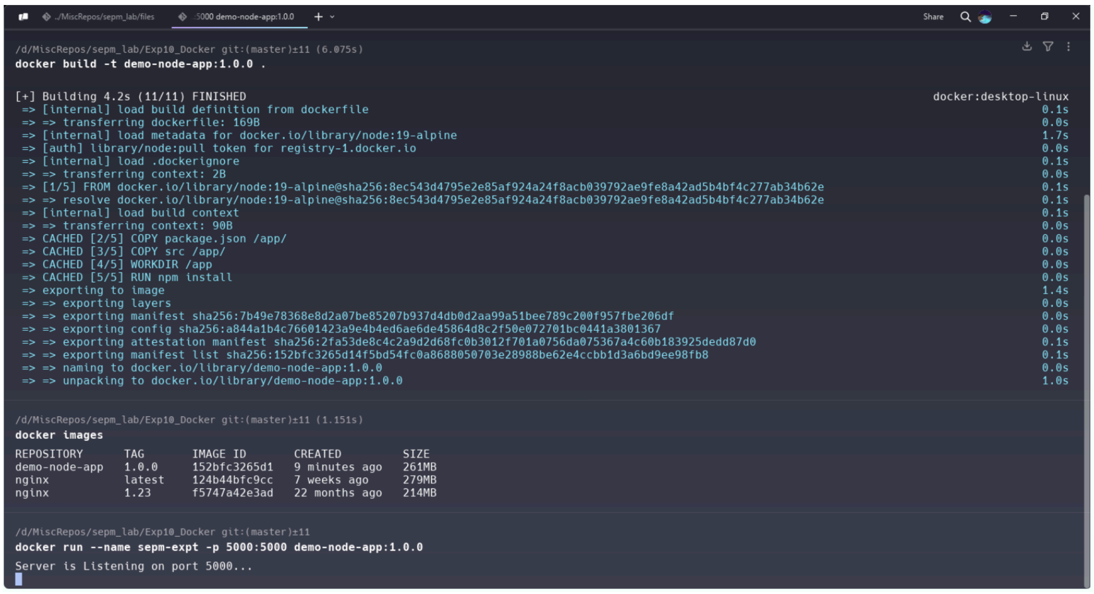


```
/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11 (0.452s)
ls -a
./  ../  dockerfile  node_modules/  package.json  package-lock.json  src/

/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11 (3.322s)
vi src/server.js

/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11 (2.621s)
vi package.json

/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11 (2.67s)
vi dockerfile
```

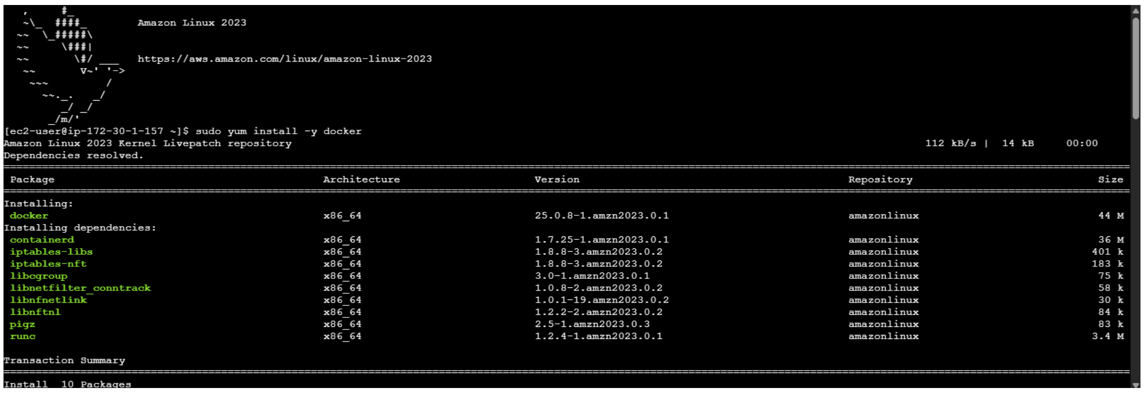


```
/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11 (6.075s)
docker build -t demo-node-app:1.0.0 .

