

Prefect User Guide

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Prefect Workflows - User Guide

Welcome to the comprehensive Prefect usage guide in Docker. This guide will teach you everything from basic concepts to advanced configurations.

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Introduction to Prefect

Prefect is a modern workflow orchestration platform that allows you to:

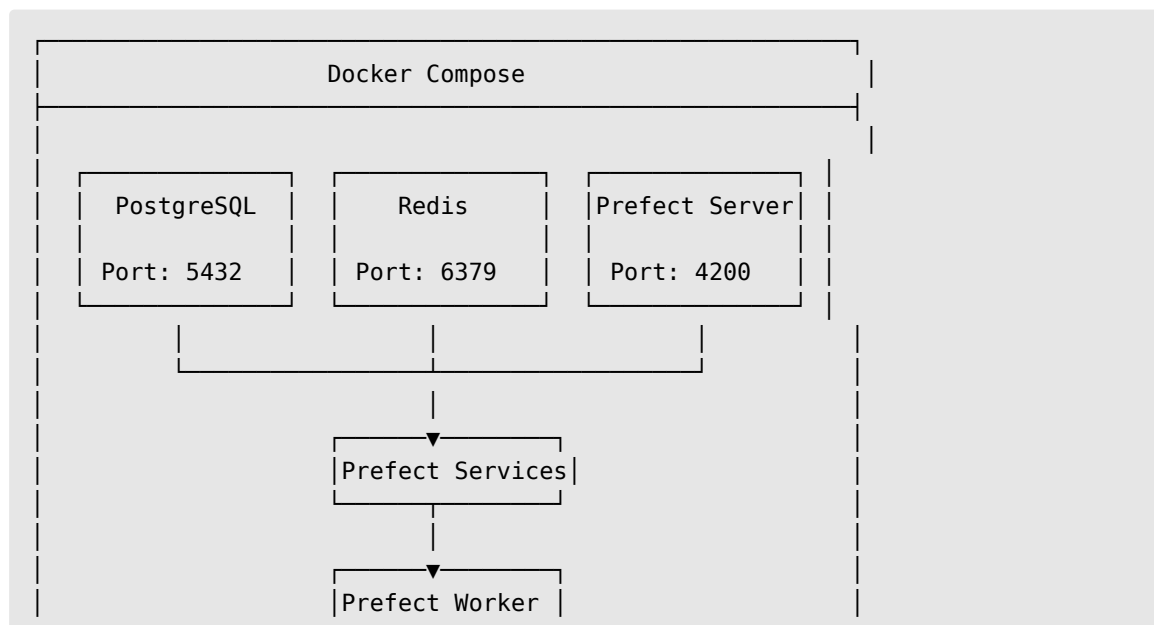
- **Orchestrate** complex data pipelines
- **Schedule** automatic executions with cron
- **Monitor** the status of your workflows in real-time
- **Receive alerts** when something fails
- **Automatically retry** failed tasks
- **Register centralized logs** of all your executions

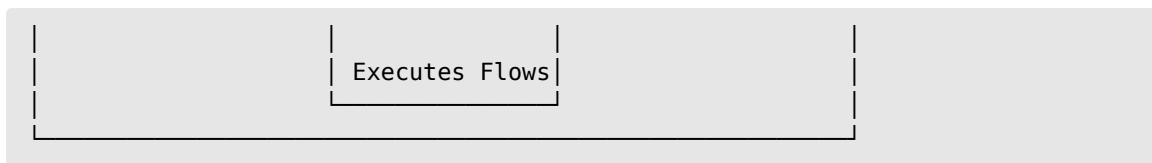
Why Prefect?

