Name : Taha Alotwala
Roll No. : 03
Batch : T11

Experiment 10 : Dockerfiles

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.

---

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

A typical Dockerfile looks like this:

```
# 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>`: Copies a file or directory from the build context to the container.
  - `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 a way to document which ports should be exposed.

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` instruction is allowed.
  - If you provide a command when running the container (`docker run`), it will override `CMD`.

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` in `docker run`.

4. Building Images from a Dockerfile

To build an image, use the `docker build` command:

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

- **`-t myapp:latest`**: Tags the image as `myapp` with the `latest` tag.
- `.`: Specifies the build context (the current directory).

Build Options:

- `-f <file>`: Specify a custom Dockerfile name.
- `--no-cache`: Build the image 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 from an Image:

```
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 the runtime environment.

```
# 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"]
```

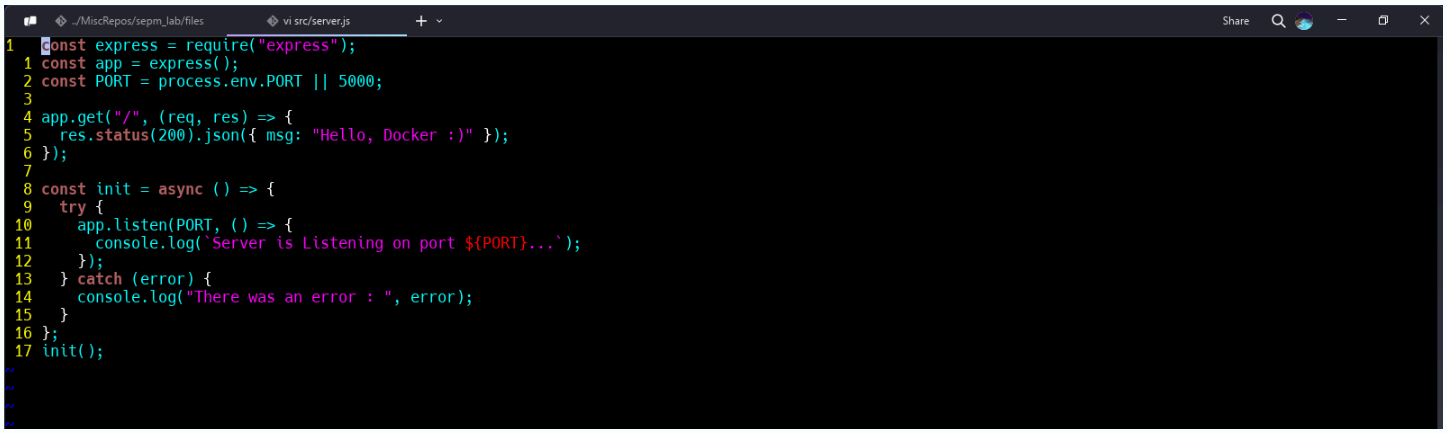
- This technique helps keep the final image lean by excluding unnecessary build tools.

