routes/bookings.py

```python
@router.post("/bookings")
async def create_booking(
  payload: BookingCreate,
  session: SessionDep,
  user: CurrentUser,
) -> BookingRead:
  return await bookings.create(
    session, user, payload)
```





async · Pydantic · SQLAlchemy · OAuth2 · pytest

THE COMPLETE PRACTICAL GUIDE

FastAPI

Building High-Performance Python APIs

Design, build, secure, test, and deploy production APIs with async Python

Pydantic v2 · SQLAlchemy 2.0 · PostgreSQL · Redis
WebSockets · Docker · Kubernetes · OpenTelemetry

ASGI · VALIDATION · SECURITY · PERFORMANCE

THENEXBOOKS

FastAPI

Building High-Performance Python APIs
The Complete Practical Guide to Designing, Building, Securing, Testing, and Deploying Production APIs

First Edition

THENEXBOOKS

FastAPI: Building High-Performance Python APIs
The Complete Practical Guide

First Edition, 2026

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Stayloft, the running example in this book, is fictional, as are all hosts, guests, listings, and payment providers mentioned in its examples. Any resemblance to real companies or products is coincidental.

Preface

Python has become one of the most widely used languages for building backend services. Data teams, machine learning teams, startups, and large engineering organizations all reach for it — and when they need an HTTP API, FastAPI has become a very popular choice. It lets you describe your API with ordinary Python type hints and turns those hints into request validation, response serialization, editor support, and interactive documentation, all at once.

That first experience is delightful: a few lines of code and you have a documented, validated endpoint. The hard part comes later. Real APIs need a structure that survives dozens of endpoints and several developers, database access that stays correct under concurrent requests, authentication and authorization that cannot be bypassed, versioning that does not break clients, async code that never quietly blocks the event loop, tests you can trust, and a deployment you can observe and scale. That is where most teams spend their time, and that is where most of this book lives.

This book is a complete, practical guide to building production APIs with FastAPI. We start from the fundamentals of ASGI, type hints, and Pydantic, build a real API step by step, and then go deep on persistence, security, API evolution, performance, background work, real-time features, testing, observability, and deployment. We explain *why* each technique works — and where it breaks — not just *how* to type it.

Who This Book Is For

- **Python developers** who want to build professional HTTP APIs, whether they are new to web backends or coming from Flask or Django.
- **Backend engineers** from other stacks who need to become productive with FastAPI and async Python quickly.
- **Data and ML engineers** who need to put models and data services behind a robust, well-documented API.
- **Tech leads** who set conventions for project structure, security, testing, and operations across teams.

What You Will Learn

- How FastAPI, Starlette, ASGI, and Pydantic fit together, and a modern Python setup with uv and Ruff.
- Path operations, parameters, request and response models, validation, and settings with Pydantic v2.
- Dependency injection, consistent error handling, and a project structure that scales.
- Pagination, filtering, file uploads, and streaming responses.

- SQLAlchemy 2.0 with sync and async sessions, Alembic migrations, transactions, and concurrency control.
- Caching and rate limiting with Redis; CORS, secrets, password hashing, OAuth2, JWT, scopes, and ownership checks.
- Versioning, idempotency, OpenAPI customization, and generated clients.
- Async done right, performance tuning, background jobs, webhooks, WebSockets, and Server-Sent Events.
- Testing with pytest and Testcontainers, observability with logs, metrics, and traces, and deployment with Docker and Kubernetes.

How This Book Is Organized

Part I — Foundations (Chapters 1–5) explains how FastAPI works, sets up your tools, covers the modern Python it relies on, and builds your first endpoints with request and response models. **Part II — Building the API** (Chapters 6–10) goes deep on validation, dependency injection, error handling, project structure, and resource design. **Part III — Data and Persistence** (Chapters 11–15) connects Stayloft to PostgreSQL and Redis with SQLAlchemy, Alembic, transactions, and caching. **Part IV — Security and API Evolution** (Chapters 16–20) protects the API and lets it change safely over time. **Part V — Performance, Integration, and Testing** (Chapters 21–25) makes the service fast, connects it to other systems, adds real-time features, and tests it thoroughly. **Part VI — Production and Case Study** (Chapters 26–28) makes the service observable, deploys it, and walks through taking the whole platform to production. The appendices provide a cheat sheet, templates and reference tables, a production checklist, and a glossary.