- **Simplicity:** Write normal Python code, Prefect handles the rest
 - **Observability:** Modern UI for visualization and debugging
 - **Reliability:** Retry system, timeouts, and error handling
 - **Scalability:** From local development to distributed production
-

Project Architecture

Docker Components





Data Persistence

Host (your computer)		Docker Containers
./data/postgres/	↔	PostgreSQL Data
./data/redis/	↔	Redis Data
./logs/server/	↔	Prefect Server Logs
./logs/services/	↔	Prefect Services Logs
./logs/worker/	↔	Prefect Worker Logs
./outputs/	↔	Task Outputs
./scripts/	↔	Python Workflows

Core Concepts

1. Tasks

A **task** is an individual unit of work. It's a Python function decorated with `@task`.

```
from prefect import task

@task
def extract_data(url: str):
    """Extracts data from an API"""
    # Your code here
    return data
```

Features: - Can receive parameters - Return values - Can be automatically retried - Have integrated logging - Execute independently

2. Flows

A **flow** is a collection of orchestrated tasks. It's a Python function decorated with `@flow`.

```
from prefect import flow, task

@task
def task_1():
    return "result 1"

@task
```

```
def task_2(input_data):
    return f"processed: {input_data}"

@flow
def my_workflow():
    result = task_1()
    final = task_2(result)
    return final
```

Features: - Orchestrate multiple tasks - Can call other flows (subflows) - Handle state and dependencies - Can be deployed and scheduled

3. Deployments

A **deployment** is a configuration that tells Prefect how and when to execute a flow.

```
if __name__ == "__main__":
    my_workflow.deploy(
        name="my-deployment",
        work_pool_name="local-pool",
        cron="0 9 * * *", # Every day at 9 AM
        tags=["production", "daily"]
    )
```

4. Work Pools and Workers

- **Work Pool:** A logical group of workers
- **Worker:** The process that executes flows

In our configuration: - Work Pool: local-pool - Worker Type: process (executes in separate processes)

Creating Your First Workflow

Step 1: Create the Python File

Create a new file in scripts/my_first_flow.py:

```
from prefect import flow, task
from prefect.logging import get_run_logger
import datetime

@task
def greet(name: str):
    logger = get_run_logger()
    message = f"Hello {name}!"
    logger.info(message)
    return message
```

```

@task
def get_timestamp():
    logger = get_run_logger()
    now = datetime.datetime.now()
    logger.info(f"Timestamp: {now}")
    return now

@flow(name="My First Flow")
def my_first_flow(name: str = "World"):
    """
    A simple flow that greets and shows the time
    """
    logger = get_run_logger()
    logger.info("Starting my first flow")

    # Execute tasks
    greeting = greet(name)
    timestamp = get_timestamp()

    logger.info("Flow completed successfully")
    return {"greeting": greeting, "timestamp": timestamp}

if __name__ == "__main__":
    # Run locally for testing
    my_first_flow(name="World")

```

Step 2: Run Locally

Test your flow directly:

```
docker compose exec prefect-worker python scripts/my_first_flow.py
```

You should see the logs in the console.

Step 3: Deploy the Flow

Modify the file to add deployment:

```

if __name__ == "__main__":
    my_first_flow.deploy(
        name="my-first-deployment",
        work_pool_name="local-pool",
        cron="*/5 * * * *", # Every 5 minutes
        tags=["tutorial", "basic"]
    )

```

Execute the deployment:

```
docker compose exec prefect-worker python scripts/my_first_flow.py
```

Step 4: Verify in the UI

1. Open <http://localhost:4200>
 2. Go to “Deployments”
 3. You should see “my-first-deployment”
 4. Go to “Flow Runs” to see executions
-

Working with Tasks

Task Configuration

Tasks support many configurations:

```
from prefect import task
from prefect.tasks import task_input_hash
from datetime import timedelta

@task(
    name="Process Data",
    description="Processes input data and returns results",
    tags=["processing", "data"],
    retries=3,                                # Retry 3 times if it fails
    retry_delay_seconds=60,                   # Wait 60s between retries
    timeout_seconds=300,                      # 5 minute timeout
    cache_key_fn=task_input_hash,             # Cache results based on inputs
    cache_expiration=timedelta(hours=1),     # Cache valid for 1 hour
    log_prints=True,                         # Capture prints as logs
)
def process_data(data: list):
    # Process data
    result = []
    for item in data:
        # Your logic here
        result.append(item * 2)
    return result
```

