Introduction to API Development Using Python

Participant Guide

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COURSE CODE IN1803 / 10.15.2024

This course covers Introduction to API Development Using Python

This course and all materials supplied to the student are designed to familiarize the student with the operation of the software programs.

This version updated: 10/15/2024

Notes

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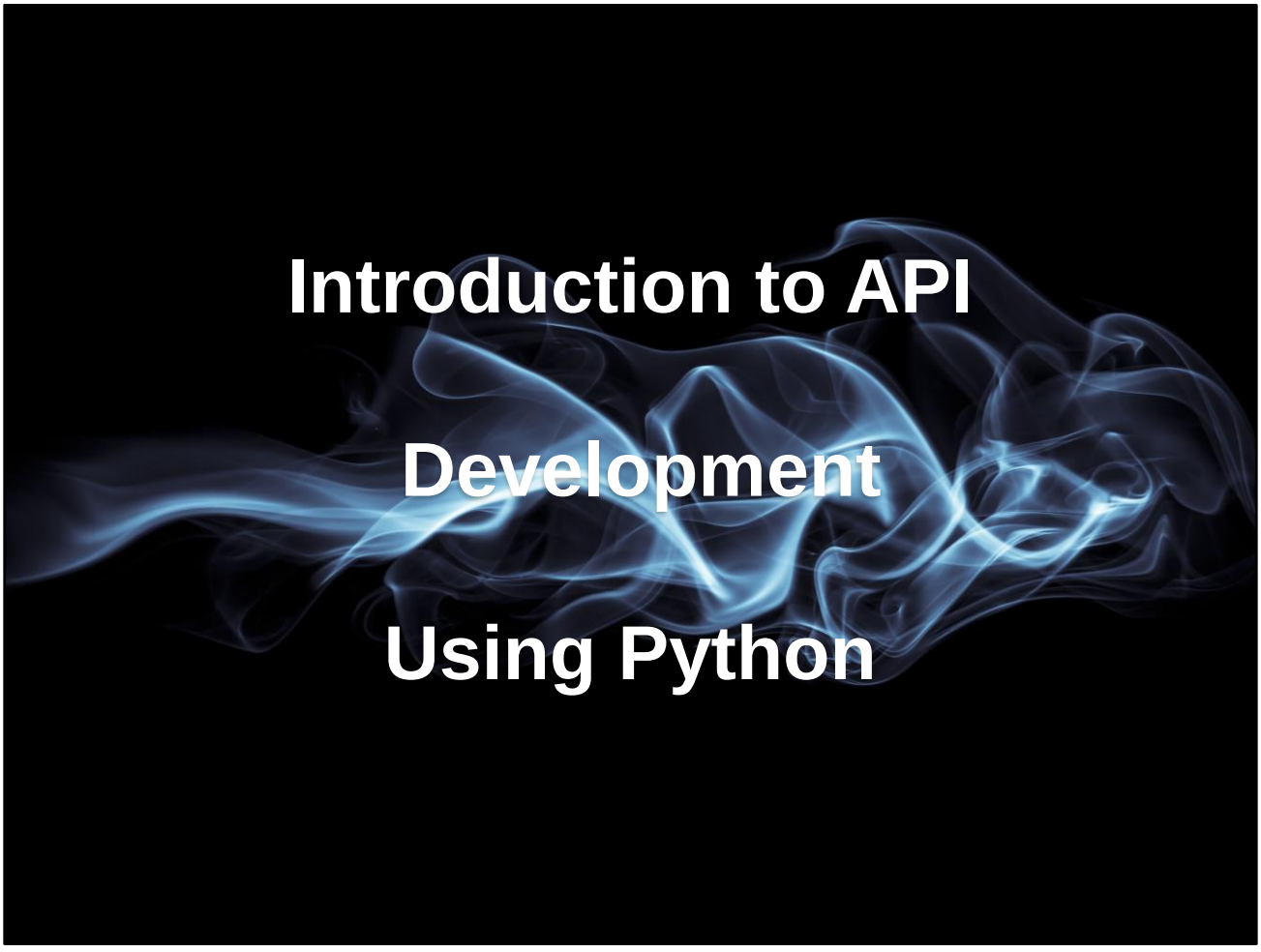
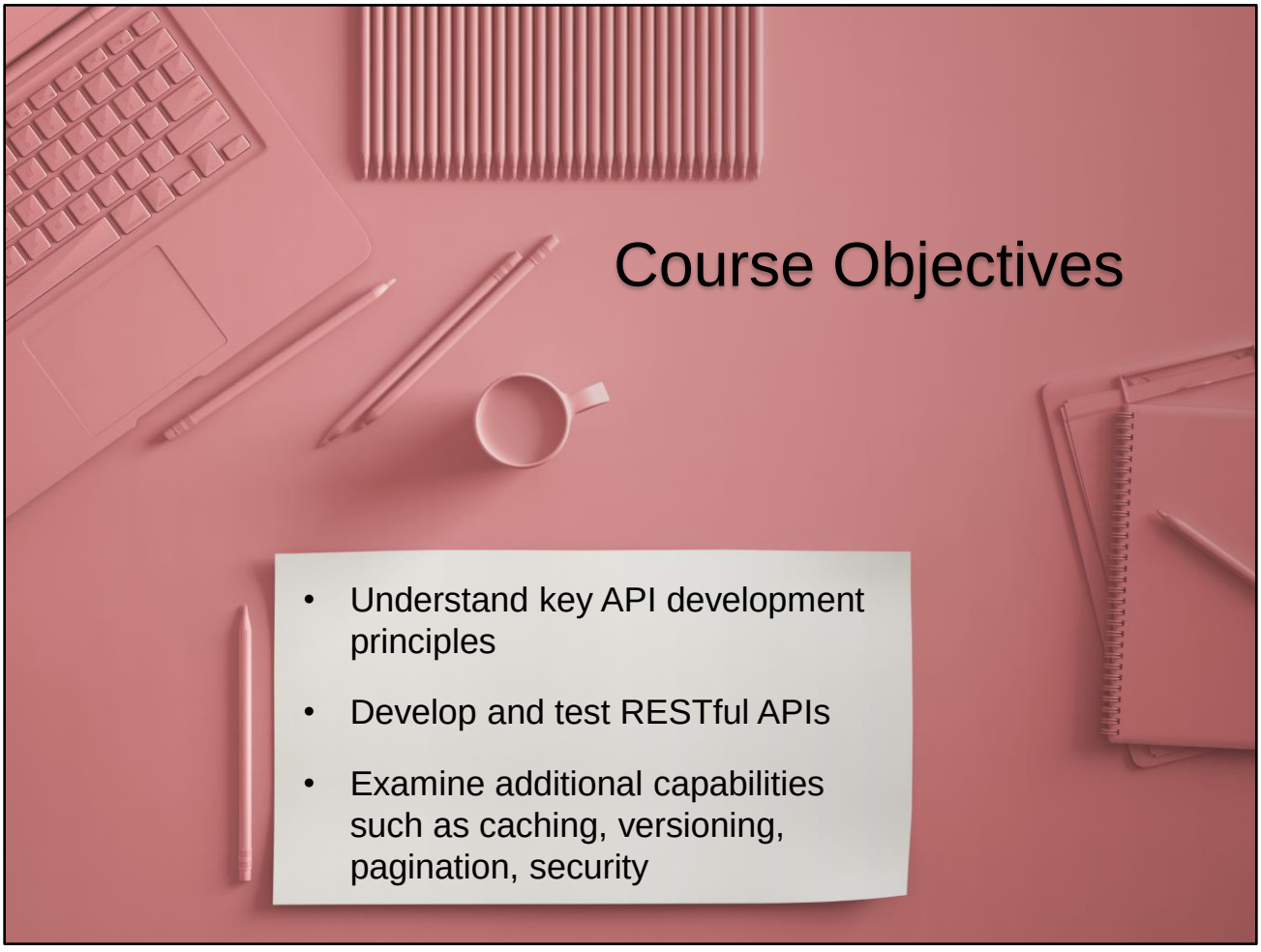
Notes





Course Agenda

Day 1

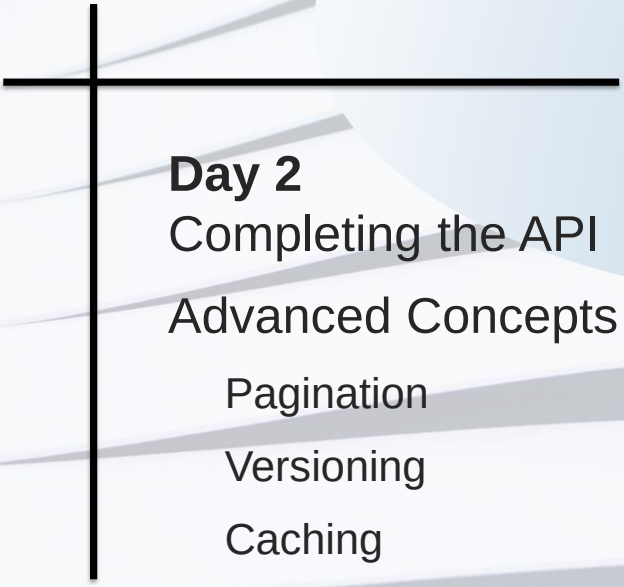
Introduction

- Overview of API Concepts
- Python Tools and Environment Setup

Developing APIs

- Creating an API
- Creating a Python-Based Client
- Incorporating the Database

Course Agenda *(continued)*



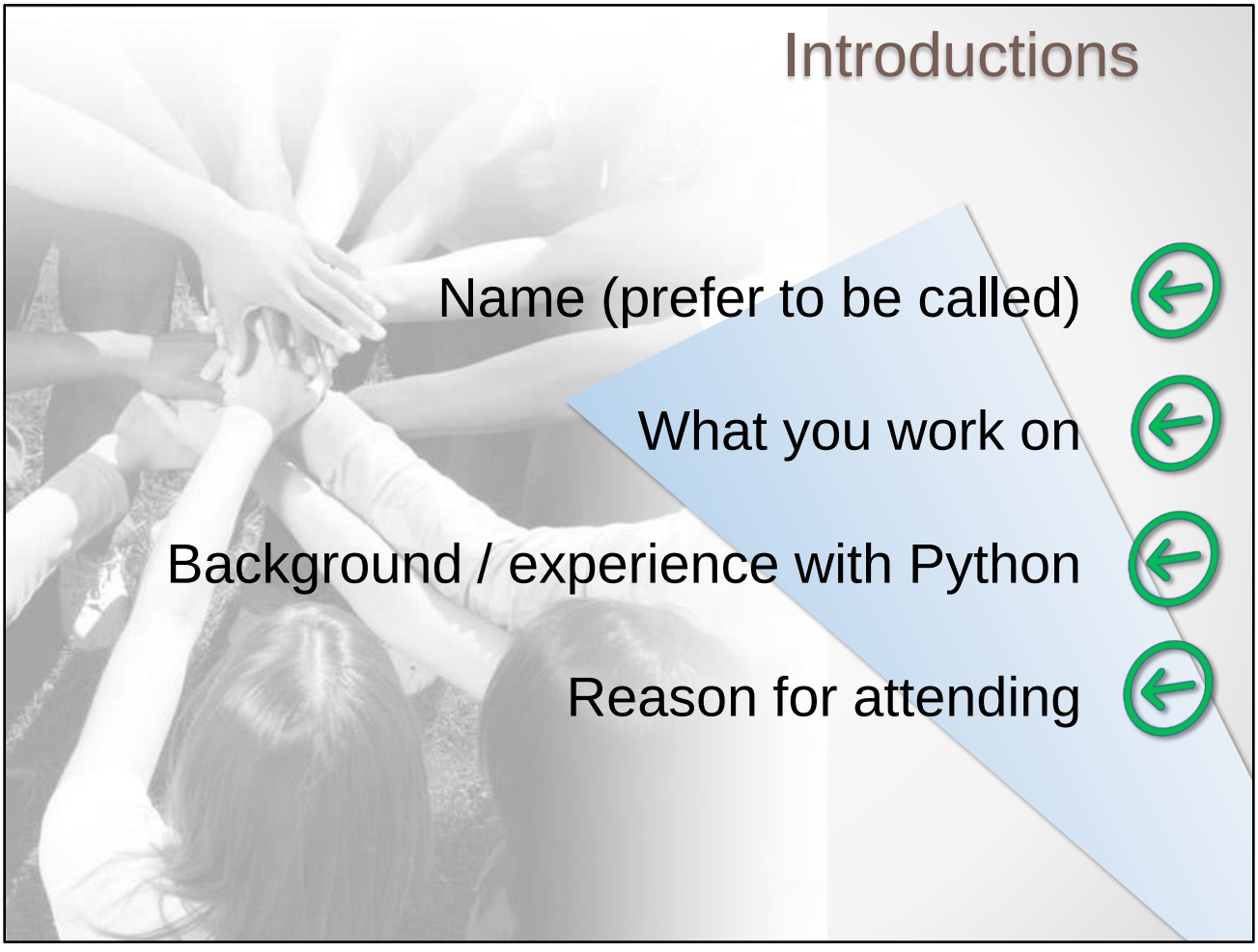
Day 2

Completing the API

Advanced Concepts

- Pagination
- Versioning
- Caching

Authorization and Authentication



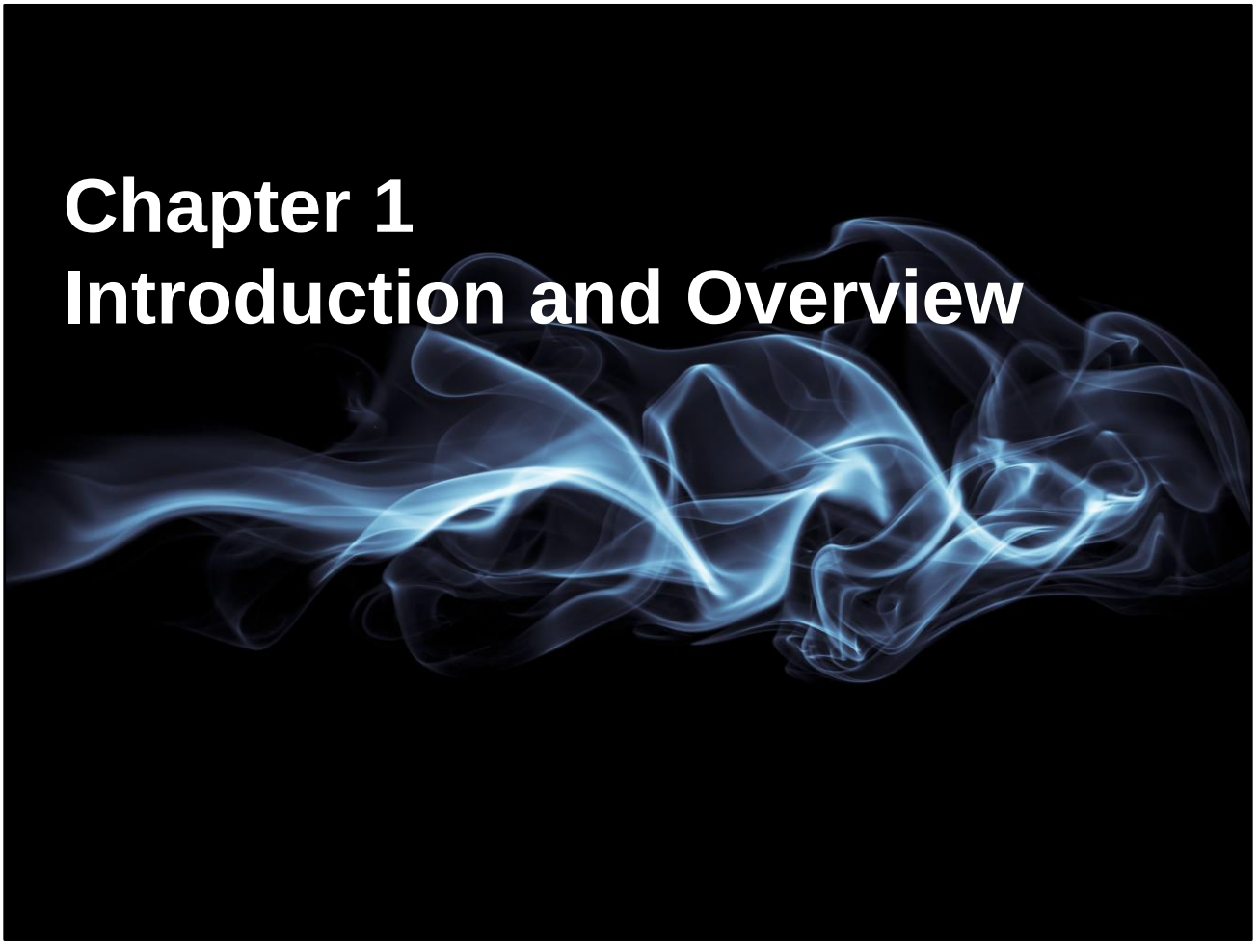
Typical Daily Schedule*

9:00	Start Day
10:10	Morning Break 1
11:20	Morning Break 2
12:30 – 1:30	Lunch
2:40	Afternoon Break 1
3:50	Afternoon Break 2
5:00	End of Day

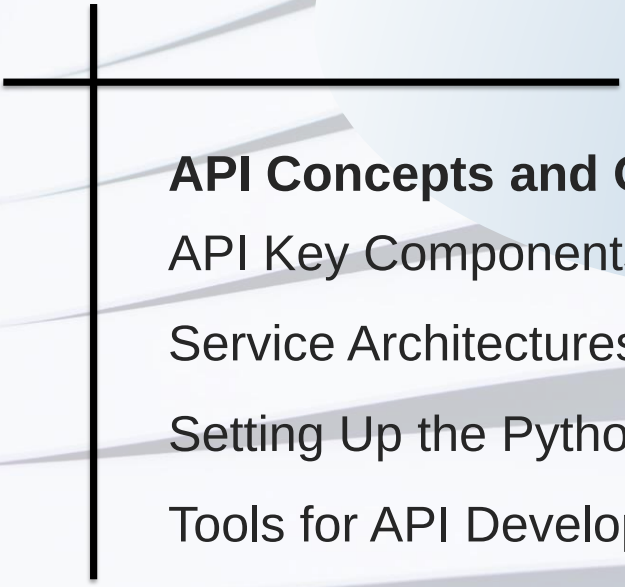
** Your schedule may vary, timing is approximate*