Each chapter ends with a **Key Takeaways** box for quick review.

The Running Example: Stayloft

Throughout the book we build **Stayloft**, a fictional vacation-rental booking platform. Hosts list apartments, cabins, and villas; guests search by city, dates, and price and book stays; payments arrive through a payment provider's webhooks; guests and hosts chat about check-in; and reviews follow each stay. That gives us everything a real API faces: search with filters and pagination, availability that must never be double-booked, money that must be exact, three kinds of users with different permissions, file uploads, real-time messaging, and traffic that spikes when a popular destination opens up. The code lives in the Python package `stayloft`, stores data in PostgreSQL, uses Redis for caching and rate limits, and exposes its API under `/api/v1`.

Versions and Conventions

Examples target Python 3.12 (most code also runs on 3.10 and later), recent FastAPI releases, Pydantic v2, and SQLAlchemy 2.0. Where a feature arrived in a specific release, we say so. FastAPI and its ecosystem move quickly; where details may have changed since writing, a Note points you to the official documentation rather than guessing.

> **TIP**
> A recommended practice or a technique that makes your work easier.

> **NOTE**
> Background information, version details, or a useful aside.

> **WARNING**
> A common mistake or a behavior that can cause bugs, security problems, or outages in production.

Code appears in `monospace`. Long lines are wrapped to fit the page. Parameters and dependencies use the `Annotated` style recommended by recent FastAPI versions, and money is always stored as integer cents.

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PART I

Foundations

How FastAPI, Starlette, ASGI, and Pydantic fit together, a modern Python project setup, the type hints and async/await that FastAPI builds on, and a first Stayloft API with validated requests and responses.

1 · Why FastAPI
2 · Setting Up
3 · Modern Python for FastAPI
4 · Your First API
5 · Request Bodies and Response Models

CHAPTER 1 · PART I — FOUNDATIONS

Why FastAPI: The Big Picture, ASGI, and How FastAPI Works

Before we write a single endpoint, we want you to understand what FastAPI actually is, what it is built on, how a request travels through it, and what "high performance" honestly means. With that mental model in place, every later chapter will make more sense.

What FastAPI Is (and What It Is Not)

FastAPI is a Python web framework for building HTTP APIs. You describe your endpoints as ordinary Python functions, annotate their parameters with type hints, and FastAPI takes care of the repetitive work that every API needs: parsing the incoming request, validating and converting data, producing helpful error messages, serializing responses to JSON, and generating an OpenAPI description of the whole API that powers interactive documentation.

The key idea is that **your type hints are the specification**. When you write a function parameter as `guests: int`, you are not just documenting intent for other developers or for a type checker. FastAPI reads that annotation at startup and uses it at runtime to decide where the value comes from, how to convert the raw text in the URL into an integer, what error to send back when the conversion fails, and how to describe that parameter in the OpenAPI schema. One declaration drives validation, conversion, documentation, and editor support at the same time.

FastAPI does not do all of this from scratch. It is deliberately a thin, well-designed layer on top of two mature libraries:

- **Starlette** is a lightweight ASGI toolkit. It provides the web plumbing: routing, request and response objects, middleware, WebSockets, background tasks, static files, and the test client. When you use FastAPI, you are using Starlette underneath, and a FastAPI application object is in fact a subclass of Starlette's application class.
- **Pydantic** is a data validation library driven by type hints. FastAPI hands your request bodies, query parameters, and response data to Pydantic, which validates them against the models and types you declare. Pydantic v2 has a core written in Rust (the `pydantic-core` package), which is one reason validation stays cheap relative to the rest of the work in a typical request.