Tasks with Error Handling

```
from prefect import task, flow
from prefect.logging import get_run_logger
import requests

@task(retries=2, retry_delay_seconds=30)
def fetch_api_data(url: str):
    logger = get_run_logger()
```

```

try:
    response = requests.get(url, timeout=10)
    response.raise_for_status()
    logger.info(f"✓ Data obtained from {url}")
    return response.json()
except requests.RequestException as e:
    logger.error(f"✗ Error obtaining data: {e}")
    raise

@task
def process_api_data(data: dict):
    logger = get_run_logger()
    # Process the data
    result = data.get("results", [])
    logger.info(f"Processed {len(result)} items")
    return result

@flow
def api_pipeline():
    data = fetch_api_data("https://api.example.com/data")
    if data:
        return process_api_data(data)

```

Parallel Tasks

Prefect executes tasks in parallel automatically when possible:

```

from prefect import flow, task
import time

@task
def process_chunk(chunk_id: int, data: list):
    time.sleep(2) # Simulate processing
    return f"Chunk {chunk_id}: {len(data)} items processed"

@flow
def parallel_processing():
    """
    Processes multiple chunks in parallel
    """
    chunks = [
        [1, 2, 3, 4, 5],
        [6, 7, 8, 9, 10],
        [11, 12, 13, 14, 15],
        [16, 17, 18, 19, 20]
    ]

    # These tasks run in parallel

```



```

results = []
for i, chunk in enumerate(chunks):
    result = process_chunk.submit(i, chunk) # .submit() = async
    results.append(result)

# Wait for all to complete
return [r.result() for r in results]

```

Deployments and Scheduling

Schedule Types

1. Cron Schedule

```

@flow
def my_flow():
    pass

if __name__ == "__main__":
    my_flow.deploy(
        name="cron-example",
        work_pool_name="local-pool",
        cron="0 9 * * 1-5" # Monday to Friday at 9 AM
    )

```

Cron Examples: - "0 * * * *" - Every hour - "*/15 * * * *" - Every 15 minutes - "0 9,17 * * *" - At 9 AM and 5 PM - "0 0 * * 0" - Sundays at midnight - "30 2 1 * *" - First day of the month at 2:30 AM

2. Interval Schedule

```

from prefect.client.schemas.schedules import IntervalSchedule
from datetime import timedelta

if __name__ == "__main__":
    my_flow.deploy(
        name="interval-example",
        work_pool_name="local-pool",
        interval=timedelta(hours=2) # Every 2 hours
    )

```

3. No Schedule (Manual)

```

if __name__ == "__main__":
    my_flow.deploy(
        name="manual-example",
    )

```

```

    work_pool_name="local-pool"
    # No cron or interval = manual execution only
)

```

Deployment with Parameters

```

from prefect import flow

@flow
def process_file(file: str, format: str = "csv"):
    # Your code here
    pass

if __name__ == "__main__":
    process_file.deploy(
        name="process-data",
        work_pool_name="local-pool",
        parameters={
            "file": "/app/outputs/data.csv",
            "format": "csv"
        },
        cron="0 10 * * *"
    )

```

Multiple Deployments of the Same Flow

You can have different schedules for the same flow:

```

if __name__ == "__main__":
    # Deployment 1: Every hour during business hours
    my_flow.deploy(
        name="business-hours",
        work_pool_name="local-pool",
        cron="0 9-18 * * 1-5",
        parameters={"mode": "incremental"}
    )

    # Deployment 2: Daily at midnight (full refresh)
    my_flow.deploy(
        name="nightly-refresh",
        work_pool_name="local-pool",
        cron="0 0 * * *",
        parameters={"mode": "full"}
    )

```

Logging and Monitoring

Using Loggers

```
from prefect import flow, task
from prefect.logging import get_run_logger

@task
def process_data(items: list):
    logger = get_run_logger()

    logger.debug("Starting processing")
    logger.info(f"Processing {len(items)} items")

    errors = 0
    for i, item in enumerate(items):
        try:
            # Process item
            result = item * 2
            logger.debug(f"Item {i}: {item} → {result}")
        except Exception as e:
            errors += 1
            logger.error(f"Error in item {i}: {e}")

    if errors > 0:
        logger.warning(f"Found {errors} errors")
    else:
        logger.info("✓ Processing completed without errors")

    return len(items) - errors

@flow
def my_pipeline():
    logger = get_run_logger()
    logger.info("=== Starting Pipeline ===")

    data = [1, 2, 3, 4, 5]
    processed = process_data(data)

    logger.info(f"=== Pipeline Completed: {processed} items ===")
```