[+] Building 4.2s (11/11) FINISHED                                                                      docker:desktop-linux
 => [internal] load build definition from dockerfile                                                                    0.1s
 => => transferring dockerfile: 169B                                                                                    0.0s
 => [internal] load metadata for docker.io/library/node:19-alpine                                                       1.7s
 => [auth] library/node:pull token for registry-1.docker.io                                                             0.0s
 => [internal] load .dockerignore                                                                                       0.1s
 => => transferring context: 2B                                                                                         0.0s
 => [1/5] FROM docker.io/library/node:19-alpine@sha256:8ec543d4795e2e85af924a24f8acb039792ae9fe8a42ad5b4bf4c277ab34b62e  0.1s
 => => resolve docker.io/library/node:19-alpine@sha256:8ec543d4795e2e85af924a24f8acb039792ae9fe8a42ad5b4bf4c277ab34b62e  0.1s
 => [internal] load build context                                                                                       0.1s
 => => transferring context: 90B                                                                                        0.0s
 => CACHED [2/5] COPY package.json /app/                                                                                0.0s
 => CACHED [3/5] COPY src /app/                                                                                         0.0s
 => CACHED [4/5] WORKDIR /app                                                                                           0.0s
 => CACHED [5/5] RUN npm install                                                                                        0.0s
 => exporting to image                                                                                                  1.4s
 => => exporting layers                                                                                                 0.0s
 => => exporting manifest sha256:7b49e78368e8d2a07be85207b937d4db0d2aa99a51bee789c200f957fbe206df                       0.0s
 => => exporting config sha256:a844a1b4c76601423a9e4b4ed6ae6de45864d8c2f50e072701bc0441a3801367                         0.0s
 => => exporting attestation manifest sha256:2fa53de8c4c2a9d2d68fc0b3012f701a0756da075367a4c60b183925dedd87d0           0.1s