---

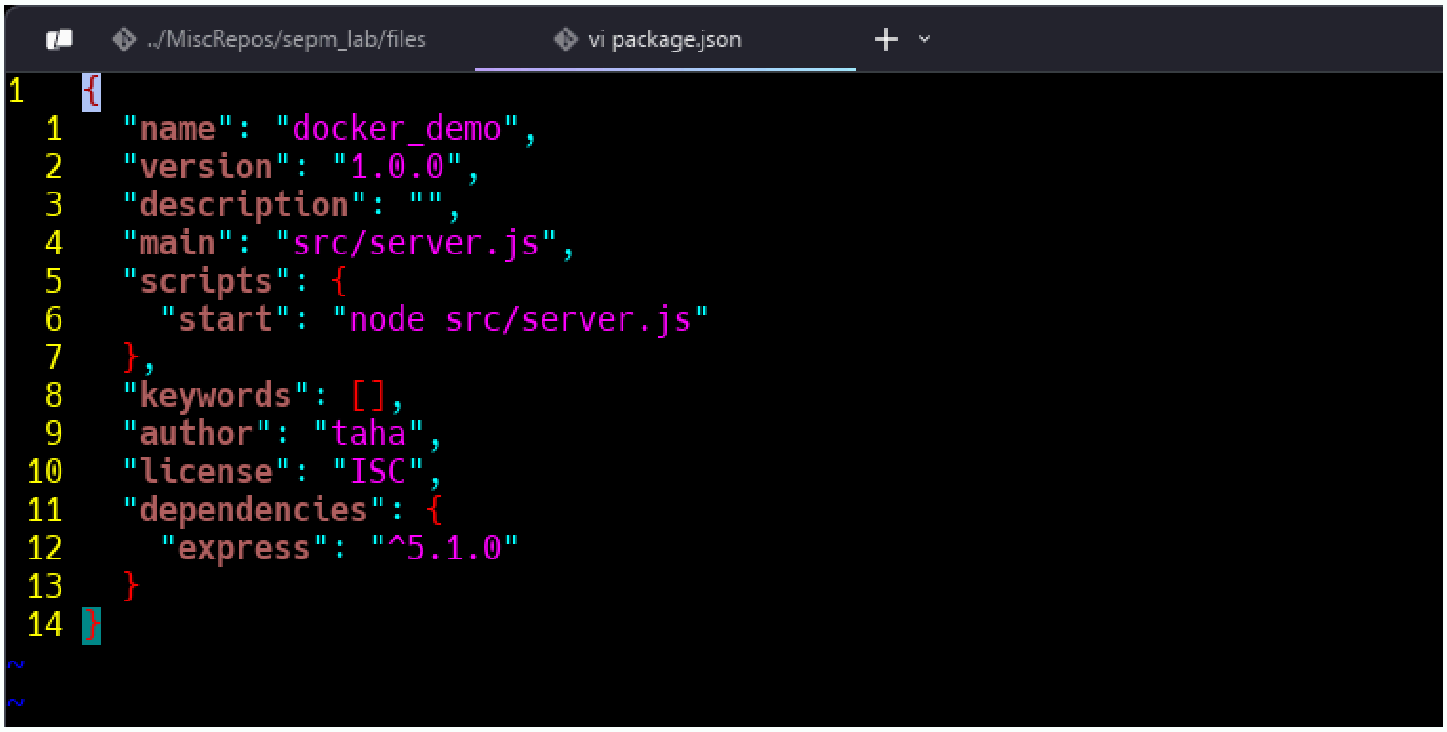
7. Best Practices for Dockerfiles

1. **Use Minimal Base Images:** e.g., `alpine` for small image sizes.
2. **Leverage Caching:** Order instructions from least to most frequently changing.
3. **Reduce Layers:** Combine `RUN` commands with `&&`.
4. **Avoid Root:** Run applications as non-root users when possible.
5. **Clean Up:** Remove unnecessary files after installation to reduce image size.