Logging Levels

Logs are automatically saved in: - **Container:** /root/.prefect/logs/ - **Host:** ./logs/worker/

Available levels: - DEBUG - Detailed information for debugging - INFO - General flow information - WARNING - Warnings that don't stop execution - ERROR - Errors that affect the task - CRITICAL - Critical system errors

View Logs

From Docker

```
# Worker logs in real-time
docker compose logs -f prefect-worker

# Server logs
docker compose logs -f prefect-server

# Logs from a specific period
docker compose logs --since 1h prefect-worker
```

From the UI

1. Go to <http://localhost:4200>
2. Navigate to “Flow Runs”
3. Click on any run
4. Go to the “Logs” tab

From the File System

```
# View most recent logs
tail -f logs/worker/*.log

# Search for errors
grep "ERROR" logs/worker/*.log

# View logs from a specific date
ls -lh logs/worker/
```

Working with Outputs

Saving Outputs to Files

```
from prefect import flow, task
from prefect.logging import get_run_logger
import json
import csv
from pathlib import Path
from datetime import datetime

@task
def save_json(data: dict, filename: str):
    """Saves data in JSON format"""
    logger = get_run_logger()

    # Create path with timestamp
    timestamp = datetime.now().strftime("%Y%m%d_%H%M%S")
```

```

filepath = Path(f"/app/outputs/{filename}_{timestamp}.json")

# Save file
with open(filepath, 'w', encoding='utf-8') as f:
    json.dump(data, f, indent=2, ensure_ascii=False)

logger.info(f"✓ File saved: {filepath}")
return str(filepath)

@task
def save_csv(data: list, filename: str):
    """Saves data in CSV format"""
    logger = get_run_logger()

    timestamp = datetime.now().strftime("%Y%m%d_%H%M%S")
    filepath = Path(f"/app/outputs/{filename}_{timestamp}.csv")

    if not data:
        logger.warning("No data to save")
        return None

    # Get headers from first row
    headers = data[0].keys()

    with open(filepath, 'w', newline='', encoding='utf-8') as f:
        writer = csv.DictWriter(f, fieldnames=headers)
        writer.writeheader()
        writer.writerows(data)

    logger.info(f"✓ CSV saved: {filepath} ({len(data)} rows)")
    return str(filepath)

@task
def save_text_report(stats: dict, filename: str):
    """Saves a text report"""
    logger = get_run_logger()

    timestamp = datetime.now().strftime("%Y%m%d_%H%M%S")
    filepath = Path(f"/app/outputs/{filename}_{timestamp}.txt")

    with open(filepath, 'w', encoding='utf-8') as f:
        f.write("=" * 60 + "\n")
        f.write(f"REPORT GENERATED: {datetime.now()}\n")
        f.write("=" * 60 + "\n\n")

        for key, value in stats.items():
            f.write(f"{key}: {value}\n")

```

```

logger.info(f"✓ Report saved: {filepath}")
return str(filepath)

@flow
def pipeline_with_outputs():
    """Flow that generates multiple outputs"""
    logger = get_run_logger()

    # Generate sample data
    data = {
        "timestamp": str(datetime.now()),
        "records_processed": 1000,
        "errors": 5,
        "success_rate": 99.5
    }

    table_data = [
        {"id": 1, "name": "Item 1", "value": 100},
        {"id": 2, "name": "Item 2", "value": 200},
        {"id": 3, "name": "Item 3", "value": 300}
    ]

    stats = {
        "Total Items": len(table_data),
        "Total Sum": sum(item["value"] for item in table_data),
        "Average": sum(item["value"] for item in table_data) / len(table_data)
    }

    # Save in different formats
    json_file = save_json(data, "results")
    csv_file = save_csv(table_data, "table_results")
    txt_file = save_text_report(stats, "statistics_report")

    logger.info(f"✓ Outputs generated: JSON, CSV, TXT")

    return {
        "json": json_file,
        "csv": csv_file,
        "txt": txt_file
    }