Get the Most From Your Experience

Ask Questions



Chapter 1 Overview



API Concepts and Overview

API Key Components and Life Cycle

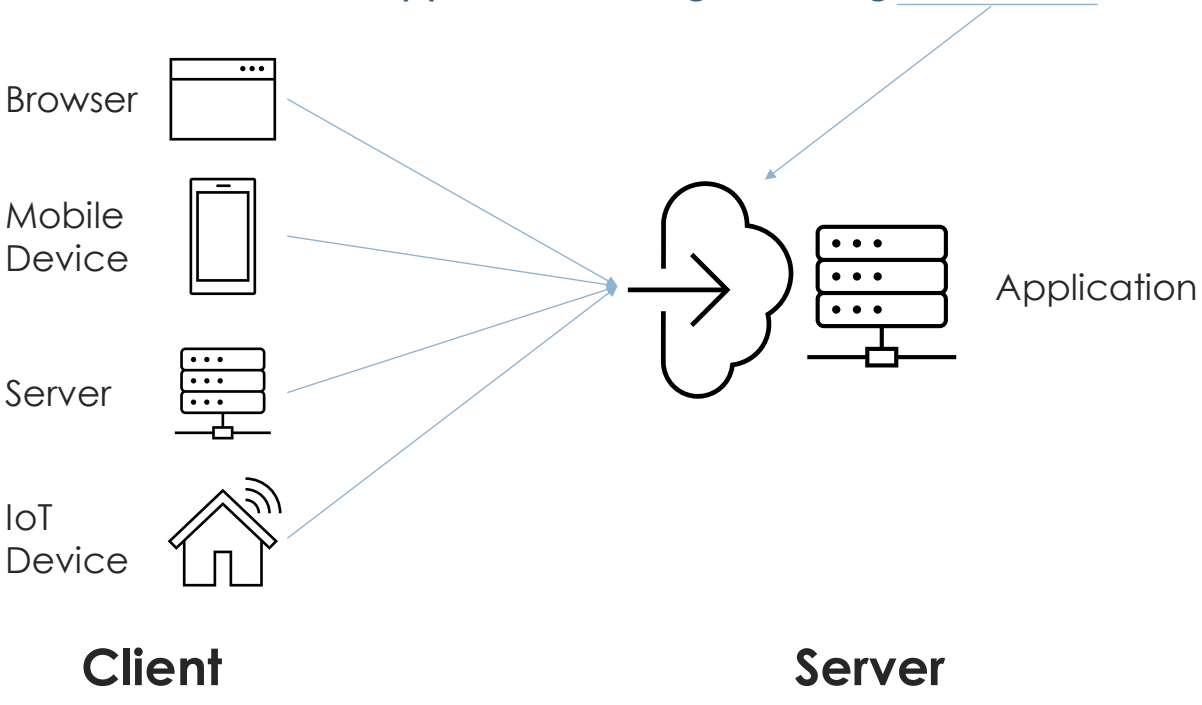
Service Architectures

Setting Up the Python Environment

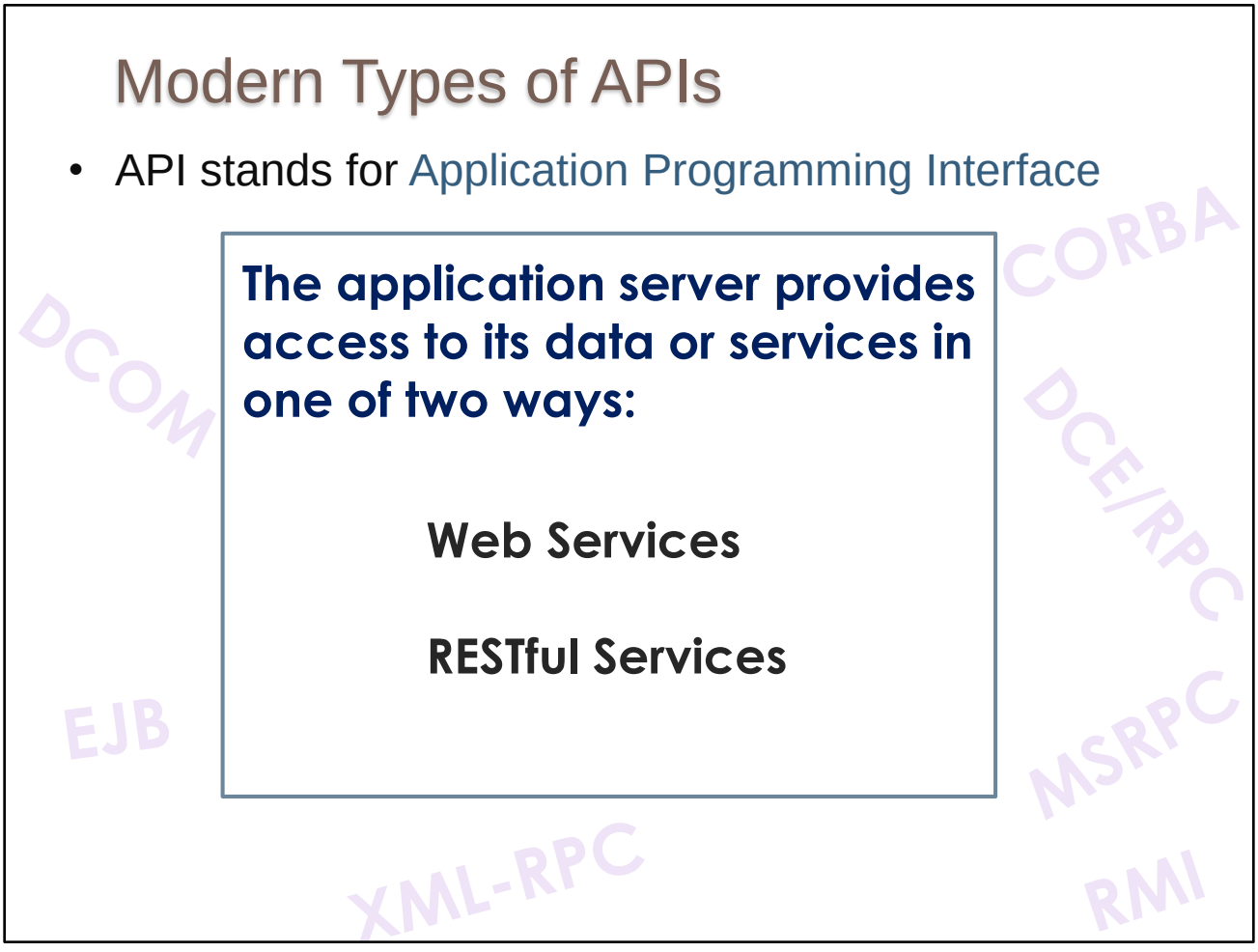
Tools for API Development

What Is an API?

- API stands for Application Programming Interface



API is an acronym that stands for Application Programming Interface. The acronym, usually used as a noun (e.g., "an API"), refers to the way in which one application communicates with another application. These applications are usually running on different machines.



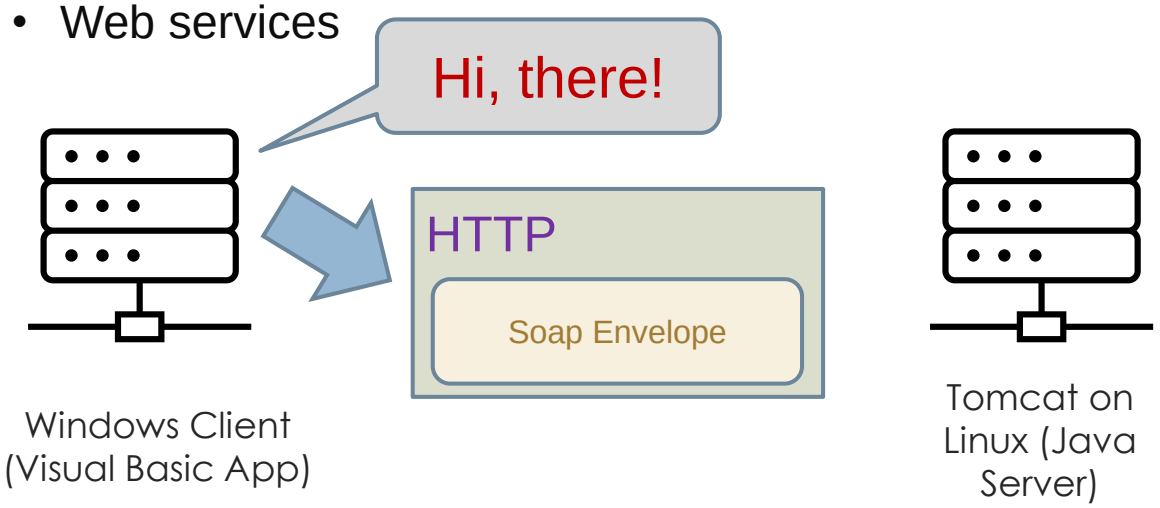
Over the years, different technologies for facilitating communication between two devices have come and gone (or largely been replaced). Many of these technologies focused on ways to transmit objects from one machine to another. They were often vendor-specific (focusing on the use of specific frameworks or tools) such as Microsoft DCOM or Java EJBs. Portability and interoperability were problems with these solutions. They were often complex and required creating special adapters called *stubs* and *skeletons* or required converting objects into other formats using serializers and deserializers. They were also very brittle requiring high maintenance.

As internet popularity grew in the 1990s, replacement technologies for distributed communications developed. Web services evolved due in part to the rise of XML at the time and the growing number of web-based servers that used the HTTP protocol.

Over time, web services would doom itself by becoming overly complicated (SOAP, WSDL, UDDI, WS-Security, WS-Reliability, etc.) and in response, the world shifted toward simpler technologies: JSON and REST.

Web Services

- Web services




```
<soap:Envelope xmlns:soap="http://www.w3.org/2003/05/soap-envelope/"
soap:encodingStyle="http://www.w3.org/2003/05/soap-encoding">
<soap:Header>...</soap:Header>
<soap:Body> ...
  <c:makeGreeting xmlns:c="http://domain.com/greetapp/">
    Hi, there!</c:makeGreeting>
</soap:Body>
</soap:Envelope>
```

Web services evolved in an effort to improve interoperability between different systems. It emphasized the HTTP protocol as the transport layer and embedded XML as the payload within an HTTP POST request (commonly). Information could now easily be exchanged between a Microsoft Visual Basic Application running on Windows and a Java application server running on Linux or Unix.

The Browser as a Client

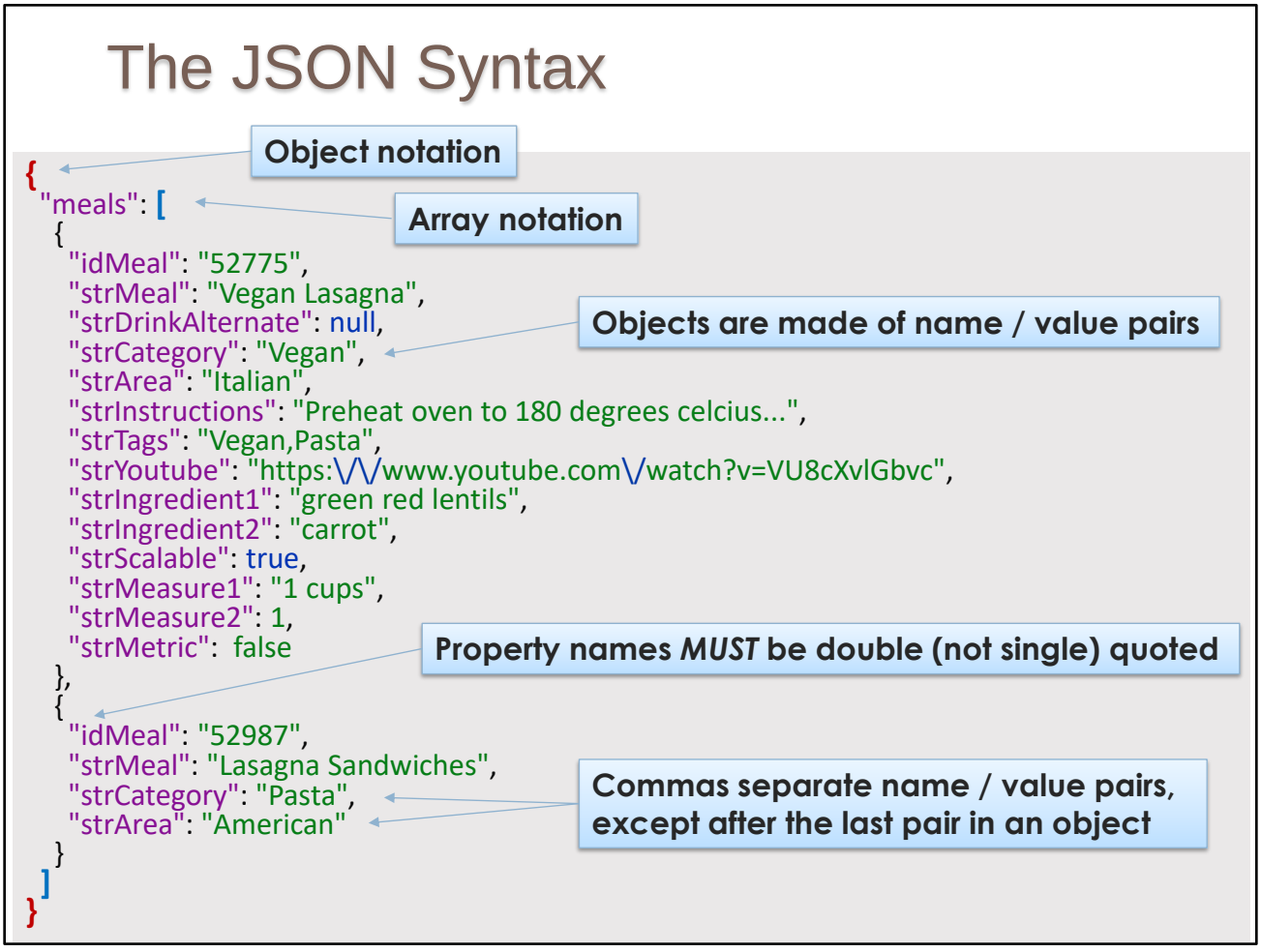
- Browsers are good at running an embedded programming language called *JavaScript*
- The combined power of HTML, CSS, and JavaScript allowed browsers to become *thinner* clients
  - Older alternatives were called "thick" clients due to the more complex code required to run them
- Browsers, however, aren't very good at manipulating XML
- The lack of good XML processing capabilities within browsers spelled trouble for web services

During the late 1990s and early 2000s, browsers evolved rapidly. JavaScript become a predominant development language and gave rise to more interactive web applications that could incorporate new techniques like Ajax. This facilitated communication between the browser and the server. The early 2000s was a transformative period where web applications became powerful clients. The growth of JavaScript also gave rise to a special data format called JSON (pronounced "Jay-son") which could easily be extracted and rendered into a web page.

JSON

- JavaScript Object Notation (JSON) naturally occurs within the JavaScript language
  - Browsers consume and create JSON data without any additional tools
- Due to the quick rise in popularity of JSON, other programming languages quickly added support for it
- Within a few years, the JSON data format became a preferred way of exchanging data

JSON wasn't actually invented, it was discovered. It already existed within the JavaScript language. Doug Crockford (writer of the book *JavaScript: the Good Parts*) readily admits that he identified JSON, he didn't create it.

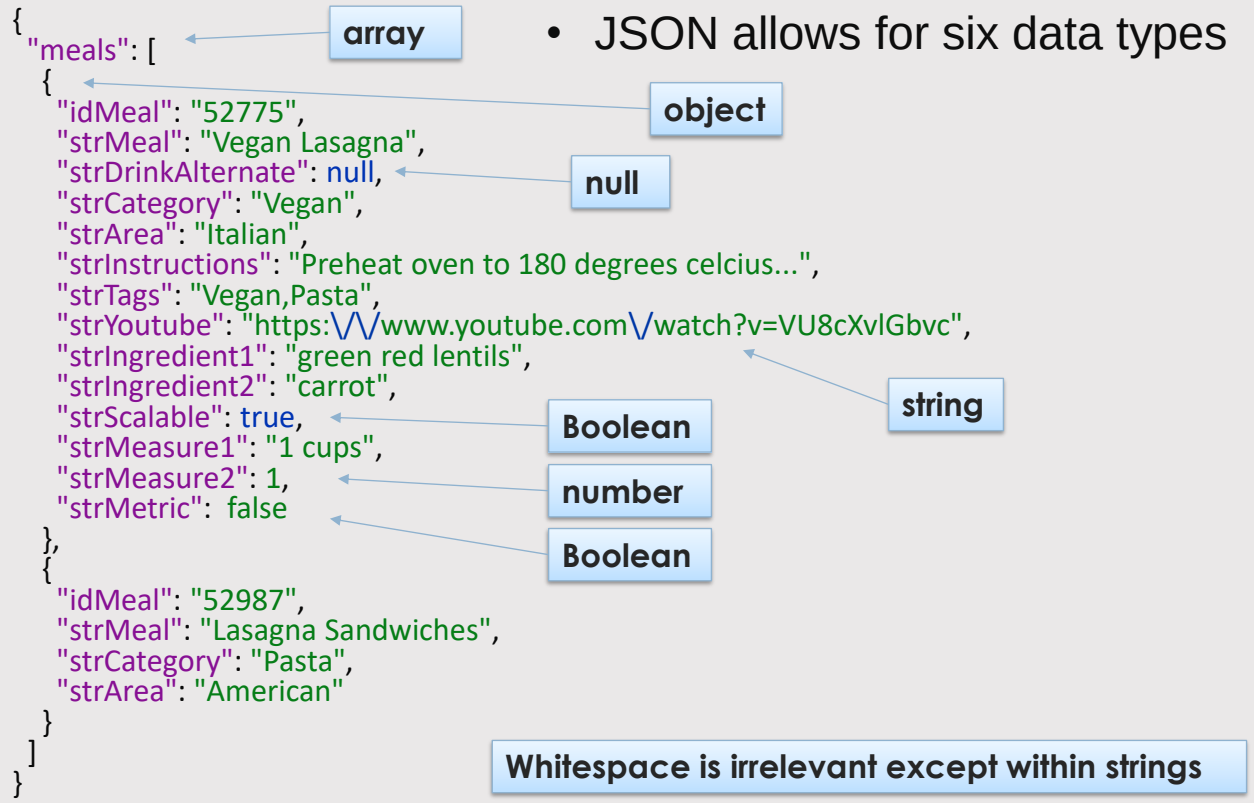


For many years, a standard for JSON did not exist. An RFC for JSON is managed by the IETF and can be found at: https://datatracker.ietf.org/doc/html/rfc8259.