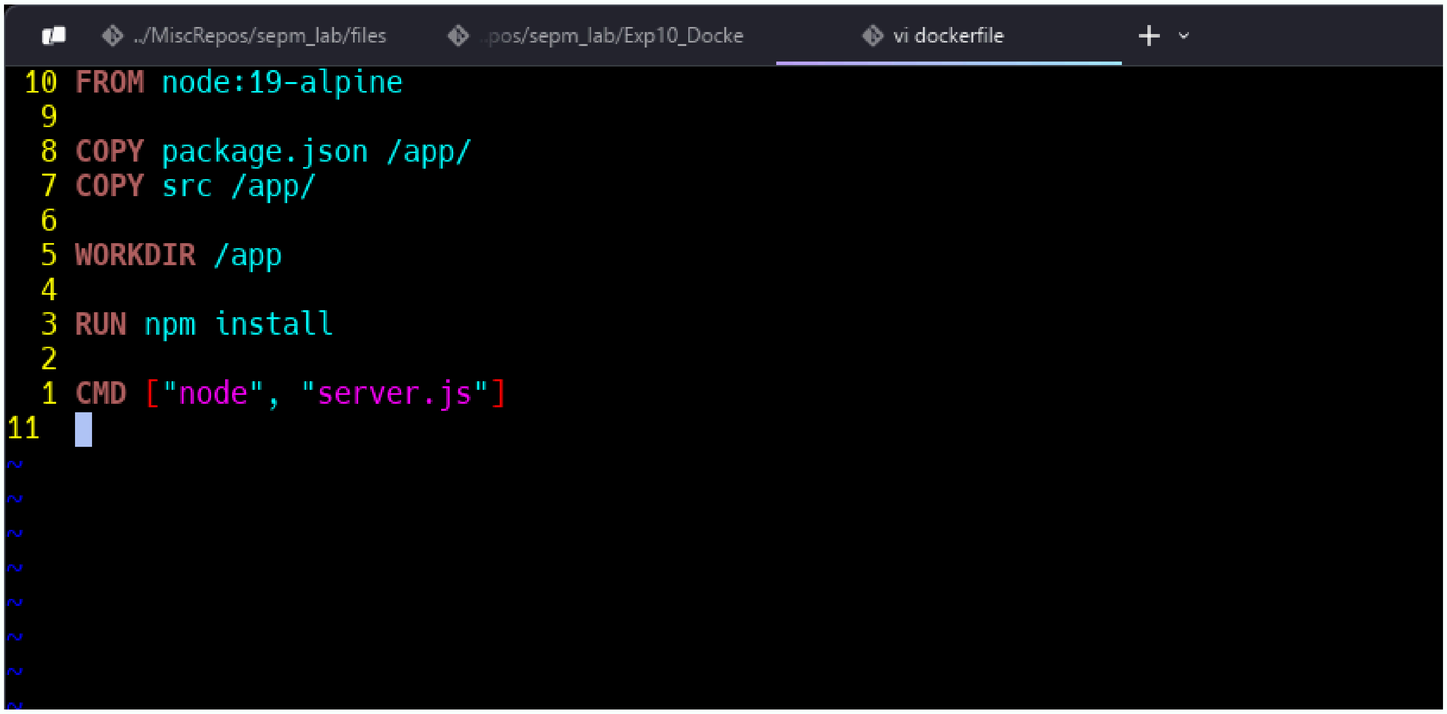
Screenshots:



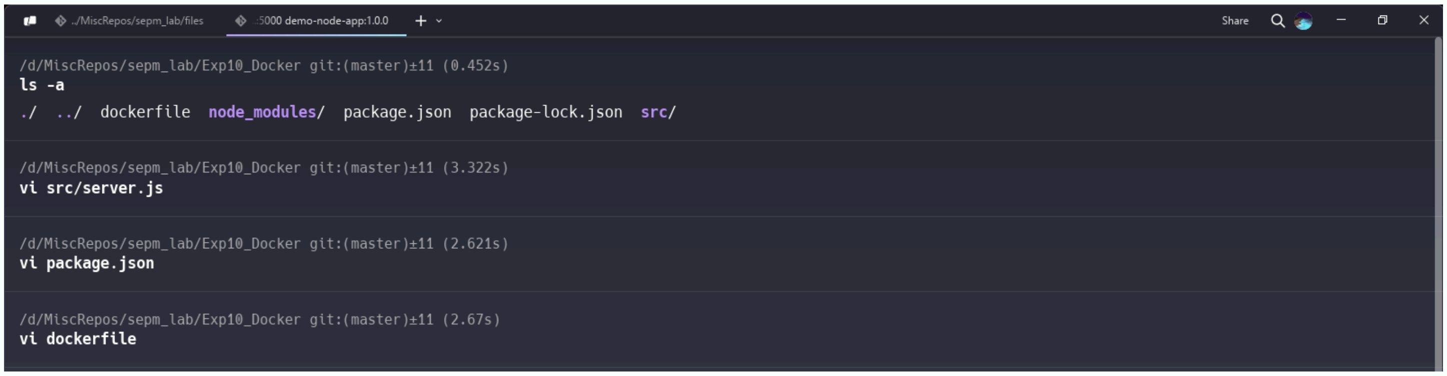
```
const express = require("express");
const app = express();
const PORT = process.env.PORT || 5000;

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();
```