```

Accessing the Outputs

Files are saved in /app/outputs/ inside the container, which is mapped to ./outputs/ on your host:

```

# View generated files
ls -lh outputs/

```

```
# View JSON content
cat outputs/results_*.json | jq .

# View CSV
cat outputs/table_results_*.csv
```

Advanced Configuration

Environment Variables in Flows

```
from prefect import flow, task
import os

@task
def use_environment_variables():
    api_key = os.getenv("API_KEY", "default_key")
    env = os.getenv("ENVIRONMENT", "development")
    return f"Env: {env}, API: {api_key[:5]}..."

@flow
def flow_with_env():
    return use_environment_variables()
```

To add environment variables, edit `docker-compose.yml`:

```
prefect-worker:
  environment:
    PREFECT_API_URL: http://prefect-server:4200/api
    API_KEY: "your_api_key_here"
    ENVIRONMENT: "production"
```

Secrets and Blocks

For sensitive data, use Prefect Blocks:

```
from prefect.blocks.system import Secret

# Create secret (do once)
secret = Secret(value="my_secret_password")
secret.save("my-db-password")

# Use in a flow
@task
def connect_db():
    from prefect.blocks.system import Secret
```

```
password = Secret.load("my-db-password").get()
# Use password
```

Notifications

Configure notifications when a flow fails:

```
from prefect import flow
from prefect.events import emit_event

@flow
def flow_with_notifications():
    try:
        # Your code here
        result = process_data()

        # Emit success event
        emit_event(
            event="flow.completed",
            resource={"prefect.resource.id": "my_flow"}
        )

        return result
    except Exception as e:
        # Emit error event
        emit_event(
            event="flow.error",
            resource={"prefect.resource.id": "my_flow"},
            payload={"error": str(e)}
        )
        raise
```

Practical Examples

Example 1: Simple ETL

```
from prefect import flow, task
from prefect.logging import get_run_logger
import requests
import json
from datetime import datetime

@task(retries=3, retry_delay_seconds=60)
def extract_data(api_url: str):
    """Extract: Get data from an API"""
    logger = get_run_logger()
```



```

logger.info(f"Extracting data from {api_url}")

response = requests.get(api_url, timeout=30)
response.raise_for_status()
data = response.json()

logger.info(f"✓ {len(data)} records extracted")
return data

@task
def transform_data(data: list):
    """Transform: Clean and transform data"""
    logger = get_run_logger()
    logger.info("Transforming data")

    clean_data = []
    for item in data:
        # Transformation example
        transformed = {
            "id": item.get("id"),
            "name": item.get("name", "").upper(),
            "value": float(item.get("value", 0)),
            "processed_at": datetime.now().isoformat()
        }
        clean_data.append(transformed)

    logger.info(f"✓ {len(clean_data)} records transformed")
    return clean_data

@task
def load_data(data: list, output_file: str):
    """Load: Save processed data"""
    logger = get_run_logger()
    logger.info(f"Loading data to {output_file}")

    filepath = f"/app/outputs/{output_file}"
    with open(filepath, 'w') as f:
        json.dump(data, f, indent=2)

    logger.info(f"✓ Data loaded successfully")
    return filepath

@flow(name="ETL Pipeline")
def etl_pipeline():
    """Complete ETL pipeline"""
    logger = get_run_logger()
    logger.info("=== Starting ETL Pipeline ===")

```

```

# Extract
raw_data = extract_data("https://jsonplaceholder.typicode.com/users")

# Transform
transformed_data = transform_data(raw_data)

# Load
timestamp = datetime.now().strftime("%Y%m%d_%H%M%S")
file = load_data(transformed_data, f"etl_output_{timestamp}.json")

logger.info("=== ETL Pipeline Completed ===")
return file

if __name__ == "__main__":
    # Deploy with daily schedule
    etl_pipeline.deploy(
        name="daily-etl",
        work_pool_name="local-pool",
        cron="0 2 * * *", # 2 AM every day
        tags=["etl", "production"]
    )