 => => exporting manifest list sha256:152bfc3265d14f5bd54fc0a8688050703e28988be62e4ccbb1d3a6bd9ee98fb8                  0.1s
 => => naming to docker.io/library/demo-node-app:1.0.0                                                                  0.0s
 => => unpacking to docker.io/library/demo-node-app:1.0.0                                                               1.0s

/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11 (1.151s)
docker images
REPOSITORY      TAG       IMAGE ID       CREATED          SIZE
demo-node-app   1.0.0     152bfc3265d1   9 minutes ago    261MB
nginx           latest    124b44bfc9cc   7 weeks ago      279MB
nginx           1.23      f5747a42e3ad   22 months ago    214MB

/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11
docker run --name sepm-expt -p 5000:5000 demo-node-app:1.0.0
Server is Listening on port 5000...
```



```
   ,     #_
   ~\_  ####_        Amazon Linux 2023
  ~~  \_#####\
  ~~     \###|
  ~~       \#/ ___   https://aws.amazon.com/linux/amazon-linux-2023
   ~~       V~' '->
    ~~~         /
      ~~._.   _/
         _/ _/
       _/m/'
[ec2-user@ip-172-30-1-157 ~]$ sudo yum install -y docker
Amazon Linux 2023 Kernel Livepatch repository                                   112 kB/s |  14 kB     00:00
Dependencies resolved.
================================================================================================================
 Package                        Architecture        Version                        Repository              Size
================================================================================================================
Installing:
 docker                         x86_64              25.0.8-1.amzn2023.0.1          amazonlinux             44 M
Installing dependencies:
 containerd                     x86_64              1.7.25-1.amzn2023.0.1          amazonlinux             36 M
 iptables-libs                  x86_64              1.8.8-3.amzn2023.0.2           amazonlinux            401 k
 iptables-nft                   x86_64              1.8.8-3.amzn2023.0.2           amazonlinux            183 k
 libcgroup                      x86_64              3.0-1.amzn2023.0.1             amazonlinux             75 k
 libnetfilter_conntrack         x86_64              1.0.8-2.amzn2023.0.2           amazonlinux             58 k
 libnfnetlink                   x86_64              1.0.1-19.amzn2023.0.2          amazonlinux             30 k