FastAPI's own contribution is the glue: it inspects your function signatures, builds a dependency graph, wires Pydantic validation to the right parts of the HTTP request, and generates an OpenAPI document from everything it learned. That division of labor matters in practice. When you need a

lower-level feature, such as a custom middleware or a streaming response, you will often reach for a Starlette class directly, and FastAPI is happy to let you.

It is equally useful to be clear about what FastAPI is *not*. It is not a full-stack framework in the style of Django: there is no built-in ORM, no admin panel, no template-driven page rendering as a primary concern, and no built-in user model. Those choices are left to you. In this book we pair FastAPI with SQLAlchemy 2.0 for persistence, Alembic for migrations, Redis for caching, and a handful of other well-known libraries. That freedom is a strength when you want to build exactly the API you need, and a cost when you want batteries included. We will come back to that trade-off when we discuss fit.

A first taste

Here is a tiny but complete FastAPI application. We will set up a proper project in Chapter 2; for now, just read it and notice how much information lives in the signatures.

hello.py

```
from typing import Annotated

from fastapi import FastAPI, Query
from pydantic import BaseModel

app = FastAPI(title="Stayloft preview")


class ListingSummary(BaseModel):
    id: int
    title: str
    city: str
    nightly_price_cents: int


FAKE_LISTINGS = [
    ListingSummary(id=1, title="Harbor loft", city="Lisbon", nightly_price_cents=14500),
    ListingSummary(id=2, title="Pine cabin", city="Denver", nightly_price_cents=11000),
]


@app.get("/listings")
async def search_listings(
    city: Annotated[str | None, Query(max_length=80)] = None,
    max_price_cents: Annotated[int | None, Query(ge=0)] = None,
) -> list[ListingSummary]:
    results = FAKE_LISTINGS
    if city is not None:
        results = [item for item in results if item.city.lower() == city.lower()]
    if max_price_cents is not None:
        results = [
            item for item in results if item.nightly_price_cents <= max_price_cents
        ]
    return results
```

From those few lines FastAPI knows that `city` and `max_price_cents` are optional query parameters, that the city must be at most 80 characters, that the price must be a non-negative integer, and that the response is a JSON array of objects with four fields. If a client sends `?max_price_cents=cheap`, FastAPI responds with a `422 Unprocessable Content` error that names the exact parameter and problem, without a single line of manual validation code on our side:

```
$ curl -s "http://127.0.0.1:8000/listings?max_price_cents=cheap"
{
  "detail": [
    {
      "type": "int_parsing",
      "loc": ["query", "max_price_cents"],
      "msg": "Input should be a valid integer, unable to parse string as an integer",
      "input": "cheap"
    }
  ]
}
```

And if you open `/docs` in a browser while the app is running, you get interactive documentation generated from the same declarations. That combination, where one set of type hints produces validation, errors, serialization, and documentation, is the reason FastAPI became popular so quickly.

> **NOTE**
> The exact wording of validation messages can differ between Pydantic releases. Clients should rely on the `loc` and `type` fields, not the message text; Chapter 8 defines our own error format.

WSGI and ASGI: The Interface Underneath

To understand why FastAPI behaves the way it does, we need to look one level down, at the contract between a Python application and the server that feeds it HTTP requests.

WSGI: the synchronous standard

For many years, Python web applications used **WSGI**, the Web Server Gateway Interface, standardized in PEP 3333. A WSGI application is a callable that receives a dictionary describing the request and a function for starting the response, and returns an iterable of bytes:

```
def application(environ: dict, start_response) -> list[bytes]:
    body = b"Hello from WSGI"
    start_response("200 OK", [("Content-Type", "text/plain"),
                              ("Content-Length", str(len(body)))])
    return [body]
```

This model is simple and it has served Flask, Django, and countless other applications well. Its limitation is structural: one call handles one request from start to finish, synchronously. While your code waits for a database query or an outbound HTTP call, the worker thread or process that is running it can do nothing else. To handle many requests at once, a WSGI server runs many processes or threads. That works, but every waiting request ties up a whole thread or process, and long-lived connections such as WebSockets do not fit the one-call-per-request shape at all.