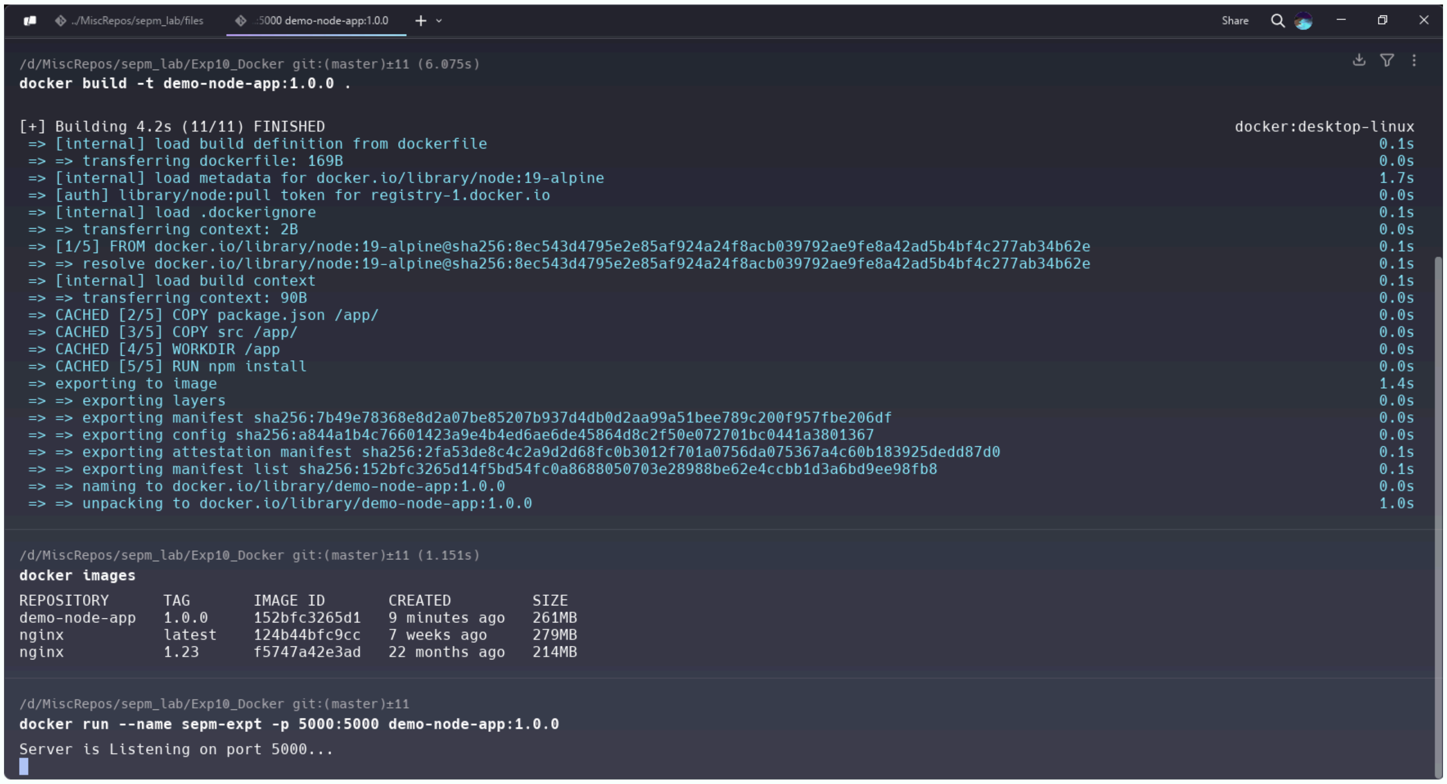
```
{
  "name": "docker_demo",
  "version": "1.0.0",
  "description": "",
  "main": "src/server.js",
  "scripts": {
    "start": "node src/server.js"
  },
  "keywords": [],
  "author": "taha",
  "license": "ISC",
  "dependencies": {
    "express": "^5.1.0"
  }
}
```