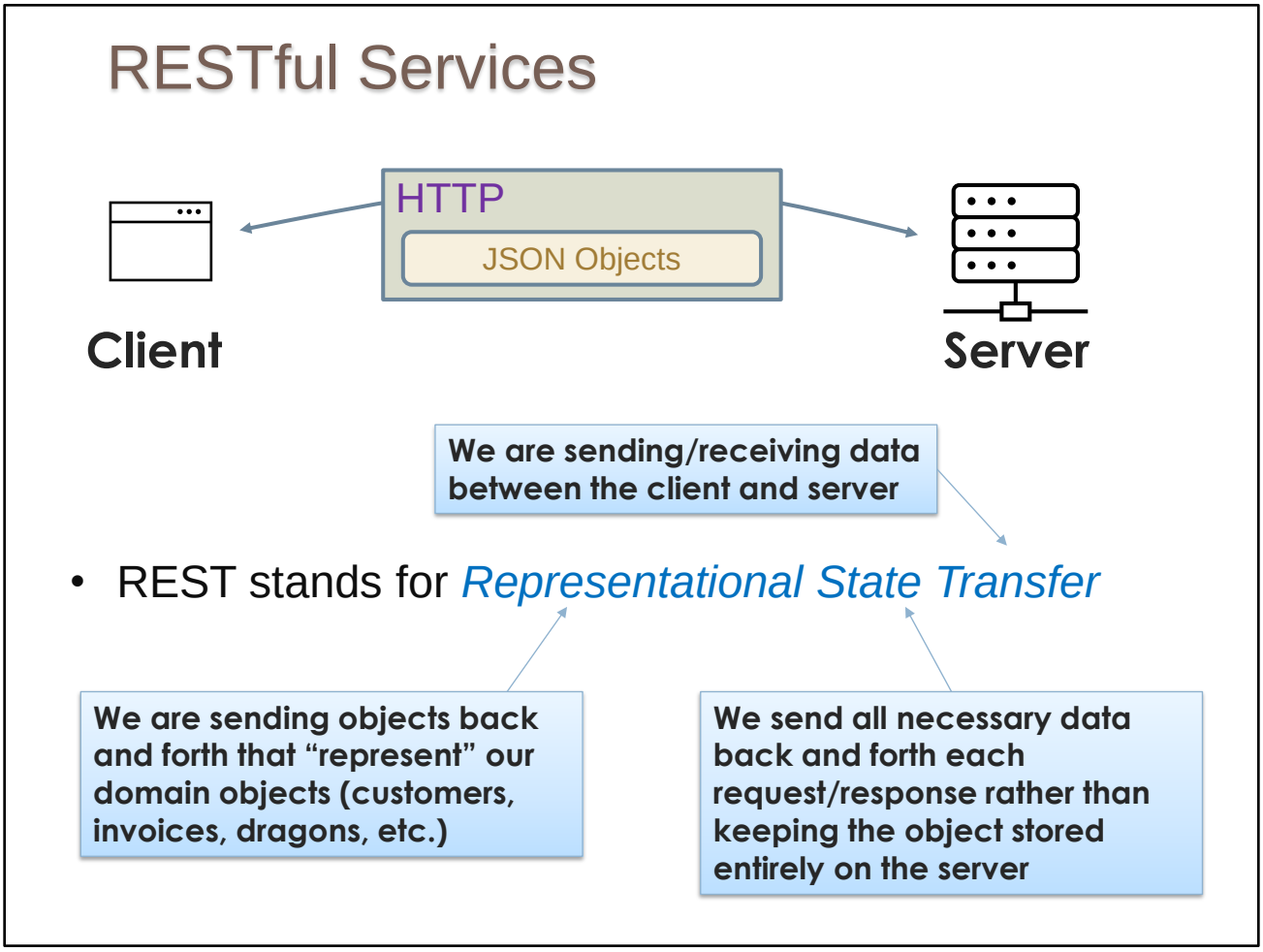
Does the top-level structure of a JSON message have to be an object or an array? While it almost always is, recently a simple string, number, Boolean, or null is now allowed also.

This API response can easily be obtained by typing **`https://www.themealdb.com/api/json/v1/1/search.php?s=lasagna`** into your browser.

Whitespace and JSON Data



Valid JSON data types include objects, arrays, strings, numbers, true, false, and null. While JSON data is used within JavaScript, they are not the same. For example, JSON does not define a function type, an undefined type, or other types, such as a date type. Only the six types mentioned above are explicitly defined within JSON.



REST is merely a style of communication between two devices.

At first, the REST acronym seems rather cryptic, but upon dissecting it, we see it identifies how this the style of communication. REST involves sending objects to and from the server (the "transfer" part of the acronym). It often uses JSON (though it is not required) as the data interchange format. JSON objects "represent" data maintained on the server. The objects are sent back and forth each time (the "state" part of the acronym) rather than using cookies, for example, to uniquely identify the user and then bring up the objects in a server session like a typical web-based application.

Classic Web Services vs RESTful APIs

Web Services	REST
XML for payload data	Can use plain-text, XML, JSON (commonly), etc.
Uses SOAP (Simple Object Access Protocol)	No specific protocol
Invokes methods remotely	Access data via URIs
Has formal standards: SOAP, WSDL, WS-Security, etc.	Solutions tend to be simpler to learn, build, and execute
XML is difficult to work with within browsers	JSON is easy to use within browsers
Has error handling capabilities built into SOAP	Errors are managed through HTTP status codes

There are several differences between classic (SOAP-based) web services and RESTful solutions. One of the primary differences is that RESTful solutions utilize the HTTP protocol to manipulate resources while web services usually make HTTP POST requests to invoke methods on the server side. We'll discuss more about REST's manipulation of URLs shortly.

RESTful Resources

- A *resource* is a core or fundamental component in a RESTful application
- A resource is an object being served (returned)
  - It usually derives from the business domain
  - Typically, operations will be performed on this entity
- Resource examples:
  - *Invoices*
  - *Orders*
  - *Patients*
  - *Customers*
  - *Documents*

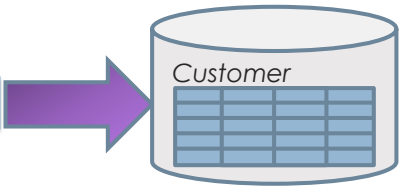
A resource can be a collection (like *accounts*) or singular (like *account*) and may contain sub-resources (like *address*)

Creating resources is a core task in designing RESTful solutions. Operations will be defined around these resources. Care must be taken on how large or small to make these resources. In other words, how coarse-grained vs. fine-grained the objects should be is a design decision that must be considered (more on resource modeling later). Larger resources will involve fewer requests made to the server but involve sending and receiving more data values.

Key Components of a RESTful Service

- URIs to map to resources

https://hostname.com/api/customers



- Manipulation of resources via HTTP methods

GET
PUT
DELETE
POST

https://hostname.com/api/customers/121

https://hostname.com/api/customers

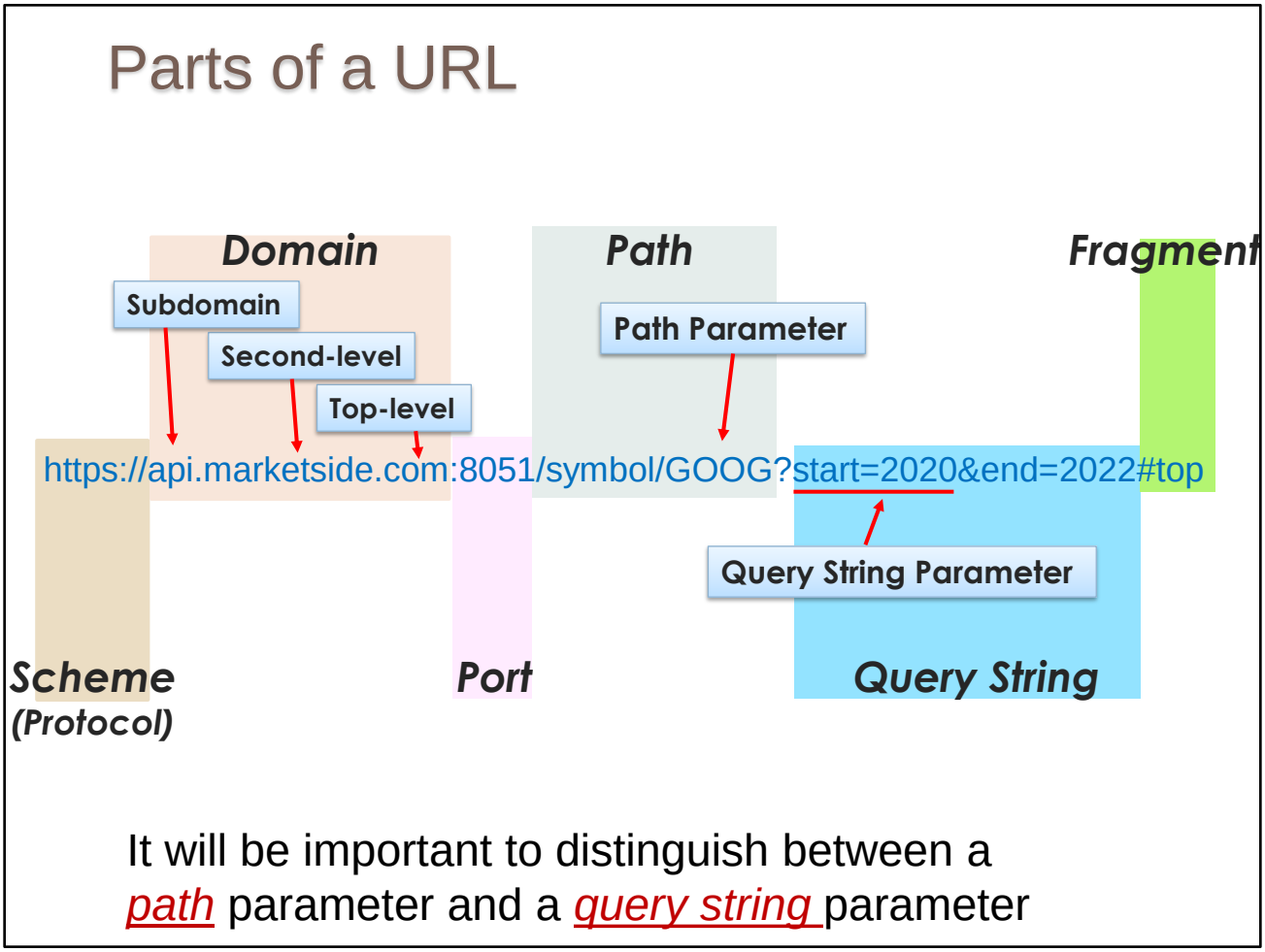
- Transfer of state (stateless)


```
{
  customer_id: 121,
  name: Blackburn Industries,
  …
}
```

- Cacheable

```
Expires: Fri, 20 May 2022 19:20:49 GMT
```

Several principles guide the development of RESTful solutions (each of these are discussed further later).

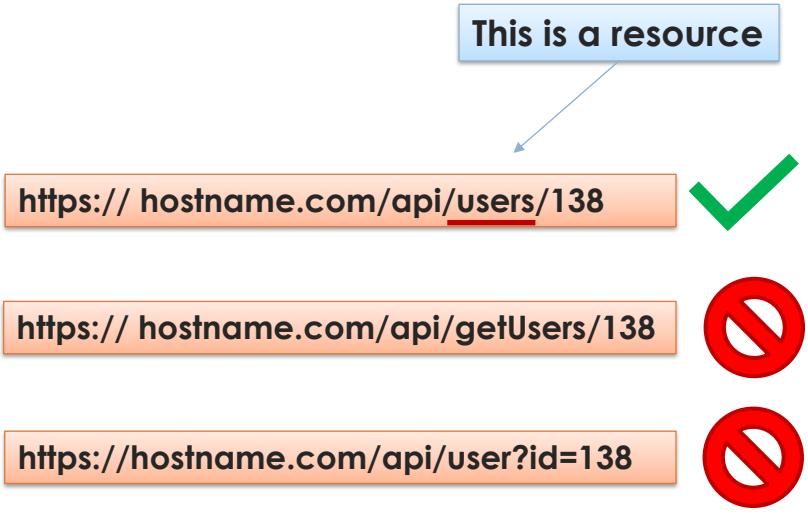


For ease of discussion throughout the course, the terms above will be used to refer to parts of a URL.

It's important to take note of the difference in placement of variables in a URL. This distinction is not only a part of the RESTful design solution but makes a difference programmatically when writing code to access these values. Take note of what is called the "path" versus the "query string."

RESTful Design Principles

- Design the API around resources (nouns)



Resources should map to a unique URI (like http://hostname.com/api/users). Resources are usually related to a domain or business objects from your application.

To make the API URL sound more consistent, generally prefer the use of plural nouns.

RESTful Design Principles *(continued)*

- Use HTTP methods to define operations

GET /api/invoices/2952	*Reads* a specific invoice
PUT /api/invoices/2952	*Updates* a specific invoice
PATCH /api/invoices/2952	*Partially Updates* a specific invoice
DELETE /api/invoices/2952	*Deletes* a specific invoice

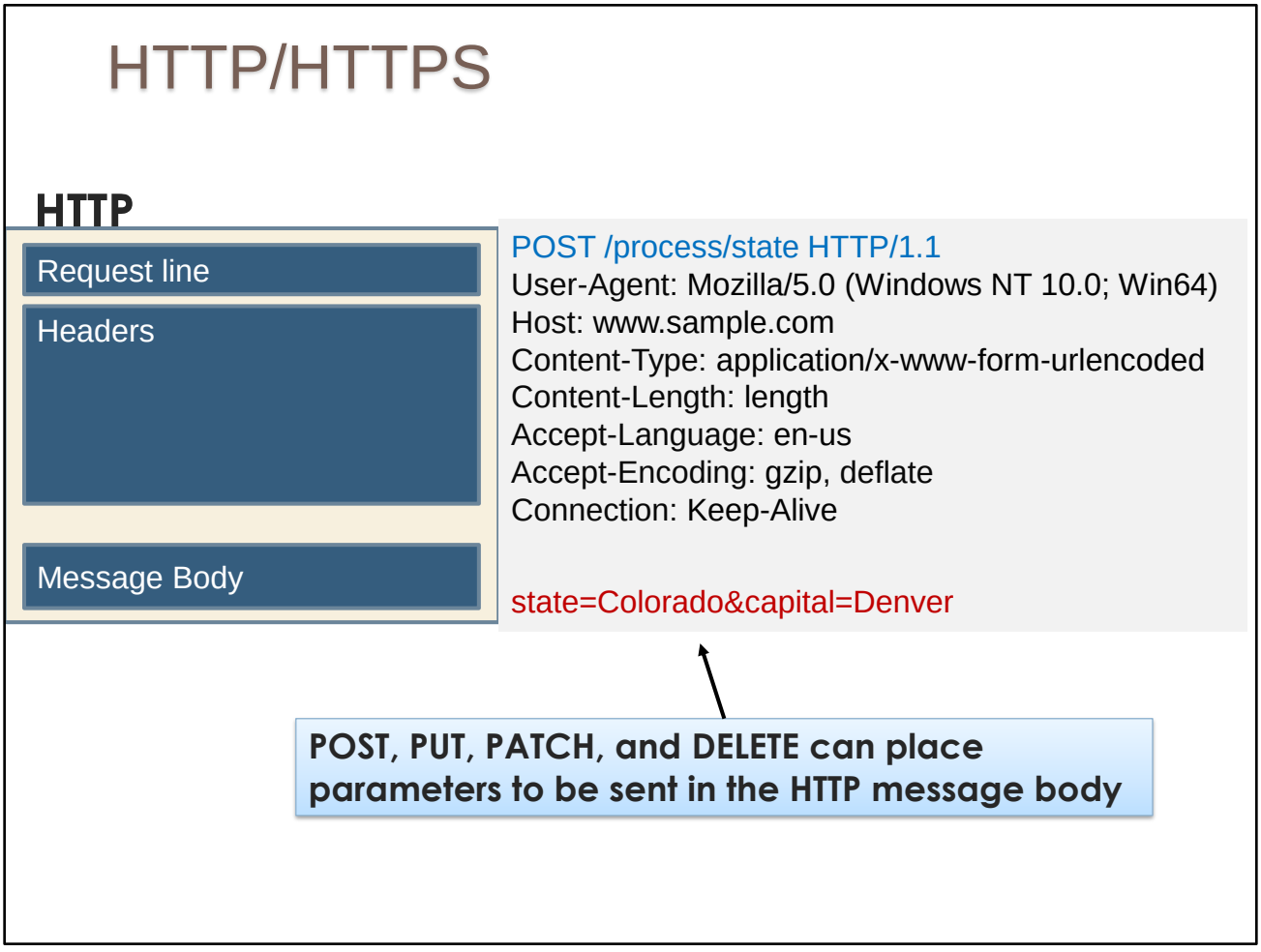
GET /api/invoices	Retrieves all invoices
POST /api/invoices	*Creates* a new invoice

Think of a RESTful request as being like a sentence. The HTTP method is the "verb" of the sentence while the resource is the noun.

(from above) "GET (verb, HTTP method) the invoice 2952 (noun, resource)."

As previously mentioned, we tend to utilize the plural form of our resource in the URL.

The PATCH method is used when you only wish to update one or two (or so) fields of an object. In doing so, you may PATCH by only sending the required fields that need updating. Generally, a PUT will "resend" the entire object, performing an overwrite of the entire object, which may overwrite fields you didn't intend to update (and may accidentally change values that you didn't intend to change). More is discussed with PATCH a little later.

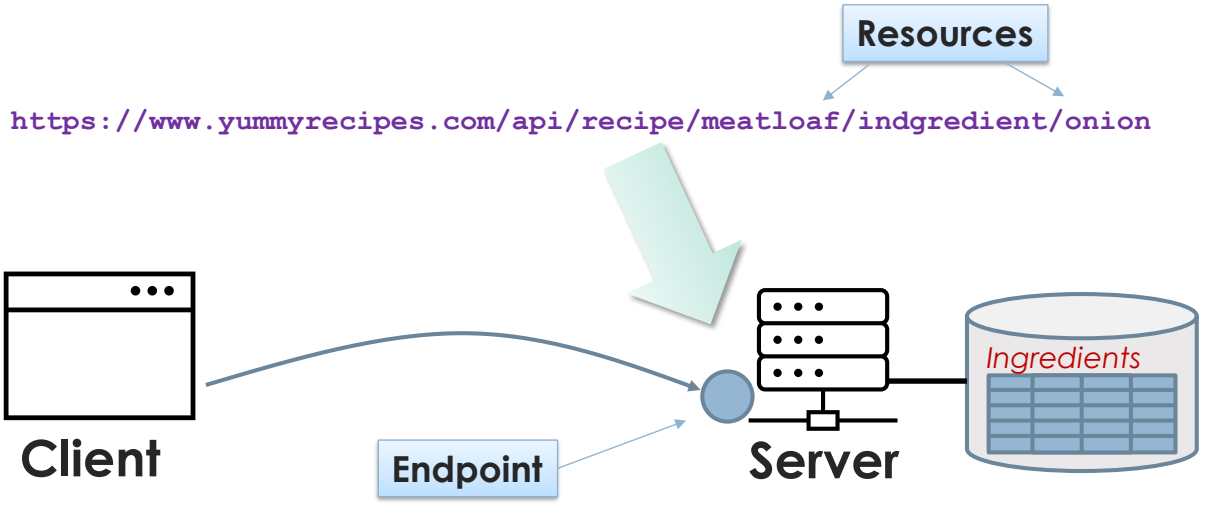


To better understand how to set up and design an API, we'll have to understand the technologies used. The HTTP protocol is a good place to begin.

Above is a dissection of a message sent using the HTTP protocol. The HTTP message defines a request line followed by zero or more headers followed by a blank line and then the message body. A GET request will not have a message body.

Endpoints vs Resources

- Endpoints are *locations* (addresses), often exposing services or resources
- Resources are objects that are returned from a URL



You may often hear the term endpoint. Endpoints are typically addresses that identify a service location (commonly described in web services, but RESTful resource URIs could also be endpoints). Different endpoints can return similar resources. In addition, a single endpoint could return different resources such as collections of objects or single objects.

Using Python for RESTful Development

- Python is a great language for developing APIs
  - One of the most popular languages to learn
  - Huge community support and tools to assist
  - Expressive language: easy to learn, easy to read
  - Works naturally with JSON data
    - Python dictionaries are very similar to the JSON format

Why Python for API development? We could specify a long list of why Python is so wonderful for RESTful development. But perhaps to help us get a better evaluation of whether Python would help, let's examine the question *why not Python?*
Here are a few disadvantages when considering Python for API development:

1. Performance. While Python can hold its own for most implementations, if high concurrency, high performance is a primary consideration, Python may not be the first choice.

2. Python on the client-side may be limited. Python isn't typically encountered frequently in mobile/handheld computing environments. However, as an option on the server-side it is a great choice.

3. Less developed database access layer. While wonderful tools do exist, like Django and SQLAlchemy, for interacting with the database, the layers sometimes feel less mature than in other languages such as Java and C# programming languages.