ASGI: the asynchronous successor

ASGI, the Asynchronous Server Gateway Interface, was designed as a spiritual successor to WSGI that embraces `async` / `await`. An ASGI application is an *async* callable that receives three arguments: a `scope` dictionary describing the connection, a `receive` coroutine for reading incoming events, and a `send` coroutine for emitting outgoing events.

raw_asgi.py

```
from typing import Any, Awaitable, Callable

Scope = dict[str, Any]
Receive = Callable[[], Awaitable[dict[str, Any]]]
Send = Callable[[dict[str, Any]], Awaitable[None]]


async def app(scope: Scope, receive: Receive, send: Send) -> None:
    if scope["type"] != "http":
        return  # this toy app ignores websocket and lifespan events

    body = b'{"message": "Hello from raw ASGI"}'
    await send(
        {
            "type": "http.response.start",
            "status": 200,
            "headers": [(b"content-type", b"application/json")],
        }
    )
    await send({"type": "http.response.body", "body": body})
```

You can run this file with Uvicorn (`uvicorn raw_asgi:app`) and it will answer every HTTP request with a small JSON document. Nobody writes production applications at this level, but seeing it once demystifies the stack. Three things stand out:

- The callable is `async`, so the server can run many of them concurrently on a single event loop. While one request awaits I/O, others make progress.
- Communication is **event-based**. A response is not a single return value; it is a sequence of messages. That is what makes streaming responses, server-sent events, and WebSockets natural in ASGI.

- The `scope["type"]` field distinguishes connection types. The standard types are `"http"`, `"websocket"`, and `"lifespan"`. The lifespan type is how the server tells the application that it is starting up or shutting down, which FastAPI exposes through its `lifespan` parameter (Chapter 9).

The stack therefore looks like this: an ASGI **server** (Uvicorn in this book; Hypercorn and Granian are alternatives) accepts TCP connections, parses HTTP, and calls the ASGI **application**. Starlette implements a friendly application on top of the raw protocol. FastAPI extends Starlette with type-driven validation, dependency injection, and OpenAPI.

```
Client (browser, mobile app, other service)
          |
          |  HTTP/1.1 over TCP (TLS usually terminated at a proxy)
          v
+----------------------------+
|  ASGI server: Uvicorn      |  sockets, HTTP parsing, event loop
+----------------------------+
          |  scope / receive / send
          v
+----------------------------+
|  Middleware stack          |  CORS, GZip, request IDs, ...
+----------------------------+
          v
+----------------------------+
|  Starlette router          |  match method + path
+----------------------------+
          v
+----------------------------+
|  FastAPI route handling    |  dependencies, Pydantic validation,
|                            |  your function, response model
+----------------------------+
```

> **TIP**
> When something strange happens in production, knowing which layer owns a behavior saves hours. Connection limits, keep-alive, and HTTP parsing belong to the server. CORS and compression belong to middleware. Path matching belongs to the router. Validation errors and response filtering belong to FastAPI. Look in the right layer first.

How a Request Travels Through FastAPI

Let us follow a single request through a FastAPI application in more detail. Suppose a guest's mobile app calls `GET /api/v1/listings?city=Lisbon&guests=2` on the Stayloft API.

1. **The server accepts the connection.** Uvicorn reads bytes from the socket, parses the request line and headers, and builds an ASGI `scope` containing the method, path, query string, headers, client address, and more.

