

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:

```
1 const express = require("express");
2 const app = express();
3 const PORT = process.env.PORT || 5000;
4 app.get("/", (req, res) => {
5   res.status(200).json({ msg: "Hello, Docker :)" });
6 });
7
8 const init = async () => {
9   try {
10    app.listen(PORT, () => {
11      console.log(`Server is Listening on port ${PORT}...`);
12    });
13   } catch (error) {
14     console.log("There was an error : ", error);
15   }
16 };
17 init();
```

```
1 {
2   "name": "docker_demo",
3   "version": "1.0.0",
4   "description": "",
5   "main": "src/server.js",
6   "scripts": {
7     "start": "node src/server.js"
8   },
9   "keywords": [],
10  "author": "taha",
11  "license": "ISC",
12  "dependencies": {
13    "express": "^5.1.0"
14  }
```

```
10 FROM node:19-alpine
9
8 COPY package.json /app/
7 COPY src /app/
6
5 WORKDIR /app
4
3 RUN npm install
2
1 CMD ["node", "server.js"]
11
```

```
/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
=> [internal] load build definition from dockerfile
=> => transferring dockerfile: 169B
=> [internal] load metadata for docker.io/library/node:19-alpine
=> [auth] library/node:pull token for registry-1.docker.io
=> [internal] load .dockerignore
=> => transferring context: 2B
=> [1/5] FROM docker.io/library/node:19-alpine@sha256:8ec543d4795e2e85af924a24f8acb039792ae9fe8a42ad5b4bf4c277ab34b62e
=> => resolve docker.io/library/node:19-alpine@sha256:8ec543d4795e2e85af924a24f8acb039792ae9fe8a42ad5b4bf4c277ab34b62e
=> [internal] load build context
=> => transferring context: 90B
=> CACHED [2/5] COPY package.json /app/
=> CACHED [3/5] COPY src /app/
=> CACHED [4/5] WORKDIR /app
=> CACHED [5/5] RUN npm install
=> exporting to image
=> => exporting layers
=> => exporting manifest sha256:7b49e78368e8d2a07be85207b937d4db0d2aa99a51bee789c200f957f9e206df
=> => exporting config sha256:a844a1b4c76601423a9e4b4ed6ae6de45864d8c2f50e072701bc0441a3801367
=> => exporting attestation manifest sha256:2fa53de8c4c2a9d2d68fc0b3012f701a0756da075367a4c60b183925dedd87d0
=> => exporting manifest list sha256:152bfc3265d14f5bd54fc0a8688050703e28988be62e4ccbb1d3a6bd9ee98fb8
=> => naming to docker.io/library/demo-node-app:1.0.0
=> => unpacking to docker.io/library/demo-node-app:1.0.0

/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

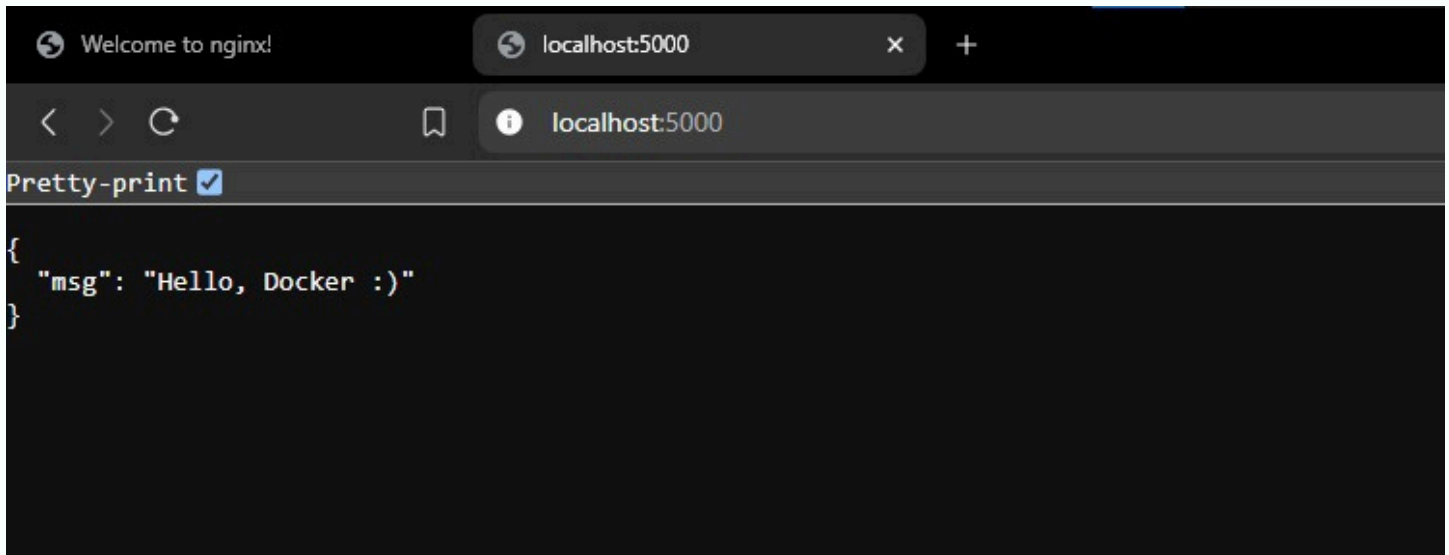
/d/MiscRepos/sepm_lab/Exp10_Docker git:(master)±11
docker run --name sepm-expt -p 5000:5000 demo-node-app:1.0.0
Server is Listening on port 5000...
```



```
/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) v ±11
```



Conclusion :

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