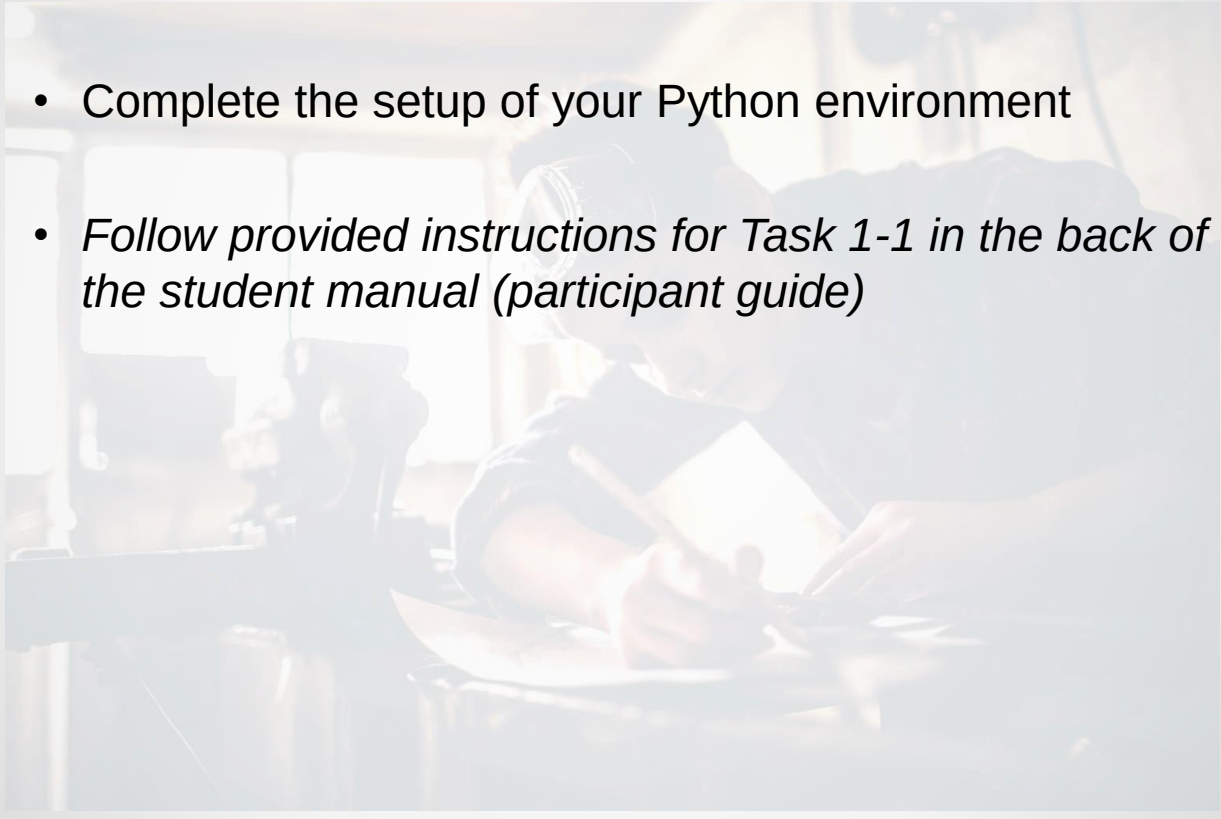
RESTful Python API Frameworks

- Numerous tools exist for developing RESTful applications

Server-side Tools	Client-side Tools
Flask	*Requests*
FastAPI	PycURL
Django / Django REST	Urllib (Standard library)
Falcon	
Bottle	

This list of tools is not exhaustive. It includes useful frameworks and libraries that can be used on both the server-side as well as client-side. Several of these tools are explored during this course. The scope of Django is too large for this course.

Your Turn! - Task 1-1



- Complete the setup of your Python environment
- *Follow provided instructions for Task 1-1 in the back of the student manual (participant guide)*

Your Turn! - Task 1-2

- Viewing APIs
- *Use your browser to view results from the URLs*
- These can be easily obtained from task1_2_starter.json

https://api.coinlore.net/api/tickers/?start=1&limit=5

Change these values, what happens?

https://apimeme.com/meme?top=some&bottom=text

Is this still an API? What does it return?

https://datausa.io/api/data?
drilldowns=State&measures=Population&year=latest

Have fun generating your own memes at https://apimeme.com/.

Dictionaries

- Dictionaries are collections of name/value pairs

```
capitals = {'Alabama': 'Montgomery', 'Alaska': 'Juneau',...,
        'Wyoming': 'Cheyenne'}

print(f'Keys: {capitals.keys()}')
```

To get just the keys

Keys: dict_keys(['Alabama', 'Alaska', … 'Wyoming'])

```
print(f'Values: {capitals.values()}')
```

To get just the values

Values: dict_values(['Montgomery', 'Juneau', …, 'Cheyenne'])

```
print(f'Keys and values: {capitals.items()}')
```

To get both at once

Keys and values: dict_items([('Alabama', 'Montgomery'), ('Alaska', 'Juneau'), …, ('Wyoming', 'Cheyenne')])

```
print(f'{capitals["Montana"]}, {capitals.get("Montana")},
      {capitals.get("Montana", "Not found.")}')
```

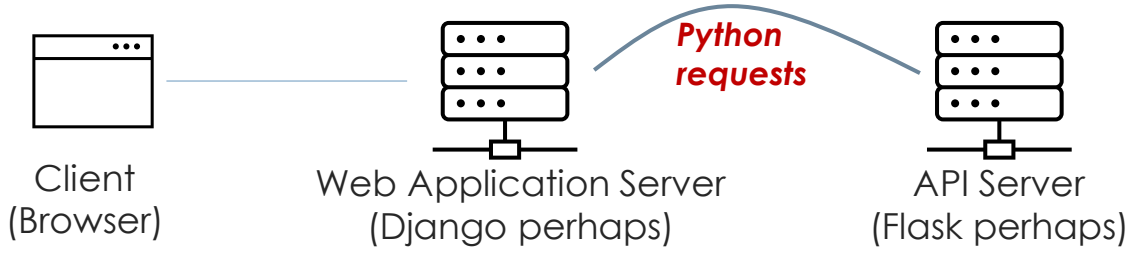
Helena, Helena, Helena

student_files/ch01_overview/01_dicts_and_json.py

Dictionaries are the default data structure encountered when going back and forth between JSON and Python. So, it is important to know to use them.

Introducing Python Requests

- While Python is not commonly used in mobile and handheld devices, it is heavily used on computing platforms (OS X, Windows, Linux)
- So, Python can also be used as a *RESTful client* in REST-based apps
- A great tool for building Python-based clients is called requests



Often, the client to an API server is another server. Quite frequently, we see a web-based server interacting with an API server.

In the Python world, this can be a Django frontend server interacting with a Flask API server (to be introduced shortly). The Django application would need to make requests to the remote API server. To do this, the requests module would need to be invoked from within the Django app.

Python *requests*

- *requests* allows for easily sending HTTP requests
- *requests* is third-party, which means it must be installed into the Python environment
  - *pip install* statements can vary:
    pip3 install requests
    python -m pip install requests

pip install requests

A basic *requests* module request

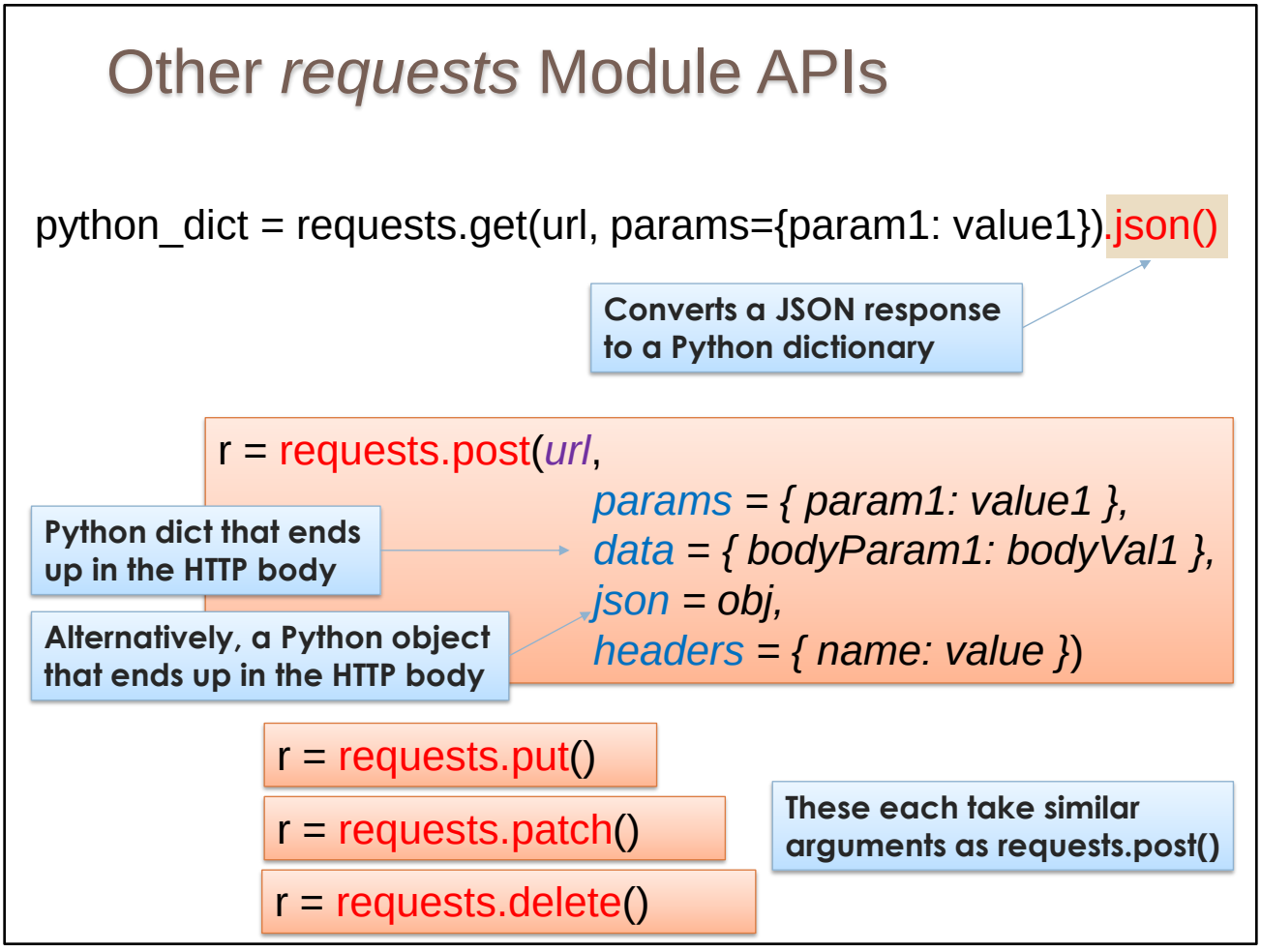
params get added into the query string

```
text_str = requests.get(url,
                        params = { param1: value1 },
                        headers = { name: value }).text
```

As with any tool used within this course, if it doesn't ship with Python originally, it is considered a third-party tool and must be installed. The utility in Python for installing third-party frameworks is called *pip* (Python Installation Package tool).

Different Python versions on different platforms installed differently will likely need to invoke the pip tool in a slightly different way. You will need to remember how it was invoked on your system. Shown above are some variations on how to invoke the pip tool. If needed, discover the approach that is appropriate on your machine.

The params parameter of the requests.get() call enables passing query string parameters.



The requests module methods shown here will serve as useful tools for creating a Python client shortly.

The ***params*** argument is useful for encoding dictionary key-value pairs into the query string of a URL.

The ***data*** argument is useful for encoding dictionary key-value pairs into the body of the HTTP message.

The object returned from *requests.get()*, *post()*, *put()*, etc., is a response object (called r here).

Using the *requests* Module

```
import requests

r = requests.get('https://jsonplaceholder.typicode.com/posts/1', params={'age': 37})

print(r.url)
```
https://jsonplaceholder.typicode.com/posts/1?age=37

```
print(r.text)
```
Raw text

```
{
  "userId": 1,
  "id": 1,
  "title": "sunt aut facere … reprehenderit",
  "body": "quia et suscipit … architecto"
}
```

Dictionary

```
print(r.json())
```
```
{'userId': 1, 'id': 1, 'title': 'sunt aut …
reprehenderit',
'body': 'quia et suscipit … architecto'}
```

```
print(r.headers)
```
```
{'Date': 'Thu, 13 Jan 2022 02:39:07 GMT',
 'Content-Type': 'application/json', …
```

```
print(r.status_code)
```
```
200
```

student_files/ch01_overview/02_using_requests.py

The code above makes a request to an API using the Python requests module. Various attributes are then displayed (shown in the green boxes) after the request completes.

Your Turn! - Task 1-3

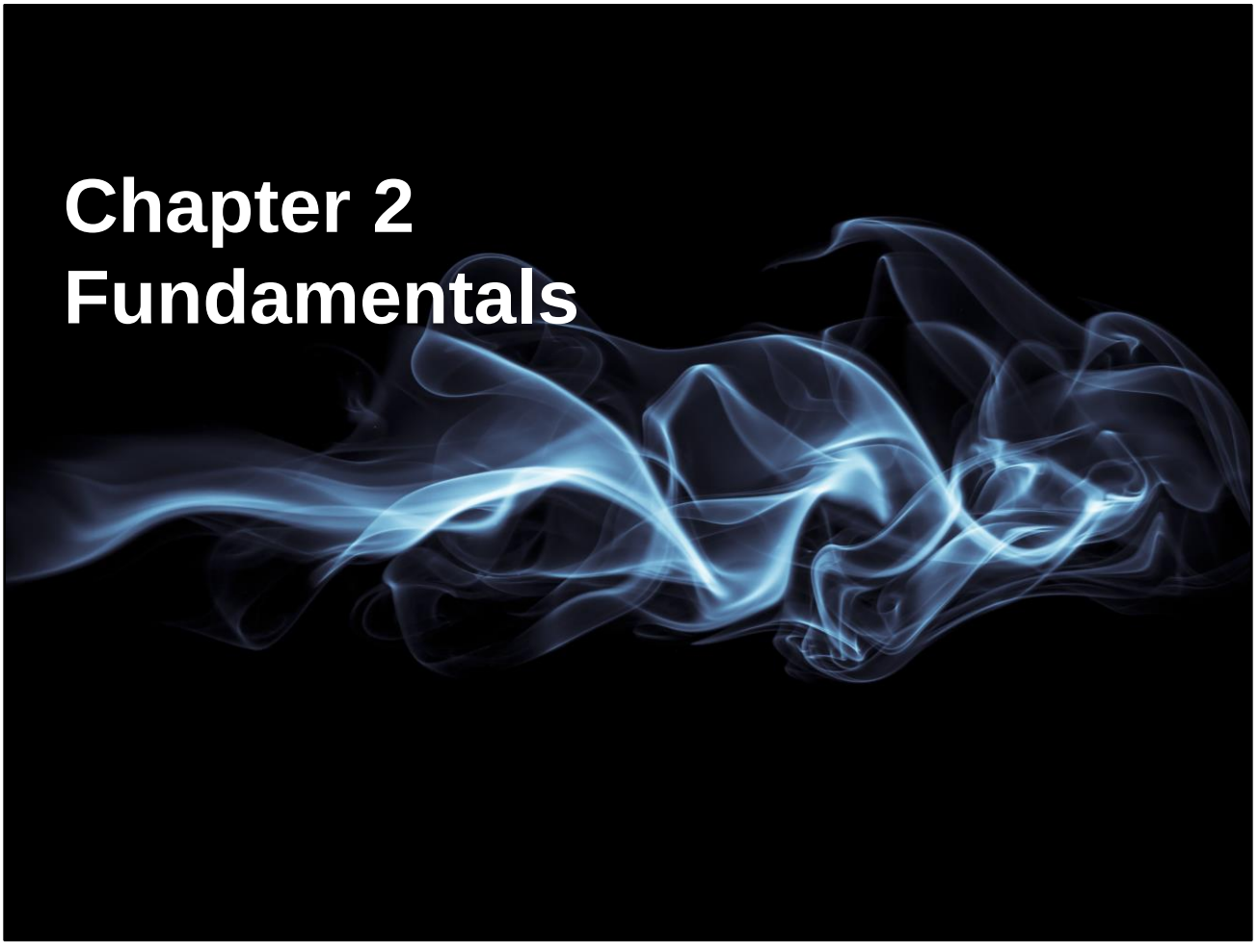
- Use the Python requests module to make a request and print the responses (either as raw text or as a dictionary) for the URLs used in Task 1-2
- *Work from the task1_3_starter.py file*

https://api.coinlore.net/api/tickers/?start=1&limit=5
https://apimeme.com/meme?top=Tell%20Me%20More&bottom=About%20Chocolate
https://datausa.io/api/data?drilldowns=State&measures=Population&year=latest

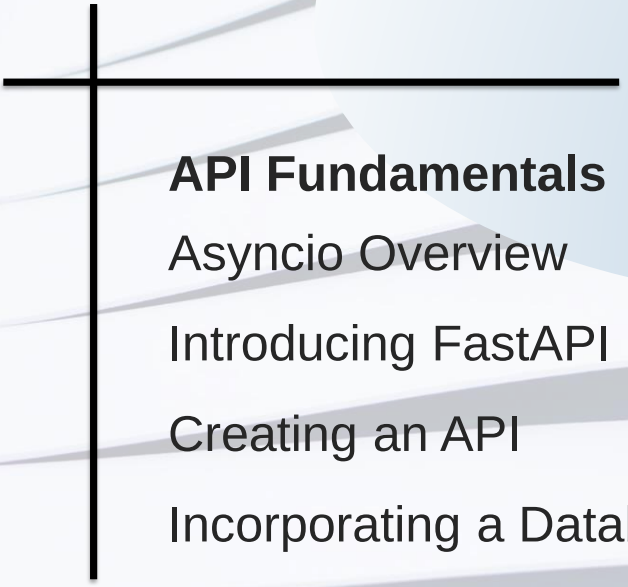
Chapter 1 Summary

- API commonly refers to RESTful services
- RESTful services expose resources on the server
  - They are accessed from a client using HTTP calls
  - Responses often return JSON data to a client
  - Various HTTP methods (GET, POST, PUT, PATCH, DELETE) are used to modify the server resource
- Python provides amazing tools to simplify RESTful application development
  - Those tools include Flask, Django, and FastAPI

Chapter 2
Fundamentals



Chapter 2 Overview



API Fundamentals

Asyncio Overview

Introducing FastAPI

Creating an API

Incorporating a Database

Several Python API Server Choices

	Advantages	Disadvantages
FastAPI	Performance, ASGI-based	Newer, less community support, few plugins
Flask (web development, one drop at a time)	Strong community support, numerous plugins	Older, updates tend to cause compatibility issues with plugins
django	All-in-one solution	Bigger learning curve, oldest of these three

- *Numerous others*

The brief summaries above understate some of the advantages and disadvantages of each server listed. While FastAPI is one of the newest entries to the crowded list of Python web servers, it has become popular quite quickly.

Users of FastAPI include Netflix, Microsoft, and many other multi-billion dollar companies. It was created and is owned by a single developer, Sebastian Ramirez, in 2018

Introducing FastAPI

- FastAPI is a newer addition to the list of popular Python tools for building RESTful applications
- Since it is a third-party tool, it must be installed first

pip install fastapi[standard]

https://fastapi.tiangolo.com/

- Fast API is based on *ASGI*...

For more on FastAPI, visit https://fastapi.tiangolo.com/.

The fastapi[standard] install includes FastAPI libraries plus Starlette, Pydantic, and uvicorn. Removing the [standard] declaration will leave out the optional dependencies mentioned.

What is ASGI?...