2. **Middleware runs.** The application is wrapped in a stack of middleware. Each one can inspect or modify the request on the way in and the response on the way out. Starlette always places an error-handling middleware at the outer edge and an exception middleware closer to the routes; your own middleware sits between them.
3. **The router finds a route.** Starlette's router compares the method and path against the registered routes. If no path matches you get a `404`; if the path matches but the method does not, you get a `405 Method Not Allowed`.
4. **FastAPI resolves dependencies and parameters.** This is FastAPI's heart. At startup, when you decorated your function, FastAPI analyzed its signature and built a description of every parameter: where it comes from (path, query, header, cookie, body, or a dependency), its type, and its constraints. At request time it extracts each value, runs any dependencies (Chapter 7), and validates everything with Pydantic. Validation errors are collected together, so the client sees all the problems in one response rather than one at a time.
5. **Your function runs.** If it is an `async def` function, FastAPI awaits it directly on the event loop. If it is a plain `def` function, FastAPI runs it in a thread pool so that it cannot block the loop. We explore that distinction deeply in Chapter 21, but you should know from day one that it exists.
6. **The return value is serialized.** If you declared a return type or `response_model`, FastAPI validates and filters the returned data through that model, dropping fields that are not declared. It then converts the result to JSON-compatible data and wraps it in a response object. If your function returned a `Response` instance directly, FastAPI sends it as is.
7. **The response flows back out.** The response passes back through the middleware stack, and the server writes the status line, headers, and body to the socket.

Two consequences of this pipeline are worth stating plainly. First, much of FastAPI's work happens **once, at startup**: signatures are analyzed when the route is registered, not on every request. Second, **validation happens at the boundaries**. Data coming in is validated before your function sees it, and data going out is validated before the client sees it. Inside your function you can trust the types you declared, which is a big part of why FastAPI code tends to be short.

```
from typing import Annotated

from fastapi import FastAPI, Query

app = FastAPI()


@app.get("/api/v1/listings")
async def search_listings(
    city: Annotated[str, Query(min_length=1, max_length=80)],
    guests: Annotated[int, Query(ge=1, le=16)] = 1,
) -> dict[str, object]:
    # By the time we get here, city is a non-empty str and guests is an int in 1..16.
    return {"city": city, "guests": guests, "results": []}
```

Notice what is *absent* from this function: no `int(request.args["guests"])`, no `try`/`except ValueError`, no manual range checks, no hand-built error response, and no separate documentation to keep in sync. All of that is derived from the signature.

> **WARNING**
> Validation at the boundary only protects you from malformed *shapes* of data. It does not check business rules such as "this listing is actually available on those dates" or "this user is allowed to see that booking". Those checks still belong in your code, and later chapters show where to put them.

What "High Performance" Really Means

The word "fast" is in the name, and the FastAPI documentation describes the framework as high performance. It is worth being precise about what that means, because misunderstanding it is one of the most common sources of disappointment and of badly performing FastAPI services.

Two kinds of "fast"

FastAPI is fast in two separate senses. The first is **development speed**: because type hints drive validation and documentation, you write less code, catch more mistakes in the editor, and spend less time keeping docs in sync. For many teams this is the bigger win, and it is not a performance claim at all.

The second sense is **runtime efficiency**, and here the honest statement is modest: FastAPI adds relatively little overhead on top of Starlette, and Starlette on an ASGI server like Uvicorn can handle many concurrent connections efficiently *when the application code cooperates*. We are not going to quote requests-per-second figures. Such numbers depend heavily on hardware, payload size, what the endpoint does, and how the benchmark was run, and they rarely predict how your real service will behave. What we can do is explain the mechanism.