```

Example 2: Web Scraping

```

from prefect import flow, task
from prefect.logging import get_run_logger
import requests
from bs4 import BeautifulSoup
import csv
from datetime import datetime

@task(retries=2)
def scrape_page(url: str):
    """Scrapes a web page"""
    logger = get_run_logger()
    logger.info(f"Scraping: {url}")

    response = requests.get(url, timeout=30)
    response.raise_for_status()

    soup = BeautifulSoup(response.content, 'html.parser')

    # Example: extract titles
    titles = []
    for element in soup.find_all('h2'):
        titles.append({
            "title": element.text.strip(),
            "url": url,

```

```

        "scrape_date": datetime.now().isoformat()
    })

    logger.info(f"✓ {len(titles)} elements found")
    return titles

@task
def save_scrape_results(data: list):
    """Saves scraping results"""
    logger = get_run_logger()

    timestamp = datetime.now().strftime("%Y%m%d_%H%M%S")
    filepath = f"/app/outputs/scrape_results_{timestamp}.csv"

    if data:
        with open(filepath, 'w', newline='', encoding='utf-8') as f:
            writer = csv.DictWriter(f, fieldnames=data[0].keys())
            writer.writeheader()
            writer.writerows(data)

        logger.info(f"✓ Results saved: {filepath}")

    return filepath

@flow
def web_scraping_flow(urls: list):
    """Web scraping flow"""
    logger = get_run_logger()
    logger.info(f"Starting scraping of {len(urls)} URLs")

    all_data = []
    for url in urls:
        data = scrape_page(url)
        all_data.extend(data)

    file = save_scrape_results(all_data)
    logger.info(f"✓ Scraping completed: {len(all_data)} items")

    return file

```

Example 3: File Processing

```

from prefect import flow, task
from prefect.logging import get_run_logger
import pandas as pd
from pathlib import Path

@task

```

```

def read_csv_file(filepath: str):
    """Reads a CSV file"""
    logger = get_run_logger()
    logger.info(f"Reading file: {filepath}")

    df = pd.read_csv(filepath)
    logger.info(f"✓ {len(df)} rows read")

    return df

@task
def analyze_data(df: pd.DataFrame):
    """Performs data analysis"""
    logger = get_run_logger()
    logger.info("Analyzing data")

    analysis = {
        "total_rows": len(df),
        "total_columns": len(df.columns),
        "columns": list(df.columns),
        "statistics": df.describe().to_dict()
    }

    logger.info(f"✓ Analysis completed")
    return analysis

@task
def generate_report(analysis: dict):
    """Generates analysis report"""
    logger = get_run_logger()

    timestamp = datetime.now().strftime("%Y%m%d_%H%M%S")
    filepath = f"/app/outputs/analysis_report_{timestamp}.txt"

    with open(filepath, 'w') as f:
        f.write("ANALYSIS REPORT\n")
        f.write("=" * 50 + "\n\n")
        f.write(f"Total Rows: {analysis['total_rows']}\n")
        f.write(f"Total Columns: {analysis['total_columns']}\n")
        f.write(f"\nColumns: {' '.join(analysis['columns'])}\n")

    logger.info(f"✓ Report saved: {filepath}")
    return filepath

@flow
def file_processing_flow(input_file: str):
    """Processes file and generates report"""
    logger = get_run_logger()

```

```

logger.info("=== Starting Processing ===")

df = read_csv_file(input_file)
analysis = analyze_data(df)
report = generate_report(analysis)

logger.info("=== Processing Completed ===")
return report

```

Best Practices

1. Code Structure

```

# ✓ GOOD: Separate concerns
@task
def extract():
    pass

@task
def transform():
    pass

@task
def load():
    pass

@flow
def etl():
    data = extract()
    clean = transform(data)
    load(clean)

# x BAD: Everything in one task
@task
def do_everything():
    # Extract, transform, load all together
    pass