- In Python, an earlier standard, called WSGI, allowed web server vendors to standardize their solutions
- ASGI, or Asynchronous Server Gateway Interface, is a modernized version of WSGI that emphasizes better concurrency

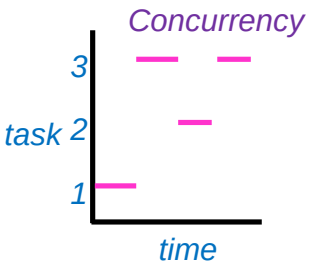
  https://asgi.readthedocs.io/en/latest/

- ASGI apps feature a single-thread used in a non-blocking mode so that it can perform more tasks than synchronous apps
  - It does this by deferring control of the thread back to an *event loop*--this is called awaiting

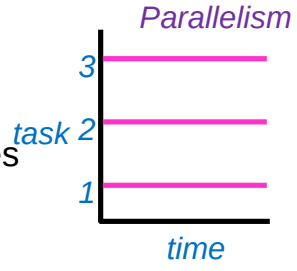
ASGI is a set of APIs in Python for handling concurrency via a single-threaded model. It attempts to use a single thread to a higher degree than a typical synchronous single-threaded application. For this to work properly, it means that single-thread must never block. When a task would normally want to block, control is returned to the event loop, via the *await* keyword, and the event loop can do other things during this time.

Concurrency vs Parallelism

- Concurrency involves running multiple tasks in a single CPU core, switching tasks as needed



- Parallelism - can schedule multiple tasks into multiple CPU cores to run simultaneously
- Python provides modules to help improve application performance
  - threading - single-process, concurrency model, GIL
  - multiprocessing - supports parallelism OS processes
  - asyncio - supports single-threaded concurrency by switching tasks executed

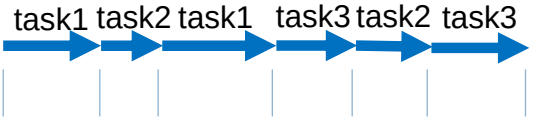


There are *high-level* asyncio APIs for general use and *low-level* asyncio API for those building libraries to gain better control over the event loop

Several options exist in Python for improving the performance of an application. The threading model suffers from having to share time with the CPU due to the presence of a global interpreter lock that only allows one thread at a time to actually execute. Multi-processing is a good way to achieve actual parallelism, but come as a cost of increased complexity. Asyncio is subject to the same constraints as the threading model, namely the global interpreter lock, but attempts to improve performance by utilizing that single thread to a higher degree.

Asynchronous Tasks

- asyncio executes multiple tasks in a *single thread* using time-slicing which allows tasks to share the CPU



  - Tasks execute until they *yield* to another thread
    - Problematic if tasks are greedy
    - Works best with lots of I/O operations

async def defines a "coroutine" or any function that will *yield* control

```
import asyncio
import time


async def my_func(val: int):
    print(f'entering my_func {val}')
    await asyncio.sleep(1)
    print(f'exiting my_func {val}')


async def main():
    await asyncio.gather(my_func(1),
                         my_func(2))


start = time.time()
asyncio.run(main())
print(f'Elapsed: {time.time() - start}')
```

Yields control

Schedules coroutines into the event loop

Runs the event loop, passes the coroutine to it

```
entering my_func 1
entering my_func 2
exiting my_func 1
exiting my_func 2
Elapsed: 1.0113542079925537
```

student_files/ch02_fundamentals/01_coroutine.py

Asyncio assumes a single-thread is executing tasks but only allows tasks to run for a period. In some cases, this approach can be less complex than a multi-threaded implementation because we aren't as susceptible to thread synchronization problems. Remember, there is only one thread executing.

When compared to the single-threaded version, asynchronous solutions can be better when there is a lot of I/O blocking. Blocking occurs when the program is waiting for input, perhaps from outside the Python environment. In solutions where there is a lot of blocking, this approach can provide a performance improvement. Also, if there are a lot of tasks, it is possible that some tasks will likely involve some IO blocking.

Good reference: https://github.com/timofurrer/awesome-asyncio

Processing Items Asynchronously

```
import asyncio
from itertools import islice

async def process_data(filepath: Path):
    with filepath.open(encoding='utf-8') as f:
        for line in islice(f, 10):
            await asyncio.sleep(0)
            print(f'{filepath.name}: {line.strip()}')

async def main(files: list[str]):
    files = (Path(f'../resources/{file_obj}') for file_obj in files)
    tasks = (process_data(f) for f in files)
    await asyncio.gather(*tasks)

data_files = ['car_crashes.csv', 'accounts.csv', 'contacts.dat']
asyncio.run(main(data_files))
```

This line allows control to return to the event loop, thus files are processed concurrently

Files are read concurrently

```
car_crashes.csv: 18.8,7.332000000000001,5.64,18.048000000000002,
accounts.csv: 100,John Smith,5500,0.025,C
contacts.dat: Sally Smith,220 E. Main Ave Phila. PA 09119,(202)421-9008
car_crashes.csv: 18.1,7.421,4.525,16.290000000000003,17.014,1053.48,133.93,AK
accounts.csv: 101,Sally Jones,6710.11,0.025,C
contacts.dat: John Brown,231 Oak Blvd. Black Hills SD 82101,(719)303-1219,
```

student_files/ch02_fundamentals/02_await.py

The example takes three files and reads 10 lines from each file. This happens by putting three process_data() calls into the event loop. To read a file in the traditional way, however, would cause the function to never yield back to the event loop. Each file would be processed entirely and sequentially.

However, in this example, await asyncio.sleep(0) causes control to be returned to the event loop. The output then renders data from the files concurrently as a result.

Async Keywords to Help Yield Control

async with **and** ***async for*** **are Python language modifications that support yielding control to the event loop**

aiofiles is a third-party library that provides methods that help yield control to the event loop

```
import aiofiles
from asyncstdlib import islice

async def process_data(filepath: Path):
    async with aiofiles.open(filepath) as f:
        async for line in islice(f, 10):
            print(f'{filepath.name}: {line.strip()}')

async def main(files: list[str]):
    files = (Path(f'../resources/{file_obj}') for file_obj in files)
    tasks = (process_data(f) for f in files)
    await asyncio.gather(*tasks)

data_files = ['car_crashes.csv', 'accounts.csv', 'contacts.dat']
asyncio.run(main(data_files))
```

This is a third-party version of islice() that allows asyncio objects to be iterated over

```
car_crashes.csv: 18.8,7.332000000000001,5.64,18.048000000000002,
accounts.csv: 100,John Smith,5500,0.025,C
contacts.dat: Sally Smith,220 E. Main Ave Phila. PA 09119,(202)421-9008
…
```

student_files/ch02_fundamentals/03_aiofiles.py

Asyncio apps can get complicated, but the key to remember is they need to yield control to the event loop. New Python control structures are designed to assist in this effort, making asyncio solutions easier to write.

Creating a First Simple API

- In our demonstration, we'll create a RESTful app that provides celebrity data

student_files/data/celebrity_100.csv

```
Name,Pay (USD millions),Year,Category
Oprah Winfrey,225.0,2005,Personalities
Tiger Woods,87.0,2005,Athletes
Mel Gibson,185.0,2005,Actors
George Lucas,290.0,2005,Directors/Producers
Shaquille O'Neal,33.4,2005,Athletes
Steven Spielberg,80.0,2005,Directors/Producers
Johnny Depp,37.0,2005,Actors
Madonna,50.0,2005,Musicians
Elton John,44.0,2005,Musicians
Tom Cruise,31.0,2005,Actors
Brad Pitt,25.0,2005,Actors
Dan Brown,76.5,2005,Authors
Will Smith,35.0,2005,Actors
David Letterman,40.0,2005,Personalities
```

The output above shows the contents of the celebrity_100.csv file. This file is found in the data directory within the student_files folder. We'll develop our initial API around this file.

Defining Resources

- As part of our design process, we must decide on what our resources will be
- Given the data on the prior slide, we'll use a *celebrity* object, and similarly a plural noun for our URI
- So, our likely URL will look like the following:

http://localhost:8000/api/celebrities/*celebrity_name*

Our initial design will be centered around our data file (celebrity_100.csv), therefore our initial resource will be a celebrity object. The URL that maps to this resource is shown above, where celebrity name will be an actual name, such as Tom Cruise.

Starting the Server

- Our first version instantiates the FastAPI server object and the uvicorn tool starts it

Defines the main FastAPI application object

Starts the server

```
import uvicorn
from fastapi import FastAPI

app = FastAPI()

uvicorn.run(app, host='localhost', port=8000)
```

Example startup within PyCharm:

Note: To run in debug mode, right-click the source code and select Debug...

student_files/ch02_fundamentals/04_simple_api.py

There's not much to test out yet. When the server is started within PyCharm, the output above will be shown.

Loading Some Data to Work With

- The app acquires data from a file at startup

```
from pathlib import Path

import uvicorn
from fastapi import FastAPI

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv').open(encoding='utf-8')][1:]
print('Celebrity data read.')

app = FastAPI()


uvicorn.run(app, host='localhost', port=8000)
```

```
[
  ['Oprah Winfrey', '225.0', '2005', 'Personalities'],
  ['Tiger Woods', '87.0', '2005', 'Athletes'],
  ['Mel Gibson', '185.0', '2005', 'Actors'],
  ['George Lucas', '290.0', '2005', 'Directors/Producers'], …
]
```

student_files/ch02_fundamentals/05_acquiring_data.py

In this updated version of our app, no new FastAPI code was added. Instead, we acquire the celebrity data from the specified file (found in the data directory of your student files). The new line of code is called a list comprehension, and it builds a list containing nested lists (as shown in green at the bottom of the slide).

Defining a Mapping

- Critical for working with FastAPI is to define which function should be called when a URI request arrives

```
from pathlib import Path

import uvicorn
from fastapi import FastAPI

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv')
                                                    .open(encoding='utf-8')][1:]
print('Celebrity data read.')

app = FastAPI()


@app.get('/api/celebrities/{name}')
def do_stuff(name):
    return f'Hi there {name}!'


uvicorn.run(app, host='localhost', port=8000)
```

This statement responsible for registering the function within FastAPI. It tells FastAPI to call the function if a GET request matching this path is encountered

student_files/ch02_fundamentals/06_creating_a_mapping.py

The app.get() decorator registers the function within FastAPI and establishes when the function should be called. In addition, it can support other important parameters (some discussed later) such as *response_model* and *status_code*.

Defining a Mapping *(continued)*

- The app.get() *path operation decorator* gives FastAPI control over your functions

```
from pathlib import Path

import uvicorn
from fastapi import FastAPI

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv')
                                                    .open(encoding='utf-8')][1:]
print('Celebrity data read.')

app = FastAPI()


@app.get('/api/celebrities/{name}')
def do_stuff(name):
    return f'Hi there {name}!'


uvicorn.run(app, host='localhost', port=8000)
```

@app.get() is a special syntax in Python called a decorator

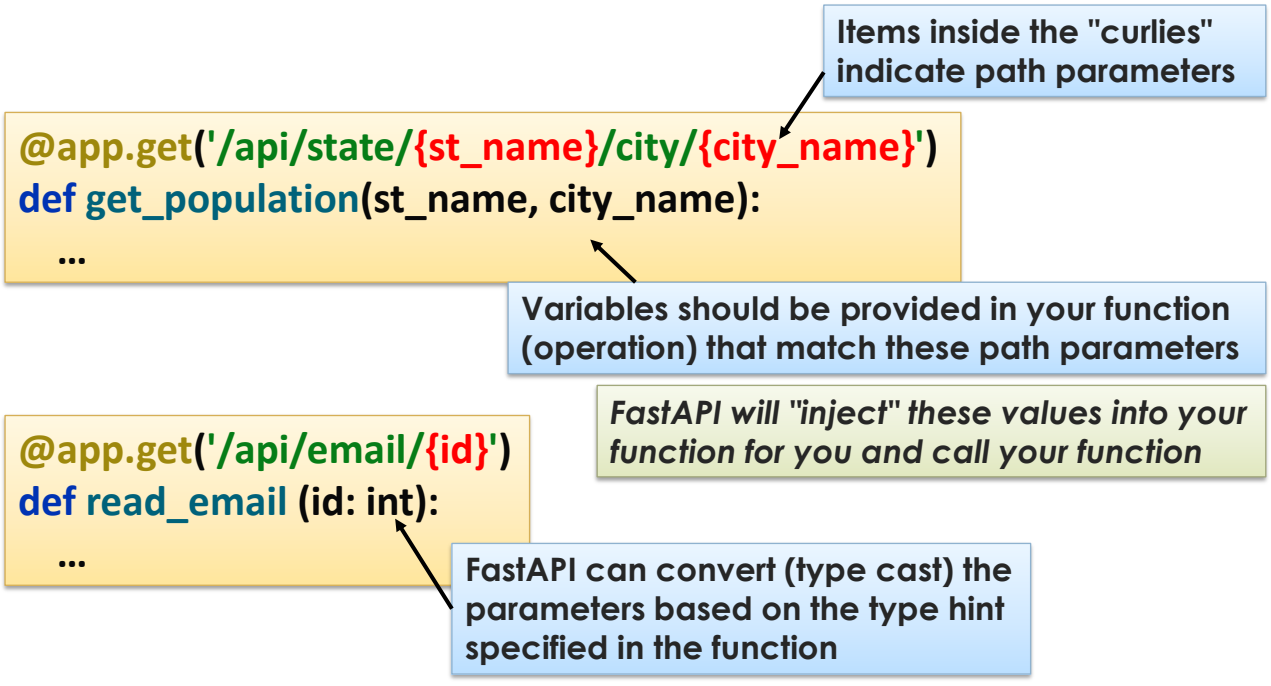
But what is this {name} item?

student_files/ch02_fundamentals/06_creating_a_mapping.py

The full topic of decorators is beyond the scope of our course and perhaps not necessary. All that is needed to understand about decorators is that they replace the stated function with a different function. So, in this case, FastAPI is replacing our do_stuff() function with another function of their own.

FastAPI Path Operation Decorators

- *Path operation decorators* are used above a path operation function to instruct FastAPI on how to call it



The curly brackets, { }, indicate path parameters. They allow variables to be provided in the path of the URL. Note: this is different from query string parameters which appear after the ? In the URL. Query string parameters are discussed later.

FastAPI will inject the path parameters into your function, so it is important to specify variables in the function that match the variables defined in the URL. Type hints may also be specified in the function and FastAPI will attempt to convert them to that type (this functionality comes from a helper tool called Pydantic, discussed further later).

A Raw Output Test

- To test out our partial implementation, first run the Python script
  - If using PyCharm, right-click anywhere in the source file and select

    Run '06_creating_a_mapping.py'

- Next, in a browser type:

  http://localhost:8000/api/celebrities/tom%20cruise

- You should get a response

  Hi there tom cruise!

Note: what happens if you type the URL, but leave off the celebrity name? (e.g., http://localhost:8000/api/celebrities/)

Note: FastAPI can also be run from the command-line by removing the uvicorn.run() statement and typing the following in the terminal: fastapi dev 06_create_a_mapping.py

Other Output Formats

- The browser can only execute HTTP GET requests from its address bar
- If other HTTP methods are created, they will have to be tested differently
- Test out the following URLs in the browser:

  http://localhost:8000/openapi.json

  http://localhost:8000/docs

  http://localhost:8000/redoc

These are discussed further later

More will be said about these URLs and output formats a little later.

Creating a JSON Response

```
from pathlib import Path

import uvicorn
from fastapi import FastAPI

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv')
                                                .open(encoding='utf-8')][1:]

print('Celebrity data read.')

app = FastAPI()



@app.get('/api/celebrities/{name}')
def do_stuff(name):
    other = ['stuff1', 'stuff2']
    return {'greeting': f'Hi there {name}', 'more': other, 'anything': {'level': 2}}


uvicorn.run(app, host='localhost', port=8000)
```

```
{
  "greeting": "Hi there tom cruise",
  "more": [
      "stuff1",
      "stuff2"
  ],
  "anything": {
    "level": 2
  }
}
```

student_files/ch02_fundamentals/07_working_with_json.py

FastAPI naturally returns data as JSON objects. So, if you merely return a string, it will try to convert the string to a JSON string which requires certain characters to be escaped (such as double quotes). If you wanted to return something else, you can change the response_model or response_class. Below shows how to return data as plain text:

from fastapi.responses import PlainTextResponse

@app.get('path', response_class=PlainTextResponse)

GET Single Celebrity

```
from pathlib import Path

import uvicorn
from fastapi import FastAPI

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv').open(encoding='utf-8')][1:]
print('Celebrity data read.')

app = FastAPI()

@app.get('/api/celebrities/{name}')
def get_one_celebrity(name):
    try:
        results = [row for row in data if name.casefold() in row[0].casefold()]
    except Exception as err:
        results = err.args

    return {'results': results, 'name': name}

uvicorn.run(app, host='localhost', port=8000)
```

Our final version adds logic to check celebrity name matches against the submitted value

student_files/ch02_fundamentals/08_get_single_celebrity.py

In our function, we wrote a little Python logic to iterate through our data and match the name from the URL to the name column in our data structure. We save any name matches and return those.

For those unfamiliar, the Python casefold() method is similar to Python's lower() method but works for larger character sets (containing characters from other languages).

We also renamed do_stuff() to get_one_celebrity() now.

FastAPI Error Handling

```
from pathlib import Path

import uvicorn
from fastapi import FastAPI, HTTPException

data = [line.strip().split(',') for line in Path('../data/celebrity_100.csv').open(encoding='utf-8')][1:]
print('Celebrity data read.')

app = FastAPI()

@app.get('/api/celebrities/{name}')
def get_one_celebrity(name):
    results = [row for row in data if name.casefold() in row[0].casefold()]

    if not results:
        raise HTTPException(status_code=404, detail='Celebrity not found')

    return {'results': results, 'name': name}

uvicorn.run(app, host='localhost', port=8000)
```

Our previous example responds with a 200 HTTP status even if no celebrity is found (e.g., try XYZ for the name)

Here we see FastAPI allows for raising exceptions that respond with an HTTP status and message of your choosing

student_files/ch02_fundamentals/09_get_single_celebrity_error_handling.py

This version improves on the previous one by adding error handling that supports changing the HTTP status code. A 404 status code is often selected when the resource sought is not found or identified.

Your Turn! - Task 2-1

- Create a RESTful app to retrieve invoice data given an invoice order number
  - Valid invoice order numbers are: *536365 - 581587*
  - *Implement only the HTTP GET method*
- Use the FastAPI starter code provided in *ch02_fundamentals/task2_1_starter.py*

```
InvoiceNo,StockCode,Description,Quantity,InvoiceDate,UnitPrice,CustomerID,Country
536365,85123A,WHITE HANGING HEART T-LIGHT HOLDER,6,12/1/2010 8:26,2.55,17850,United Kingdom
536365,71053,WHITE METAL LANTERN,6,12/1/2010 8:26,3.39,17850,United Kingdom
536365,84406B,CREAM CUPID HEARTS COAT HANGER,8,12/1/2010 8:26,2.75,17850,United Kingdom
536365,84029G,KNITTED UNION FLAG HOT WATER BOTTLE,6,12/1/2010 8:26,3.39,17850,United Kingdom
536365,84029E,RED WOOLLY HOTTIE WHITE HEART.,6,12/1/2010 8:26,3.39,17850,United Kingdom
536365,22752,SET 7 BABUSHKA NESTING BOXES,2,12/1/2010 8:26,7.65,17850,United Kingdom
536365,21730,GLASS STAR FROSTED T-LIGHT HOLDER,6
536366,22633,HAND WARMER UNION JACK,6,12/1/2010
536366,22632,HAND WARMER RED POLKA DOT,6,12/1/20
536367,84879,ASSORTED COLOUR BIRD ORNAMENT,32,12
```

For now, test it out in a browser using invoice 536365.
Also, test it out using invoice 1.