 libnftnl                       x86_64              1.2.2-2.amzn2023.0.2           amazonlinux             84 k
 pigz                           x86_64              2.5-1.amzn2023.0.3             amazonlinux             83 k
 runc                           x86_64              1.2.4-1.amzn2023.0.1           amazonlinux            3.4 M

Transaction Summary
================================================================================================================
Install  10 Packages
```

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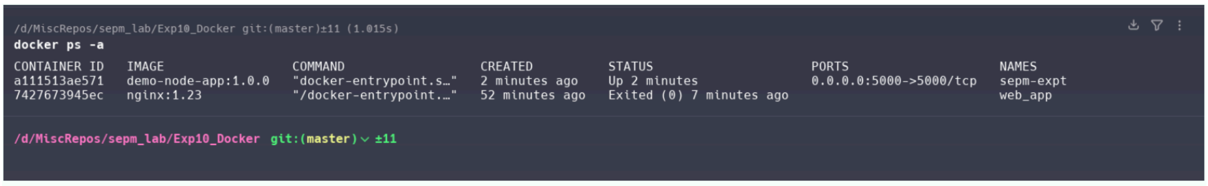
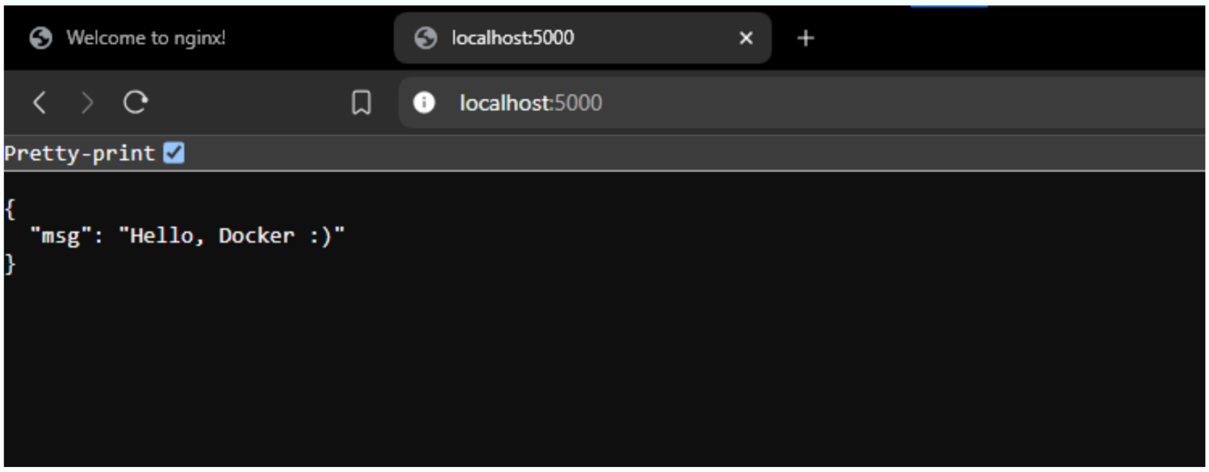
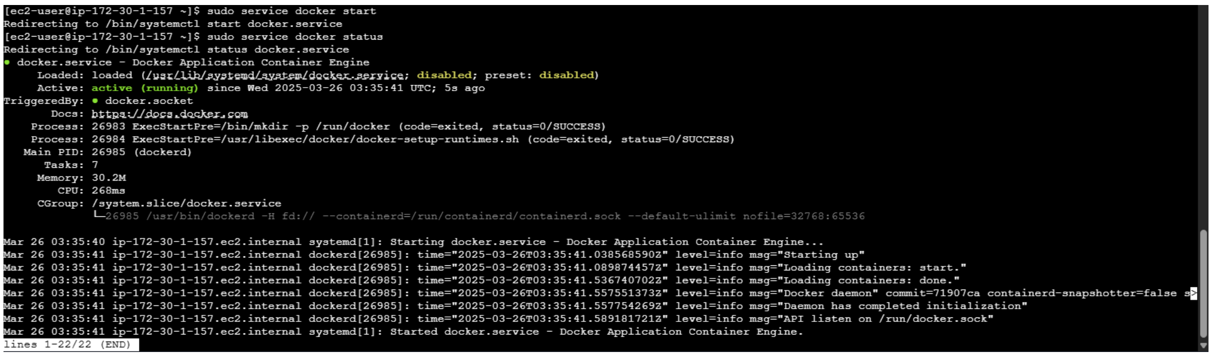


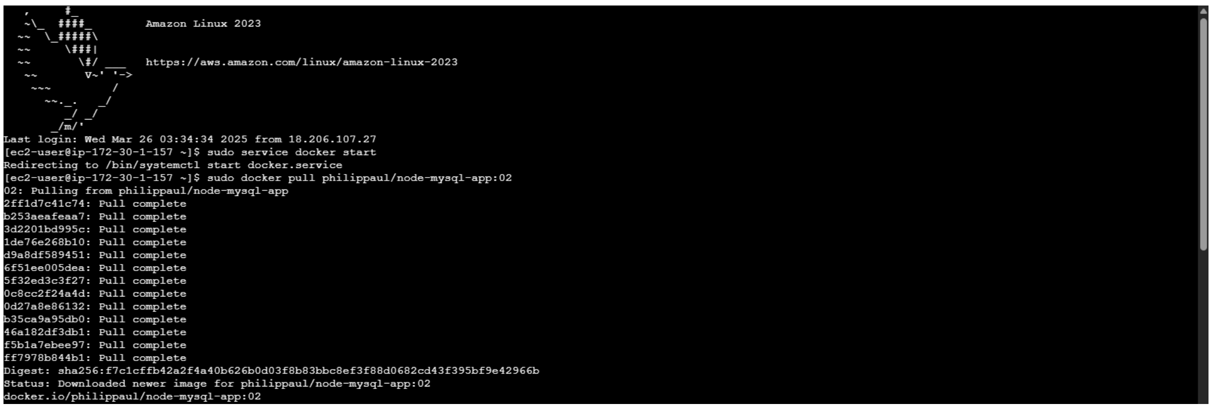
```
/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11 (1.015s)
docker ps -a
CONTAINER ID   IMAGE                COMMAND                  CREATED          STATUS                     PORTS                    NAMES
a111513ae571   demo-node-app:1.0.0  "docker-entrypoint.s…"   2 minutes ago    Up 2 minutes               0.0.0.0:5000->5000/tcp   sepm-expt
7427673945ec   nginx:1.23           "/docker-entrypoint.…"   52 minutes ago   Exited (0) 7 minutes ago                            web_app

/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)✓ ±11
```



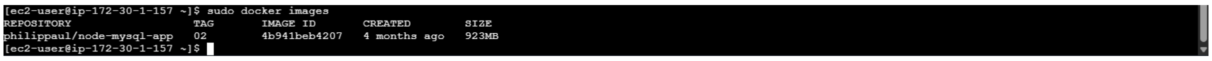
```
{
  "msg": "Hello, Docker :)"
}
```



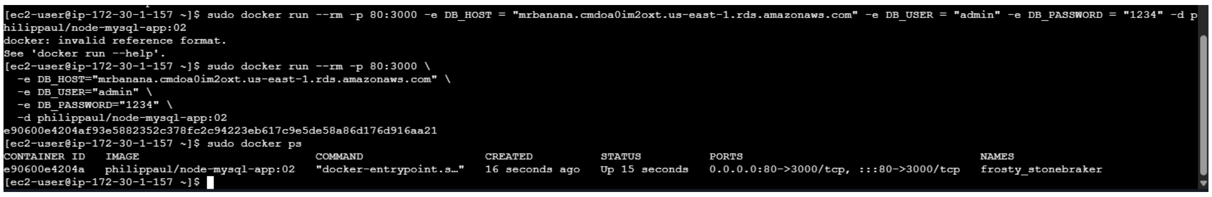
```
[ec2-user@ip-172-30-1-157 ~]$ sudo service docker start
Redirecting to /bin/systemctl start docker.service
[ec2-user@ip-172-30-1-157 ~]$ sudo service docker status
Redirecting to /bin/systemctl status docker.service
● docker.service - Docker Application Container Engine
     Loaded: loaded (/usr/lib/systemd/system/docker.service; disabled; preset: disabled)
     Active: active (running) since Wed 2025-03-26 03:35:41 UTC; 5s ago
TriggeredBy: ● docker.socket
       Docs: https://docs.docker.com
    Process: 26983 ExecStartPre=/bin/mkdir -p /run/docker (code=exited, status=0/SUCCESS)
    Process: 26984 ExecStartPre=/usr/libexec/docker/docker-setup-runtimes.sh (code=exited, status=0/SUCCESS)
   Main PID: 26985 (dockerd)
      Tasks: 7
     Memory: 30.2M
        CPU: 268ms
     CGroup: /system.slice/docker.service
             └─26985 /usr/bin/dockerd -H fd:// --containerd=/run/containerd/containerd.sock --default-ulimit nofile=32768:65536

Mar 26 03:35:40 ip-172-30-1-157.ec2.internal systemd[1]: Starting docker.service - Docker Application Container Engine...