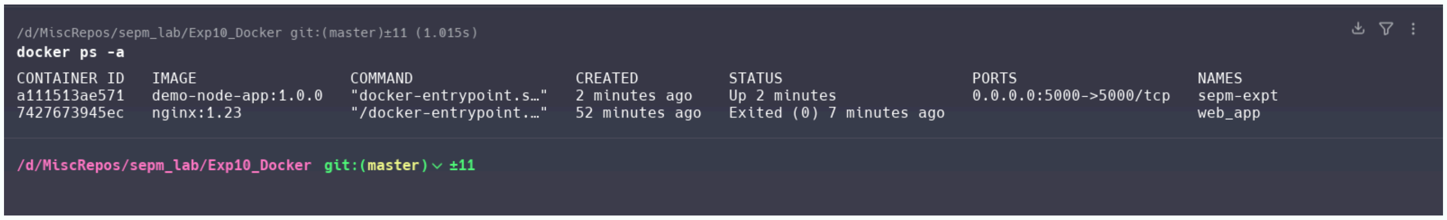
```
FROM node:19-alpine

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

WORKDIR /app

RUN npm install

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

~
~
~
~
~
~
~
```



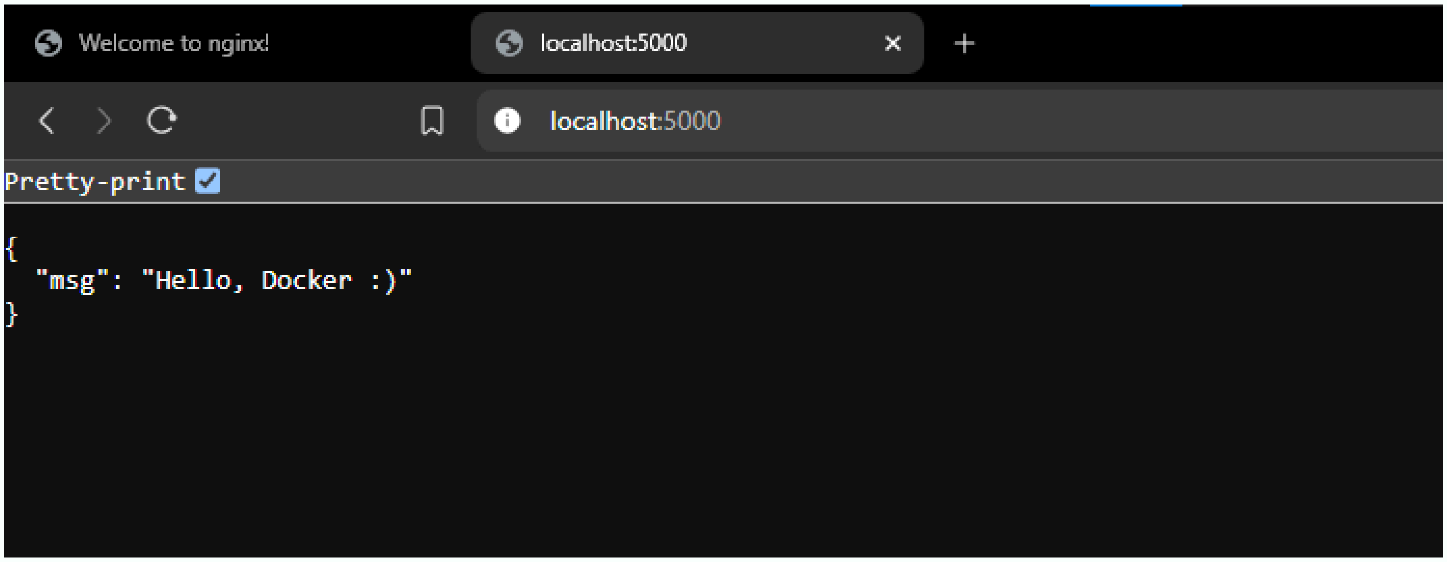
```
/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11 (0.452s)
ls -a
./  ../  dockerfile  node_modules/  package.json  package-lock.json  src/

/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...
```



```
/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 :)"
}
```

Conclusion :

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