Consuming APIs

- The Python requests module could be used to consume API data

```
import json
import requests

base_url = 'http://localhost:8051'
path = '/api/celebrities/'
default = 'Kevin'

celeb_name = input('Enter celebrity to find info about (def. Kevin): ')
if not celeb_name:
   celeb_name = default

results = requests.get(f'{base_url}{path}{celeb_name}').json()

print(json.dumps(results, indent=4))
```

http://localhost:8051/api/celebrities/Kevin

student_files/ch02_fundamentals/10_consuming_apis.py

The variable 'results' will be a Python dictionary. It would look (in part) like this:

```
{
   "name": "Kevin",
   "results": [
      [
         "Kevin Garnett",
         "29.0",
         "2008",
         "Athletes"
      ],
      [
         "Kevin Spacey",
         "16.0",
         "2014",
         "Television actors"
      ],
      [
         "Kevin Hart",
         "87.5",
         "2016",
         "Comedians"
      ],
      [
         "Kevin Hart",
         "39.0",
         "2020",
         "Comedians"
      ]
   ]
}
```

Using *requests* to Check HTTP Status

```
import requests

r = requests.get('http://httpbin.org/status/200')

if r.ok:
    print('Request was successful.')

if r.status_code == 200:
    print('Request was successful.')

if r:
    print('Request returned a non-400 or 500 error code.')

r = requests.get('http://httpbin.org/status/400')
try:
    r.raise_for_status()
except requests.exceptions.HTTPError as err:
    print(err)
```

student_files/ch02_fundamentals/11_checking_status.py

The third conditional above will return true for any non-400 or 500 error status codes. The bottom example shows how the request could be checked for any kind of errors returned in the response and then raise an exception because of it.

Your Turn! - Task 2-2

- Create a *Python client* to access the invoicing API created in task 2-1

`http://localhost:8051/api/invoices/536365`

- Work from the provided task2_2_starter.py file
- Ensure your FastAPI server from task 2-1 is running before testing your answer
  - Access invoice 536365 and display its results

Passing Data in RESTful Methods

- Different HTTP methods will follow slightly different ways of passing data:

Request Type	Data Passed
GET /api/invoices/2952 ***Reads* a specific invoice**	Invoice ID (or values) passed in path only
POST /api/invoices ***Creates* a new invoice**	Invoice data passed without an ID in the body of the HTTP method
PUT /api/invoices/2952 ***Updates* a specific invoice**	Invoice ID passed in path, invoice data values passed in body
DELETE /api/invoices/2952 ***Deletes* a specific invoice**	Invoice ID passed in path only, body can be empty

Passing data for an HTTP PATCH is similar to an HTTP PUT. Also, an HTTP GET that does not include a specific ID could be used to retrieve *many* records.

Python Classes

```
class Celebrity:
    def __init__(self, name, pay, year, category):
        self.name = name
        self.pay = pay
        self.year = year
        self.category = category

    def __str__(self):
        return f'{self.year:<6}{self.name} ({self.category}) ${self.pay:>} million'


f = Path('../data/celebrity_100.csv').open(encoding='utf-8')
header = f.readline().strip().lower().split(',')
header[1] = re.sub(r'\([^()]*\)', '', header[1]).strip()          # regex removes "(millions)"
                                                                  # ['name', 'pay', 'year', 'category']
data = f.readline().strip().split(',')              # ['Oprah Winfrey', '225.0', '2005', 'Personalities']

data_dict = {h: d for h, d in zip(header, data)}       # {'name': 'Oprah Winfrey', 'pay': '225.0',
                                                       #  'year': '2005', 'category': 'Personalities'}
celeb = Celebrity(**data_dict)
print(celeb)
```

```
2005  Oprah Winfrey (Personalities) $225.0 million
```

student_files/ch02_fundamentals/12_classes.py

Classes are commonly used within Python. The self parameter is required for all class methods (with a couple of exceptions not important here). The __init__() method will be called when an object instance is created of our class. Within the __init__() we attached the values passed in to our new object instance (a celebrity object called celeb).

The ** notation is used to expand (unpack) the dictionary into keyword arguments.

Python Annotations (Type Hints)

- Annotations provide developers and tools a means for determining what types to pass into a function

```
from pydantic import validate_call

@validate_call
def read_celebs(filepath: str | Path,
                size: int = 10,
                encoding: str = 'utf-8') -> list[Celebrity]:
    results = []
    with open(Path(filepath), encoding=encoding) as f:
        f.readline()
        for line in islice(f, size):
            values = line.strip().split(',')
            results.append(Celebrity(values[0], float(values[1],
                                     int(values[2], values[3]))

    return results
```

```
print(read_celebs(datafile, 7))
print(read_ celebs(size='7', filepath=datafile))
print(read_celebs (datafile, 'hello'))
```

Okay
Okay, Pydantic will coerce string to int safely
Not okay, Pydantic can't convert 'hello' to int

student_files/ch02_fundamentals/13_python_type_hints.py

Shown here is the use of Python annotations. Annotations are a vital part of FastAPIs success.

Also shown is a framework called PydanticPydantic is a popular third-party data validation framework. It relies on type hints within Python to work properly. In the example, a decorator gains control of the user function (read_definitions()) and checks function call parameters *before* the function actually gets called. If the parameters are invalid types, a ValidationError is raised.

Pydantic can convert string types to int if desired. This happens in the second call to read_definitions(). If it can't make that conversion, a ValidationError will occur.

Pydantic

- Pydantic provides runtime type validation *(and more)*

```
import sys

from pydantic import BaseModel, ValidationError


class Celebrity(BaseModel):
    name: str
    pay: float
    year: int
    category: str


c1 = Celebrity(name='Oprah', pay=225.0, year=2005, category='Personalities')
c2 = Celebrity(name='Oprah', pay=225.0, year='2005', category='Personalities')
try:
    c3 = Celebrity(name='Oprah', pay=225.0, year='hello', category='Personalities')
except ValidationError as err:
    print(err, file=sys.stderr)
```

Pydantic models should inherit from *BaseModel*

Like a Dataclass, declare attributes within the class, but not within an __init__()

Use keyword args when instantiating Pydantic model objects

Fails at runtime

student_files/ch02_fundamentals/14_using_pydantic.py

In the example, three celebrity objects are instantiated. Being Pydantic models, they should only use keyword arguments for creation. The first two will work. The second works because Pydantic can coerce the string provided for the year. The third fails at runtime during instantiation and raises a ValidationError.

Pydantic, FastAPI, and POST Form Data

FastAPI

```
from typing import Annotated

from fastapi import FastAPI, Form

app = FastAPI()

@app.post('/api/celebrities')
def create_celebrity(name: Annotated[str, Form()],
                     pay: Annotated[float, Form()],
                     year: Annotated[int, Form()],
                     category: Annotated[str, Form()]):
    return {'action': 'POST response',
            'name': name, 'pay': pay, 'year': year, 'category': category}
```

The server is told to call create_celebrity() on a POST request

Data is expected to arrive as form encoded data values

Client

```
results = requests.post(f'{base_url}{path}'.strip('/'),
                        data={'name': celeb_name,
                              'category': 'Actors',
                              'pay': 3.0,
                              'year': 2024})
print(results.text)
print(results.request.body)
```

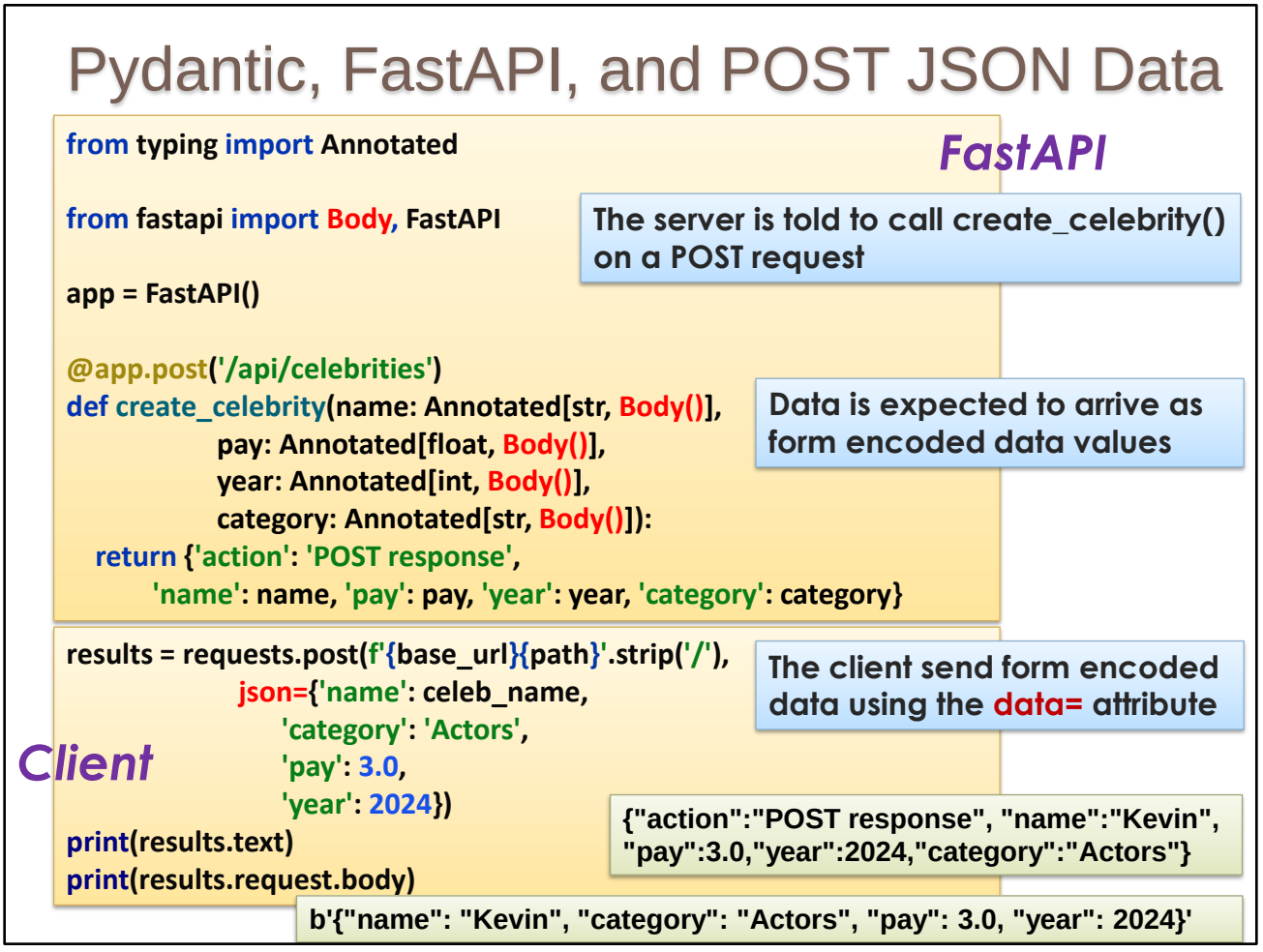
The client send form encoded data using the data= attribute

```
{"action":"POST response", "name":"Kevin",
"pay":3.0,"year":2024,"category":"Actors"}
```

```
name=Kevin&category=Actors&pay=3.0&year=2024
```

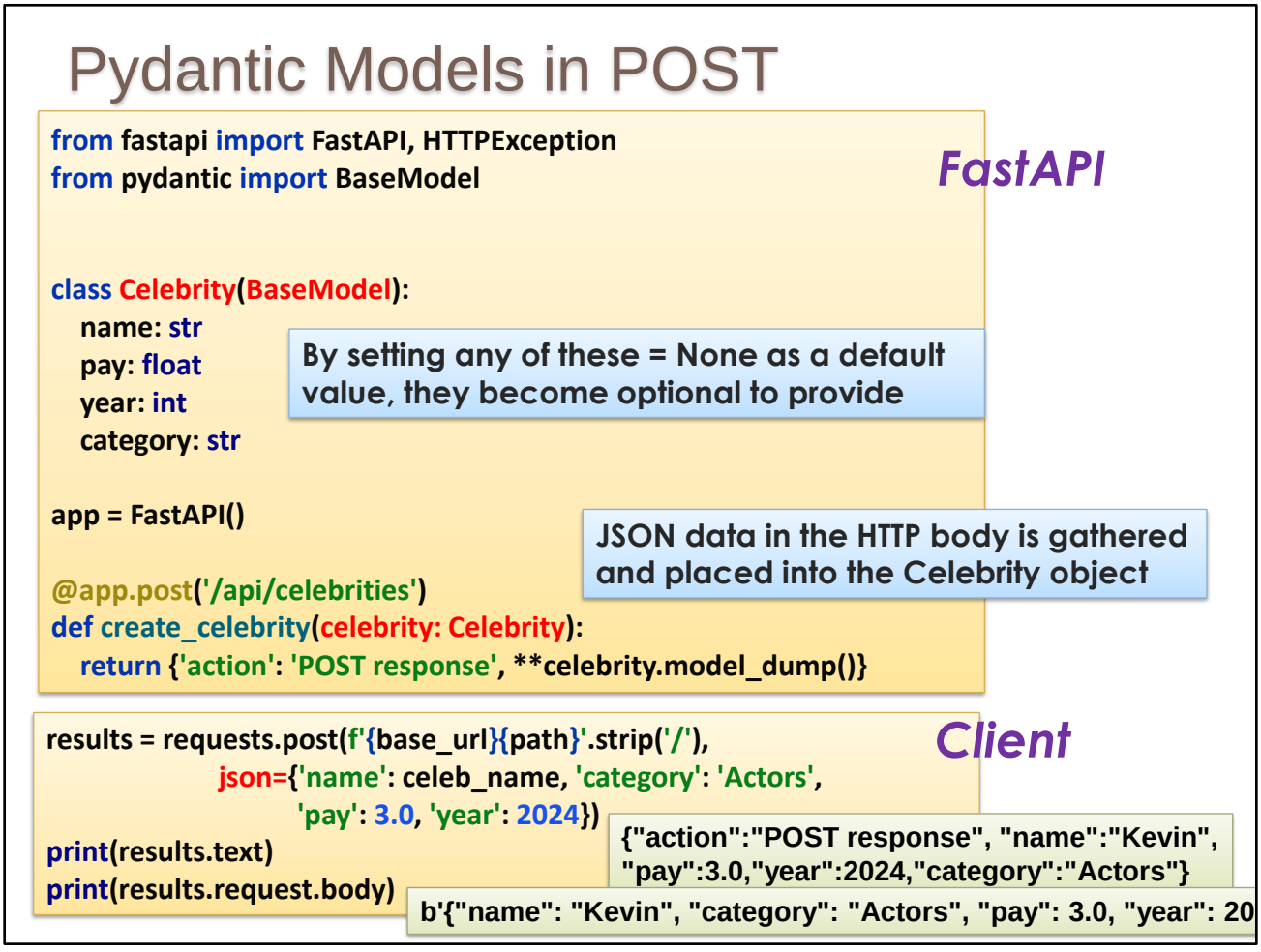
student_files/ch02_fundamentals/15_post_as_form_data.py and 16_testing_post_as_form_send.py

There are actually two files depicted here. The upper (first) is the FastAPI stub for the POST method. This method is told to expect data coming in as form encoded data values



student_files/ch02_fundamentals/17_post_as_json_data.py and 18_testing_post_as_json_send.py

This version is nearly identical to the previous except the HTTP body of the request will send the data in a JSON format.



student_files/ch02_fundamentals/19_post_using_pydantic_models.py and 20_testing_post_using_pydantic_models.py

While the client still sends data as JSON in the HTTP body, the server is told to expect a Celebrity (Pydantic model) object. FastAPI extracts the data from the HTTP body and creates a Celebrity object. It does Pydantic runtime type validation as well as injection of this object into the create_celebrity() method.

Providing the Other HTTP Methods

```python
@app.get('/api/celebrities')
def get_all_celebrities():
    return {'action': 'GET (all) response'}

@app.put('/api/celebrities/{name}')
def update_celebrity():
    return {'action': 'PUT response'}

@app.delete('/api/celebrities/{name}')
def delete_celebrity():
    return {'action': 'DELETE response'}
```

FastAPI

These are the other HTTP methods (though they are not finished yet)

The client issuing other HTTP requests (though incomplete also) to the server

```python
results = requests.put(f'{base_url}{path}{celeb_name}')
print(results.text)
```

```
{"action":"PUT response"}
```

```python
results = requests.delete(f'{base_url}{path}{celeb_name}')
print(results.text)
```

```
{"action":"DELETE response"}
```

```python
results = requests.get(f'{base_url}{path}'.strip('/'))
print(results.text)
```

```
{"action":"GET (all) response"}
```

Client

student_files/ch02_fundamentals/19_post_using_pydantic_models.py and 20_testing_post_using_pydantic_models.py

Your Turn! - Task 2-3

- Incorporate the POST, PUT, DELETE, and GET (all) into our previous invoice application (Task 2-1)
  - Work from the newly provided task2_3_starter.py file
- Create an *Invoice* Pydantic Model which defines a stock_code (str), quantity (int), description (str), invoice_date (str), unit_price (float), customer_id (str), and country (str)
- Write the function (operation) signatures and decorators for each of the above mentioned HTTP methods
- Place temporary return values in each of the functions
- Use the provided test client to test your solution (*task2_3_client.py*)

Optional Topic: Postman and Testing APIs

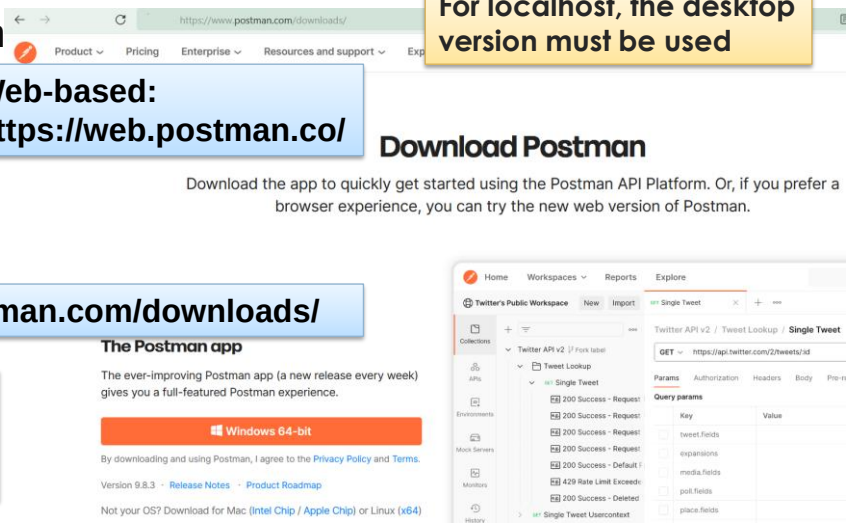
- Postman is a popular client for creating and testing APIs
  - Runs on Windows, Mac, Linux
  - Postman has several tiers for usage including a Free plan for small teams

Homepage: https://www.postman.com/

  - Can be used from a web-based interface, or

Web-based: https://web.postman.co/

For localhost, the desktop version must be used



  - As a desktop app installed from

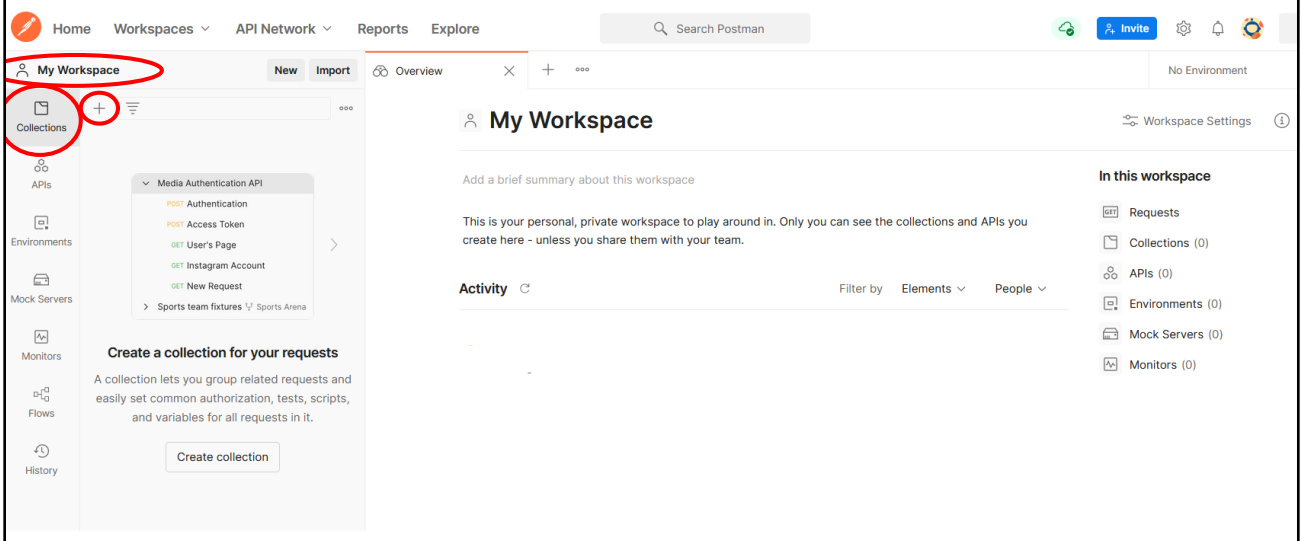
https://www.postman.com/downloads/

Either the web or desktop versions require creating an account (free)

Postman is widely used and is offered at several levels depending on needs and team size. For many, the free plan will suffice, but for large-scale collaborative needs, higher-level plans may be necessary.