Mar 26 03:35:41 ip-172-30-1-157.ec2.internal dockerd[26985]: time="2025-03-26T03:35:41.038568590Z" level=info msg="Starting up"
Mar 26 03:35:41 ip-172-30-1-157.ec2.internal dockerd[26985]: time="2025-03-26T03:35:41.089874457Z" level=info msg="Loading containers: start."
Mar 26 03:35:41 ip-172-30-1-157.ec2.internal dockerd[26985]: time="2025-03-26T03:35:41.536740702Z" level=info msg="Loading containers: done."
Mar 26 03:35:41 ip-172-30-1-157.ec2.internal dockerd[26985]: time="2025-03-26T03:35:41.557551373Z" level=info msg="Docker daemon" commit=71907ca containerd-snapshotter=false s>
Mar 26 03:35:41 ip-172-30-1-157.ec2.internal dockerd[26985]: time="2025-03-26T03:35:41.557754269Z" level=info msg="Daemon has completed initialization"
Mar 26 03:35:41 ip-172-30-1-157.ec2.internal dockerd[26985]: time="2025-03-26T03:35:41.589181721Z" level=info msg="API listen on /run/docker.sock"
Mar 26 03:35:41 ip-172-30-1-157.ec2.internal systemd[1]: Started docker.service - Docker Application Container Engine.
lines 1-22/22 (END)
```



```
   ,     #_
   ~\_  ####_        Amazon Linux 2023
  ~~  \_#####\
  ~~     \###|
  ~~       \#/ ___   https://aws.amazon.com/linux/amazon-linux-2023
   ~~       V~' '->
    ~~~         /
      ~~._.   _/
         _/ _/
       _/m/'
Last login: Wed Mar 26 03:34:34 2025 from 18.206.107.27
[ec2-user@ip-172-30-1-157 ~]$ sudo service docker start
Redirecting to /bin/systemctl start docker.service
[ec2-user@ip-172-30-1-157 ~]$ sudo docker pull philippaul/node-mysql-app:02
02: Pulling from philippaul/node-mysql-app
2ff1d7c41c74: Pull complete
b253aeafeaa7: Pull complete
3d2201bd995c: Pull complete
1de76e268b10: Pull complete
d9a8df589451: Pull complete
6f51ee005dea: Pull complete
5f32ed3c3f27: Pull complete
0c8cc2f24a4d: Pull complete
0d27a8e86132: Pull complete
b35ca9a95db0: Pull complete
46a182df3db1: Pull complete
f5b1a7ebee97: Pull complete
ff7978b844b1: Pull complete
Digest: sha256:f7c1cffb42a2f4a40b626b0d03f8b83bbc8ef3f88d0682cd43f395bf9e42966b
Status: Downloaded newer image for philippaul/node-mysql-app:02
docker.io/philippaul/node-mysql-app:02
```



```
[ec2-user@ip-172-30-1-157 ~]$ sudo docker images
REPOSITORY                  TAG       IMAGE ID       CREATED        SIZE
philippaul/node-mysql-app   02        4b941beb4207   4 months ago   923MB
[ec2-user@ip-172-30-1-157 ~]$
```



```
[ec2-user@ip-172-30-1-157 ~]$ sudo docker run --rm -p 80:3000 -e DB_HOST = "mrbanana.cmdoa0im2oxt.us-east-1.rds.amazonaws.com" -e DB_USER = "admin" -e DB_PASSWORD = "1234" -d p
hilippaul/node-mysql-app:02
docker: invalid reference format.
See 'docker run --help'.
[ec2-user@ip-172-30-1-157 ~]$ sudo docker run --rm -p 80:3000 \
  -e DB_HOST="mrbanana.cmdoa0im2oxt.us-east-1.rds.amazonaws.com" \
  -e DB_USER="admin" \
  -e DB_PASSWORD="1234" \
  -d philippaul/node-mysql-app:02
e90600e4204af93e5882352c378fc2c94223eb617c9e5de58a86d176d916aa21
[ec2-user@ip-172-30-1-157 ~]$ sudo docker ps
CONTAINER ID   IMAGE                          COMMAND                  CREATED          STATUS          PORTS                                   NAMES
e90600e4204a   philippaul/node-mysql-app:02   "docker-entrypoint.s…"   16 seconds ago   Up 15 seconds   0.0.0.0:80->3000/tcp, :::80->3000/tcp   frosty_stonebraker
[ec2-user@ip-172-30-1-157 ~]$
```

Conclusion :

We have learnt Dockerfile instructions, built an image for a sample web application using DOCKERFILE.