Concurrency, not raw speed

A typical API request spends most of its wall-clock time **waiting**: for the database, for Redis, for a payment provider, for the network. Python code itself executes quickly relative to those waits. In a synchronous, thread-per-request model, each waiting request occupies a thread. In an asynchronous model, a waiting request is just a suspended coroutine; the event loop switches to other work until the awaited I/O completes.

```
Synchronous worker (one request at a time per thread):

  req A: [parse][---- wait for DB ----][render]
  req B:                                        [parse][---- wait for DB ----][render]

Asynchronous worker (one event loop, requests interleave while waiting):
```

```
  req A: [parse][---- wait for DB ----][render]
  req B:   [parse][---- wait for DB ----][render]
  req C:     [parse][---- wait for DB ----][render]
```

An async worker does not make any individual request faster. The database query takes as long as it takes. What changes is **throughput under concurrency**: one process can keep many requests in flight at once, because it is not stuck waiting on any single one of them. That is the real performance story of FastAPI, and it has an important corollary.

The corollary: blocking code ruins it

The event loop can only switch between tasks at `await` points. If an `async def` endpoint calls something that blocks, such as `time.sleep()`, the synchronous `requests` library, a synchronous database driver, or a heavy CPU computation, the entire event loop stops. Every other request being served by that process freezes until the blocking call returns.

```
import time

import httpx
from fastapi import FastAPI

app = FastAPI()


@app.get("/bad")
async def bad_endpoint() -> dict[str, str]:
    time.sleep(2)  # BLOCKS the event loop: every other request on this worker waits
    return {"status": "done"}


@app.get("/good")
async def good_endpoint() -> dict[str, int]:
    async with httpx.AsyncClient(timeout=5.0) as client:
        response = await client.get("https://example.com/")  # yields while waiting
    return {"upstream_status": response.status_code}


@app.get("/also-fine")
def sync_endpoint() -> dict[str, str]:
    time.sleep(2)  # plain def: FastAPI runs this in a thread pool, loop stays free
    return {"status": "done"}
```

This example previews a rule we will repeat throughout the book: **use `async def` only when everything you await inside is truly asynchronous; otherwise use plain `def`** and let FastAPI move the work to a thread. The thread pool has a limited size, so plain `def` is a safety net rather than a free lunch, but it prevents the worst failure mode. Chapter 21 covers the details, including how to offload blocking calls from inside async code.

> **WARNING**
>
> A single blocking call hidden inside an `async def` endpoint can make a service look fine in local testing, where you send one request at a time, and then collapse under real concurrent traffic. When latency climbs for *all* endpoints at once under load, suspect a blocked event loop first.

Where the time actually goes

In real Stayloft-style services, the framework is rarely the bottleneck. Time usually goes to database queries (missing indexes, N+1 query patterns, oversized result sets), network calls to other services, serialization of large responses, and occasionally CPU-heavy work like image processing. A framework with low overhead gives you headroom, but the decisions that dominate performance are architectural: how you query, what you cache, what you move to background workers, and how many worker processes you run per machine. Part III and Part V of this book are largely about those decisions, and Chapter 22 is about measuring before optimizing.

So when this book talks about "high-performance APIs", it means APIs that use async I/O correctly, avoid blocking the event loop, query the database efficiently, cache sensibly, serialize only what is needed, and scale horizontally. FastAPI makes those things natural. It does not make them automatic.

When FastAPI Is a Good Fit, and When It Is Not

No framework is the right answer to every problem. Here is how we think about FastAPI's sweet spot.

Strong fits

- **JSON APIs consumed by other programs**: mobile apps, single-page web frontends, partner integrations, and internal microservices. This is what FastAPI was designed for.
- **I/O-heavy services** that talk to databases, caches, message brokers, and other HTTP APIs, where async concurrency pays off.
- **Teams that value explicit contracts.** The generated OpenAPI schema can drive client generation, contract tests, and documentation portals (Chapter 20).
- **Serving machine-learning models or data services** from Python, where the surrounding ecosystem already lives in Python and a thin, typed HTTP layer is exactly what you need. Heavy inference is CPU- or GPU-bound, so it still needs care with workers and threads.
- **Real-time features** such as WebSockets and server-sent events, which ASGI supports natively (Chapter 24).