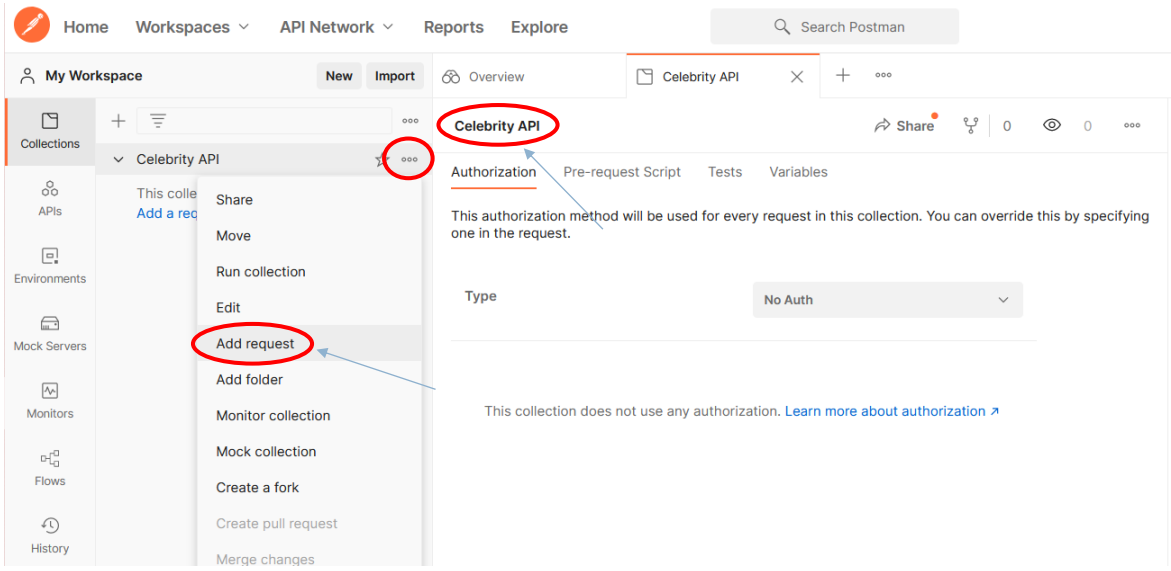
To test using localhost as the domain of the URL, the desktop app version must be used.

Using Postman: Creating Collections



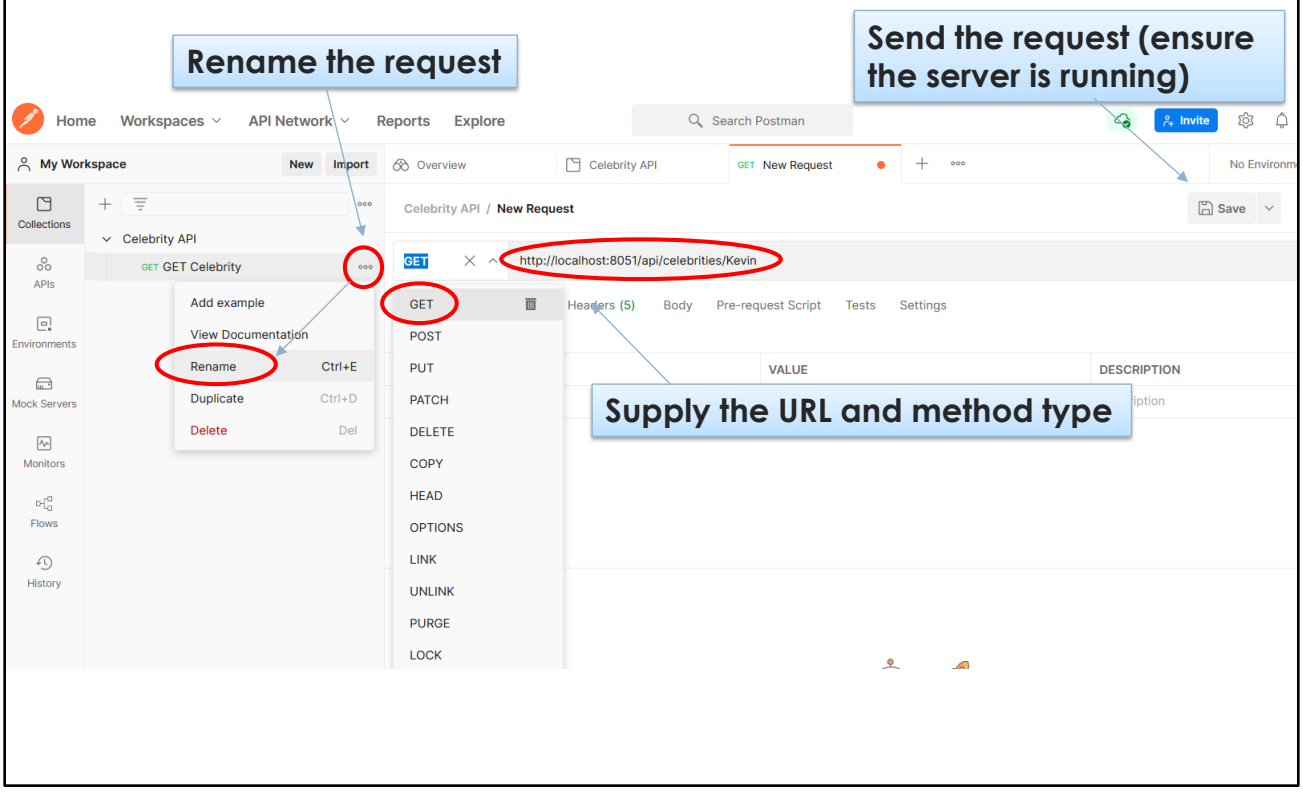
On the screen shown above, the browser-based version loaded the **web.postman.co** url and signed in. Next, a collection was created. Collections are groupings of URLs (typically related to an API set).

Using Postman: Adding Requests



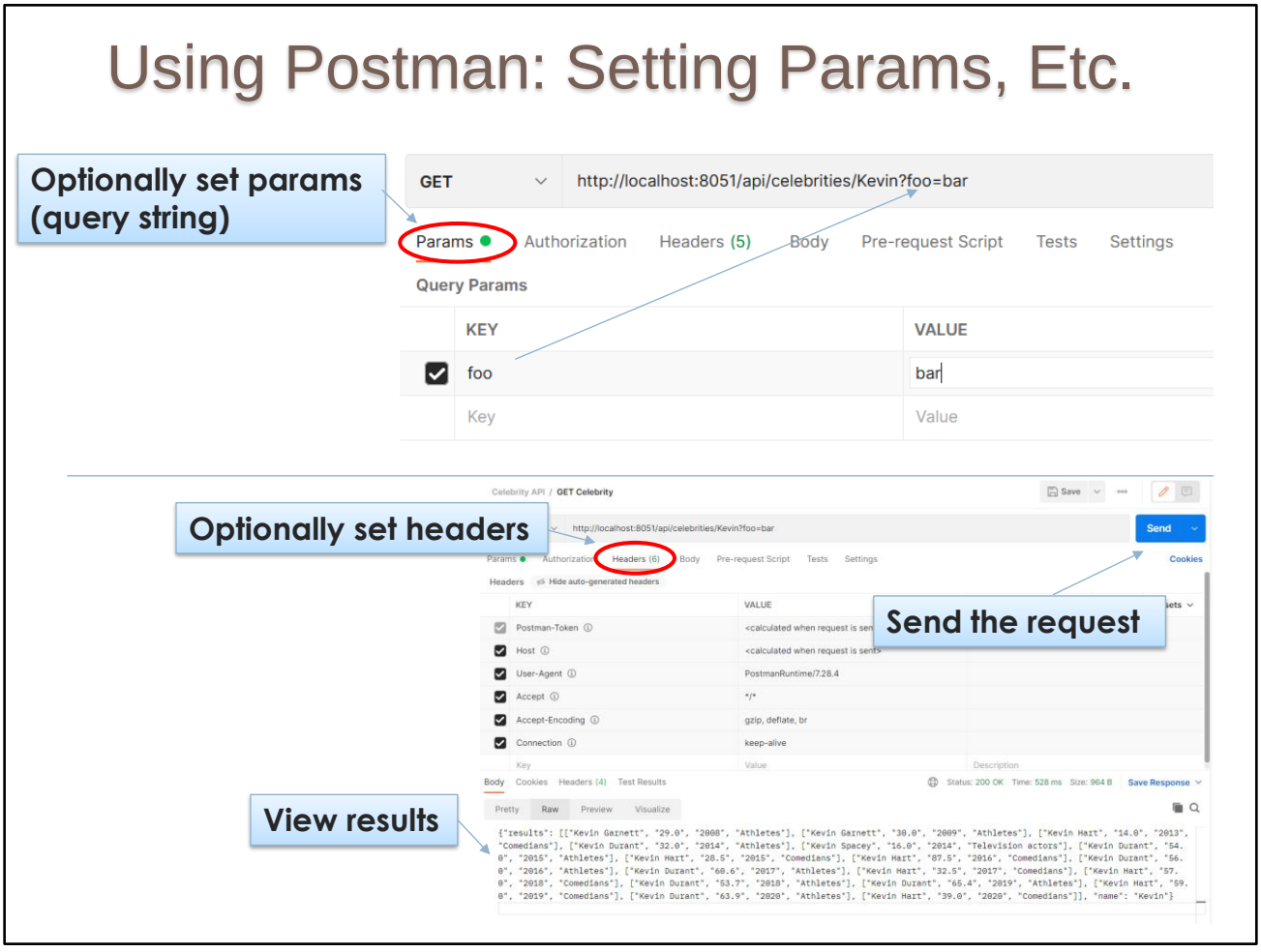
Once a collection is created, you can give the overall API a name and define API requests.

Using Postman: Sending Requests



By supplying the URL and method type for the request, it can easily be sent or re-sent anytime.

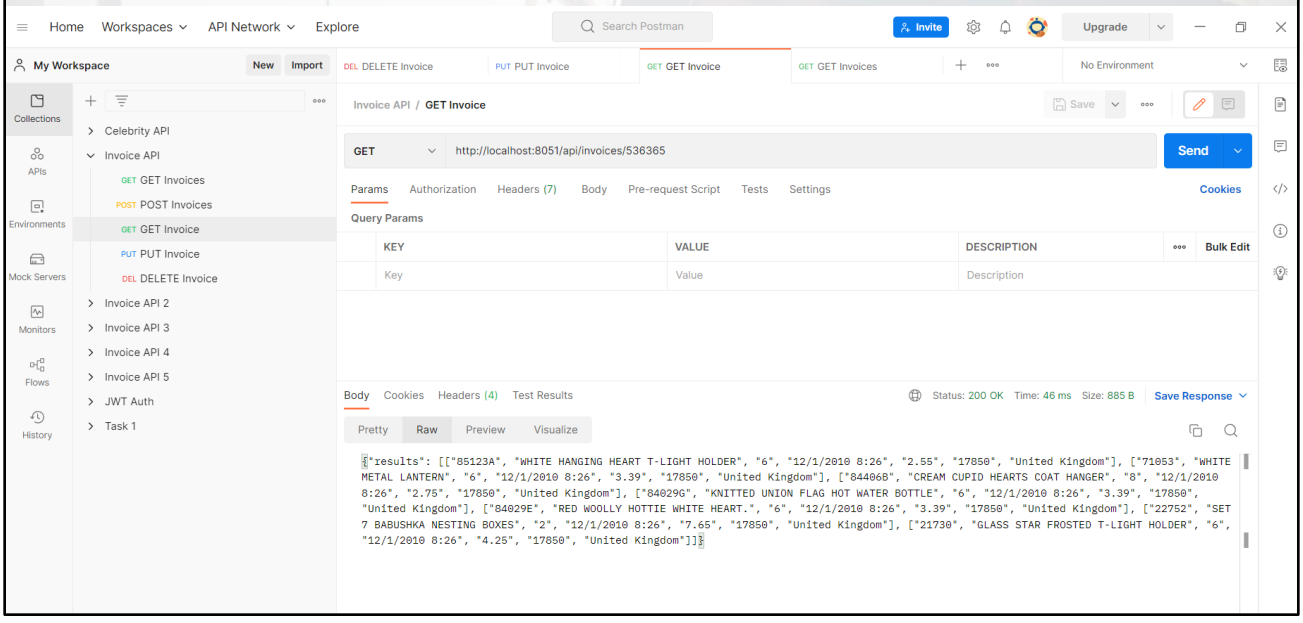
Using Postman: Setting Params, Etc.



Postman provides a nice degree of customization of requests including the ability to set query string params, headers, and body parameters.

Your Turn! - Task 2-4 (optional)

- Use Postman to verify our Invoice application
- Test each of the endpoints and methods created in the previous exercise



Bringing In the Database

- A commonly used Python tool for interacting with a database is called *SQLAlchemy*

https://docs.sqlalchemy.org/en/20/index.html

- SQLAlchemy performs *automatic Python object-to-relational database mapping* (ORM)
- SQLAlchemy is a third-party tool and must be installed

pip install sqlalchemy

SQLAlchemy provides a means to integrate the Python world with the database. It not only converts relations to objects (and vice-versa), but it takes care of the database SQL statements as well.

Configuring SQLAlchemy

- Three steps to get SQLAlchemy up and running
  1. Configure the SQLAlchemy engine (shown below)
  2. Define SQLAlchemy models to interact with the database
  3. Invoke model methods to perform database operations

- Step 1. Configure the tool via create_engine() which defines how to connect to the database

```
from pydantic import BaseModel
from sqlalchemy import create_engine, Column
from sqlalchemy.orm import declarative_base, sessionmaker
from sqlalchemy.types import Float, Integer, String


db_url = Path(__file__).parents[1] / 'data/course_data.db'

app = FastAPI()

engine = create_engine('sqlite:///' + str(db_url), echo=True)
Session = sessionmaker(bind=engine)
session = Session()
```

This is the location of our database

student_files/ch02_fundamentals/21_fastapi_sqlalchemy.py

To configure SQLAlchemy, we call create_engine() passing a preconfigured string (URL) to identify how to connect to the database. SQLAlchemy doesn't actually connect until it needs to. For other databases, other properties may be required, such as properties for a username and password to authenticate with the database.

A session is also defined which will be used to perform the SQL operations.

For more on SQLAlchemy connection strings, visit the following URL:
https://docs.sqlalchemy.org/en/20/core/engines.html

Define SQLALchemy Models

- Step 2. Create a model class to map to the database

```
app = FastAPI()

Base = declarative_base()


class CelebrityModel(Base):
    __tablename__ = 'celebrity'
    id = db.Column(db.Integer, primary_key=True)
    name = db.Column(db.String(100))
    pay = db.Column(db.Float)
    year = db.Column(db.String(15))
    category = db.Column(db.String(50))

    def __init__(self, name: str, pay: float, year: str, category: str):
        self.name = name
        self.pay = pay
        self.year = year
        self.category = category

    def __str__(self):
        return f'{self.year} {self.name} {self.pay} {self.category}'
```

The model inherits from Base

Define the fields and types to map to the table

The __init__ and __str__ are optional but can be helpful

student_files/ch02_fundamentals/21_fastapi_sqlalchemy.py

A model class should inherit from Base (which is a SQLAlchemy-derived object). Then, (at the class level!) add field definitions to the class that correspond to the fields that will map to the database. Optional __init__() and __str__() methods are provided for convenience for instantiation and debugging or logging purposes.

API POST with FastAPI & SQLAlchemy

- Step 3.
  We'll modify our POST path parameter operation to support SQLAlchemy

```
@app.post('/api/celebrities')
async def create_celebrity(new_celeb_request: Celebrity):
    try:
        new_celeb_db =
              CelebrityModel(**new_celeb_request.model_dump())
        session.add(new_celeb_db)
        session.commit()
        results = new_celeb_db.to_dict()
    except Exception as err:
        raise HTTPException(status_code=404,
                            detail=f'Error creating celebrity: {err.args[0]}')

    return results
```

Instantiate a model, perform an INSERT

Commonly, the inserted object is returned

Test the POST operation either using Postman or by running 22_testing_fastapi_sqlalchemy.py

student_files/ch02_fundamentals/21_fastapi_sqlalchemy.py

Our POST method of the Celebrities class has been modified. It now extracts the HTTP request (body) parameters placing them into a new_celeb_request object. There are other ways to obtain the HTTP request data as well. This data is provided to the model class and then it is inserted into the database (via an SQL INSERT operation) using the db object session's add() method. We commonly return to the client a JSON-based form of the object that was inserted. Here, we returned that object by manually creating it.

About the Database

- The database used in the course is a SQLITE database file found in the *data* directory (called course_data.db)

- Since the DB tables will now have an id (primary key) column, we'll modify our solution slightly to work with the id column for GET, PUT, and DELETE

Note: When interacting with the database, it can be reset anytime by simply running the restore_db.py file in the student_files/data directory.