```

2. Appropriate Logging

```

# ✓ GOOD: Informative logging
@task
def process(items: list):
    logger = get_run_logger()
    logger.info(f"Processing {len(items)} items")

```

```

    for i, item in enumerate(items):
        logger.debug(f"Processing item {i}")
        # process

    logger.info("✓ Processing completed")

# x BAD: Excessive or absent logging
@task
def process(items: list):
    for item in items:
        print(f"Item: {item}") # Don't use print

```

3. Error Handling

```

# ✓ GOOD: Specific error handling
@task(retries=3)
def task_with_handling():
    logger = get_run_logger()
    try:
        # code
        pass
    except SpecificException as e:
        logger.error(f"Specific error: {e}")
        raise
    except Exception as e:
        logger.error(f"Unexpected error: {e}")
        raise

# x BAD: Silencing errors
@task
def bad_task():
    try:
        # code
        pass
    except:
        pass # Don't do this!

```

4. Parameterization

```

# ✓ GOOD: Use parameters
@flow
def pipeline(date: str, mode: str = "incremental"):
    # Flexible and reusable
    pass

# x BAD: Hardcode values
@flow

```

```
def pipeline():
    date = "2024-01-01" # Hardcoded
    mode = "full"
```

5. Documentation

```
# ✓ GOOD: Document flows and tasks
@task
def process_data(data: list) -> dict:
    """
    Processes a list of data and returns statistics.

    Args:
        data: List of dictionaries with data to process

    Returns:
        Dict with processing statistics

    Raises:
        ValueError: If data is empty
    """
    if not data:
        raise ValueError("Empty data")

    # processing
    return {"processed": len(data)}
```

Useful Reference Commands

Flow Management

```
# List flows
docker compose exec prefect-server prefect flow ls

# View flow details
docker compose exec prefect-server prefect flow inspect "flow-name"

# List recent runs
docker compose exec prefect-server prefect flow-run ls --limit 10
```

Deployment Management

```
# List deployments
docker compose exec prefect-server prefect deployment ls

# View deployment details
```

```
docker compose exec prefect-server prefect deployment inspect "flow-name/
deployment-name"

# Execute a deployment manually
docker compose exec prefect-server prefect deployment run "flow-name/deployment-
name"

# Pause a deployment
docker compose exec prefect-server prefect deployment pause "flow-name/
deployment-name"

# Resume a deployment
docker compose exec prefect-server prefect deployment resume "flow-name/
deployment-name"
```

Work Pool Management

```
# List work pools
docker compose exec prefect-server prefect work-pool ls

# View work pool details
docker compose exec prefect-server prefect work-pool inspect local-pool

# Pause a work pool
docker compose exec prefect-server prefect work-pool pause local-pool
```

Additional Resources

Official Documentation

- **Prefect Docs:** <https://docs.prefect.io>
- **API Reference:** <https://docs.prefect.io/api-ref/>
- **Concepts:** <https://docs.prefect.io/concepts/>

Community

- **Slack:** <https://prefect.io/slack>
- **GitHub:** <https://github.com/PrefectHQ/prefect>
- **Discourse:** <https://discourse.prefect.io>

Tutorials

- **Prefect Recipes:** <https://docs.prefect.io/recipes/>
- **Examples:** <https://github.com/PrefectHQ/prefect/tree/main/examples>

Common Troubleshooting

Flow doesn't execute on schedule

1. Verify the worker is running: `docker compose ps`
2. Verify the deployment is active in the UI
3. Check the logs: `docker compose logs -f prefect-worker`

Tasks fail with timeout

Increase the timeout in the task configuration:

```
@task(timeout_seconds=600) # 10 minutes
def slow_task():
    pass
```

Cannot save outputs

Verify permissions of the outputs folder:

```
chmod -R 777 outputs/
```

Logs don't appear in the UI

Verify you're using `get_run_logger()`:

```
from prefect.logging import get_run_logger

@task
def my_task():
    logger = get_run_logger() # Use this
    logger.info("Message")    # Not print()
```

You're now ready to create powerful workflows with Prefect!

For deployment, see `deploy.md`.