Weaker fits

- **Content-heavy, server-rendered websites** with an admin back office, user management, and forms. You can do this with FastAPI and a template engine, but a batteries-included framework like Django will give you more out of the box.

- **Pure CPU-bound workloads.** Async I/O does nothing for code that computes rather than waits. Such work belongs in worker processes, task queues, or specialized services, whatever the web framework.
- **Teams that want strong conventions decided for them.** FastAPI leaves project structure, database access, and authentication strategy to you. That freedom requires discipline, which is why this book prescribes a structure in Chapter 9.

Concern	FastAPI	Flask	Django
Interface	ASGI	WSGI (async views possible)	WSGI and ASGI
Validation	Built in via Pydantic	Via extensions	Forms; DRF serializers
OpenAPI docs	Generated automatically	Via extensions	Via third-party packages
ORM	Bring your own	Bring your own	Built in
Admin UI	None built in	Via extensions	Built in
Primary focus	APIs	General web	Full-stack web

This table is intentionally coarse. Each framework has a large ecosystem, and all three are used successfully for APIs. The point is not that one is better, but that FastAPI's strengths line up with typed, documented, I/O-bound HTTP APIs, which is exactly what we are going to build.

> **NOTE**
>
> You will sometimes see comparisons that claim FastAPI is "as fast as" services written in Go or Node.js. Treat such claims skeptically. Performance depends on the whole system, and Python has real costs for CPU-bound work. FastAPI is an efficient way to build Python APIs; whether it meets your latency and throughput goals is something you establish by measuring your own service.

Core Concepts at a Glance

Before we meet Stayloft, here is a quick vocabulary of the FastAPI concepts you will see in every chapter. Each gets a full treatment later; this section exists so that nothing in the next few chapters surprises you.

- **Path operation**: the combination of an HTTP method and a path, such as `GET /api/v1/listings`, together with the function that handles it. The function is called the *path operation function*, and the decorator (`@app.get(...)`) is the *path operation decorator*. Chapter 4.
- **Parameters**: values extracted from the path, query string, headers, cookies, or body, declared as function parameters. Chapters 4 and 5.
- **Models**: Pydantic classes that describe the shape of request and response data. Chapters 3, 5, and 6.

- **Dependencies**: reusable functions declared with `Depends` that FastAPI calls for you, used for database sessions, authentication, pagination, and more. Chapter 7.
- **Routers**: `APIRouter` objects that group related path operations so a large application can be split into modules. Chapter 9.
- **Middleware**: code that wraps every request and response, used for cross-cutting concerns like CORS, compression, and request IDs. Chapters 16 and 26.
- **Lifespan**: an async context manager that runs setup code before the app starts serving and teardown code when it stops, such as creating a database engine or an HTTP client. Chapter 9.

Here is a compact example that touches most of these at once, so you can see how they fit together. Do not worry about every detail; we will rebuild each piece carefully.

concepts.py

```
from collections.abc import AsyncIterator
from contextlib import asynccontextmanager
from typing import Annotated

from fastapi import APIRouter, Depends, FastAPI, Header, HTTPException
from pydantic import BaseModel


@asynccontextmanager
async def lifespan(app: FastAPI) -> AsyncIterator[None]:
    app.state.greeting = "Welcome to Stayloft"  # setup: runs before serving
    yield
    # teardown: runs on shutdown (close pools, clients, and so on)


class UserRead(BaseModel):
    id: int
    email: str
    role: str


def get_current_user(x_demo_user: Annotated[str | None, Header()] = None) -> UserRead:
    if x_demo_user is None:
        raise HTTPException(status_code=401, detail="Missing X-Demo-User header")
    return UserRead(id=1, email=x_demo_user, role="guest")


router = APIRouter(prefix="/api/v1/users", tags=["users"])


@router.get("/me")
async def read_me(user: Annotated[UserRead, Depends(get_current_user)]) -> UserRead:
    return user


app = FastAPI(title="Stayloft API", lifespan=lifespan)
app.include_router(router)
```