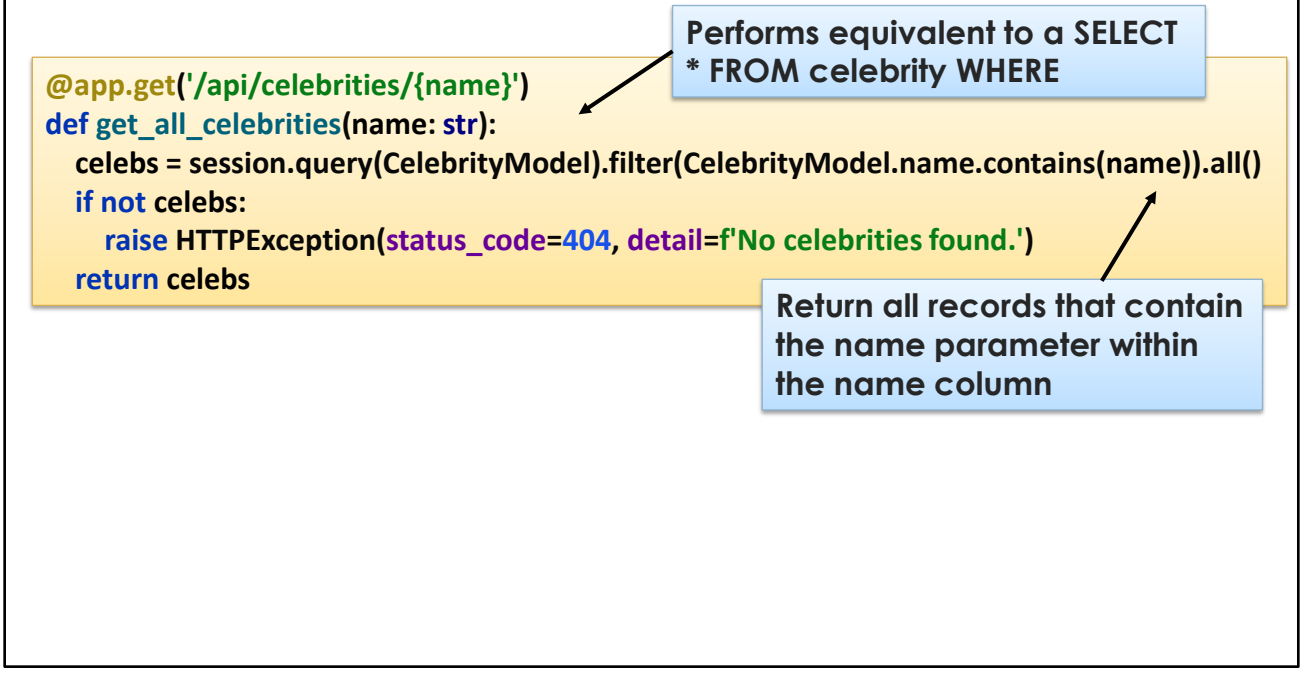
This resets the tables back to their original datasets.

Your Turn! - Task 2-5:

Implement GET (singular) and POST

- Add SQLAlchemy to the current Invoice API
- Complete the API's POST method to use it
- Work from the provided task2_5_starter.py file
- Test it by running the provided task2_5_client.py

Implementing GET (All) SQLAlchemy



student_files/ch02_fundamentals/21_fastapi_sqlalchemy.py

Now that the pieces are in place, the remaining methods should come along easily. The get() (all) method is shown above. This returns matches to a celebrity name.

Implementing PUT with SQLAlchemy

```python
@app.put('/api/celebrities/id/{celeb_id}')
def update_celebrity(celeb_id: int, updated_celeb: Celebrity):
    try:
        celeb = session.get(CelebrityModel, celeb_id)

        celeb.name = updated_celeb.name if updated_celeb.name else celeb.name
        celeb.year = updated_celeb.year if updated_celeb.year else celeb.year
        celeb.category = updated_celeb.category if updated_celeb.category else celeb.category
        celeb.pay = updated_celeb.pay if updated_celeb.pay else celeb.pay

        session.commit()

        results = celeb.to_dict()
    except Exception as err:
        raise HTTPException(status_code=404, detail=f'Error updating celebrity: {err.args[0]}')

    return results
```

Using the object id, lookup the object in the database, then use the object to update it

Make any changes (e.g., celeb.year = year) to our model based on the updated_celeb

student_files/ch02_fundamentals/21_fastapi_sqlalchemy.py

The put() is implemented now.

Implementing DELETE with SQLAlchemy

Using the object id, lookup the object in the database, then use the object to perform a delete

```python
@app.delete('/api/celebrities/id/{celeb_id}')
def delete_celebrity(celeb_id: int):
    try:
        celeb = session.get(CelebrityModel, celeb_id)
        session.delete(celeb)
        session.commit()

        results = celeb.to_dict()
    except Exception as err:
        raise HTTPException(status_code=404, detail=f'Error removing celebrity: {err.args[0]}')

    return results
```

student_files/ch02_fundamentals/21_fastapi_sqlalchemy.py

The delete_celebrity() is implemented now and shown above.

Your Turn! - Task 2-6

- Complete the Invoice API
- Add the remaining API methods: get() all, put(), and delete()
- Work from your provided task2_6_starter.py file
- Test it by running the provided task2_6_client.py file or by running it within http://localhost:8000/docs

Error Handling and Common HTTP Statuses

- Best practices dictate that any error encountered on the server should return an appropriate 400 (usually) or 500 HTTP status code

Status Code	Description
400	Bad Request (Usually no URL mapping)
401	Unauthorized (Usually when client is not authenticated)
403	Forbidden (Usually when client is not authorized but is authenticated)
404	Not found (Good when resource id isn't found)
405	Method not allowed (e.g., A POST occurred on a GET only method)
429	Too many requests (User sent too many requests in a given period of time)
500	Internal Server Error (Usually a code execution error occurred on the server)

There are many more HTTP status codes.
A good reference is: *https://restfulapi.net/http-status-codes/*.

APIs should return an appropriate status code based on the condition of the error. Don't return 200 when the application has a logic error (even if the request was processed properly). Send back an appropriate 4xx code.

Non-Error Status Values

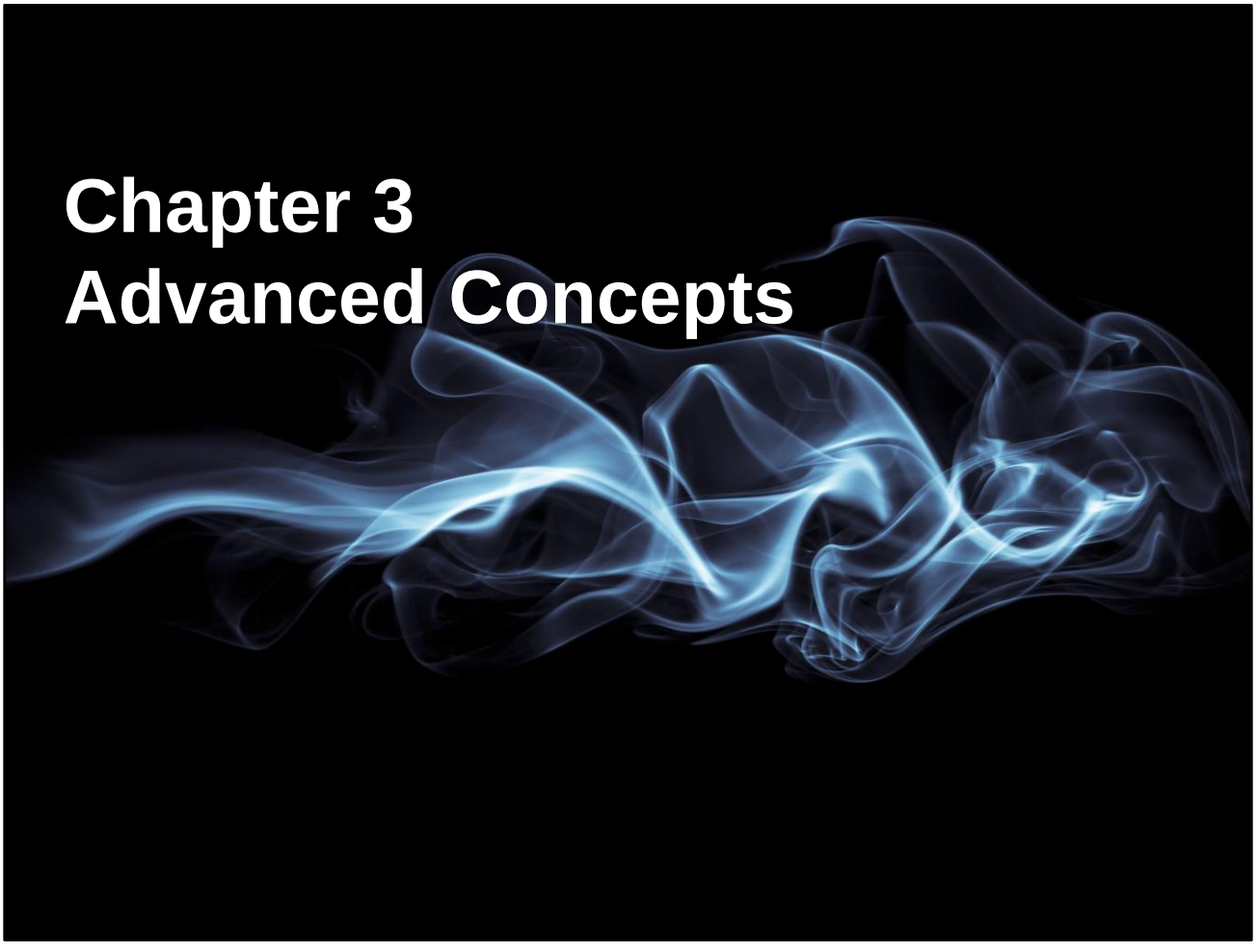
- There are other return status values that can be used to indicate non-error conditions

Status Code	Description
200	Ok (The majority of response status codes are 200)
201	Created (The server created a new resource)
204	No Content (The request processed successfully, but the server didn't have anything to respond with)
300	Multiple Choices (The request has multiple possible responses)
304	Not modified (Server code is not changed, client's cached version is okay to use)

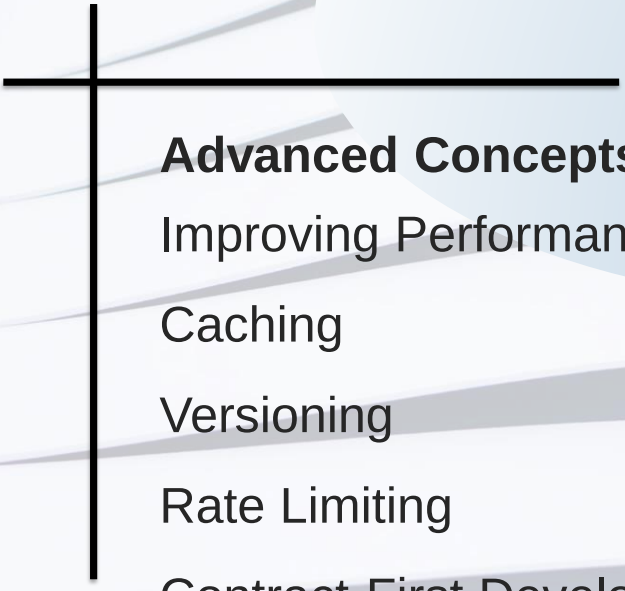
Even though most successful responses will return 200 status, sometimes other values might make sense. For example, a 204 status code could be sent back in situations where a request was processed successfully but the server didn't have any message to return.

Chapter 2 Summary

- Python provides tools to facilitate building all aspects of APIs
- FastAPI is only one of many options for serving content
- The FastAPI environment provides a modern approach that uses ASGI to perform at competitive speeds to what other languages have to offer
- FastAPI can work with database by integrating with SQLAlchemy
  - Using SQLAlchemy within FastAPI is optional, however



Chapter 3 Overview



Advanced Concepts

Improving Performance

Caching

Versioning

Rate Limiting

Contract-First Development

HATEOAS

Improving Performance

- There are several ways in which application performance can be improved
  - Pagination - Limits the amount of data returned for large responses
  - Caching - Lets the client re-use data saved from previous responses
  - Rate Limits - Limit a client's number of requests over time
  - Versioning - Less for performance than to ensure continuity for clients

Let's explore these techniques over the remainder of this chapter…

Limiting Results Via Pagination

Query string parameters

```python
@app.get('/api/celebrities/{name}')
def get_all_celebrities(name: str, limit: int = 5, page: int = 0):
    celebs = session.query(CelebrityModel).filter(CelebrityModel.name.contains(name))
                                          .limit(limit).offset(page * limit).all()
    if not celebs:
        raise HTTPException(status_code=404, detail=f'No celebrities found.')
    return {f'{name}_results{page}': celebs}
```

Our test client retrieves 3 pages of 3 records per page

```python
import requests

base_url = 'http://localhost:8000'
path = '/api/celebrities/'
name = 'Tom'

for n in range(0, 3):
    print(f'\ngetting page ({n}):')
    results = requests.get(f'{base_url}{path}{name}', params={'limit': 3, 'page': n})
    print(f'Status: {results.status_code}')
    print(results.text)
```

student_files/ch03_adv_concepts/01_sqlalchemy_pagination.py

In the code shown above, we see our get_all_celebrities() method has been modified to accept query string parameters.

Default values are provided but can be overridden by the client in their URL of the request.

Caching

- Caching improves API performance by minimizing the amount of client requests made to the server
  - Caching only applies to GET requests
  - Caching can be implemented by setting just a couple of HTTP response headers
  - Use the Cache-Control header to define if and for how long response data can be saved

    Cache-Control: max-age=600 *(use browser cache if request is within 10 minutes of original)*

    Cache-Control: no-cache *(don't cache the response)*

    - With this header, browser-based clients will look toward their own cache implementation before making a request

Caching within browsers is automatic, however, non-browser clients may require logic to process the header. Caching only works in one direction. In other words, if the request indicates it is not to be cached with a Cache-Control header, it will only be obeyed in one direction (client to server). The response would have to indicate with its own header whether to cache the response info.

It's worth noting that leaving off the Cache-Control header doesn't necessarily disable caching. Browsers can attempt to employ caching on their own for certain types of content. The no-cache value will force the browser (client) to make a new request each time.

Rules for Caching

- If content is mutable (as most business entities), use Control-Cache: no-cache
- If content is deemed immutable set a reasonable max-age with
  Control-Cache: max-age= 31536000

Your Turn! - Task 3-1

- Currently, the invoice API returns too many records when retrieving all records (within Task 2-6)
  - Implement pagination on the Invoice application
  - Return 50 records at a time for the GET all method
  - Retrieve a page argument from the client
  - Use the SQLAlchemy limit() and offset() functions
- Work from the provided task3_1_starter.py

Rate Limiting: Slowapi

Homepage: https://slowapi.readthedocs.io/en/latest/

- Clients can make too many API requests overwhelming the server

pip install slowapi

  - Applying rate limits can reduce CPU workload and bandwidth
  - FastAPI provides a third party tool (that must be installed), called Slowapi

```
from slowapi.errors import RateLimitExceeded
from slowapi import Limiter, _rate_limit_exceeded_handler
from slowapi.util import get_remote_address

limiter = Limiter(get_remote_address, app=app)
app = FastAPI()
app.state.limiter = limiter
app.add_exception_handler(RateLimitExceeded,
                          _rate_limit_exceeded_handler)


@limiter.limit('3/minute')
@app.get('/api/celebrities/{name}')
def get_all_celebrities(name: str):

  ...
```

student_files/ch03_adv_concepts/05_rate_limiting.py

This plugin is based on the similar performing Flask rate limiter, found at: https://flask-limiter.readthedocs.io/en/stable/.

Different rate limit values can be specified (they are parsed by the framework). Here are a few examples:

- 100 per hour
- 75/hour
- 50 per 2 hours
- 500/day;1000 per 7 days

API Versioning

- Versioning is needed when an API interface changes
  - Versioning refers to the client's perspective of the API
- Versioning *is required* when
  - The API sends back a new data format or values
  - APIs are removed
- Versioning *is not required* when a server *implementation* changes
  - For example, if you change your database implementation from MySQL to MS SQL Server
- Versioning *is also not required* when
  - New endpoints are added
  - New parameters are added to the response (generally)

Clients may spend considerable effort developing their apps to work with your API.

If you change your API, the client will need to update their apps as well. This can take time. To ensure the smoothest transition from the old API version to the new one, for a time, you will need to have both versions available simultaneously.

But how to do this? The answer is versioning. How do we version our API? Several strategies exist and are easy for the client to implement (mentioned momentarily).

Versioning Approaches

- Versioning can be implemented several ways
  - Via the domain name: **http://apiv1.sample.com/api/celebrities**
  - Via the path: **http://localhost:8051/api/v1/celebrities**
  - Via query string: **http://localhost:8051/api/celebrities?version=1**
  - Via custom HTTP headers:

```
POST /celebrities  HTTP/1.1
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64)
Host: www.sample.com
Content-Type: application/x-www-form-urlencoded
…
Accept-version: v1

name=Fred%20Savage&pay=3.0&category=Actors
```

The path approach is one of the most common techniques used, particularly for some of the large domain public APIs.

Defining the Contract and OAS

- RESTful services can be written as contract-first or contract-last
  - Contract-first - define and design the service, then code it
  - Contract-last - code up the API, then document it
- One way to create a contract-first solution is by using an Open-API Specification (OAS)
  - OAS uses either YAML or JSON for its format
    - Classic Swagger solutions favor YAML, while OAS proposed a JSON-based format

For more on OAS version 3.x, visit https://spec.openapis.org/oas/v3.1.0 and https://swagger.io/specification/.

Defining the API with OAS

```
{
  "openapi": "3.1.0",
  "info": {
    "title": "Celebrity App",
    "summary": "A celebrity info retrieval system.",
    "description": "This is a partial listing for our celebrity api.",
    "version": "1.0.0"
  },
  "paths": {
    "/api/celebrities": {
      "get": {
        "description": "Returns all celebrities.",
        "responses": {
          "200": {
            "description": "A list of celebrities.",
            "content": {
              "application/json": {
                "schema": {
                  "type": "array"
                }
              }
            }
          }
        }
      }
    },
    "/api/v2/celebrities": { ...
```

student_files/ch03_adv_concepts/openapi.json

This shows only a partial listing of what an OAS document structure looks like. It can be somewhat lengthy identifying numerous other items, such as servers involved, all of the operations and various paths, security information, and much more. It can also maintain multiple API versions (partially shown here).

Auto Generating an API

- Tools (for many languages) exist to generate code from an OAS document for both the API server and client

https://openapi-generator.tech/ *Select "Generators"*

- Swagger Codegen provides the ability to create an API based on an OpenAPI document

- Connexion, is a framework that generates an API server that maps your functions to your endpoints from a JSON or YAML-defined document (see next example)

For more on OAS version 3.x, visit https://spec.openapis.org/oas/v3.1.0 and https://swagger.io/specification/.

Generating a Solution with Connexion *(1 of 3)*

- The following runs Connexion to create our auto-generated API interface

To run this:
1) Go to ch03_adv_concepts/connexion_example
2) Run connexion_sample.py
3) Navigate to: http://localhost:8051/ui/

api.py

```
def get_celebrity(name):
    return f'You selected: {name}', 200
```

connexion_sample.py

```
import connexion

from connexion.resolver import RestyResolver

app = connexion.App(__name__)
app.add_api('swagger.yaml', resolver=RestyResolver('api'))


app.run(host='localhost', port=8051)
```

api.py

ch03_adv_concepts/connexion_example

This example uses Flask to demonstrate how it reads a swagger document and generates the UI automatically from it. It uses tools such as Flask and Connexion[swagger-ui]. These should already be installed from your initial requirements.txt setup.

Generating a Solution with Connexion *(2 of 3)*

swagger.yaml

```
swagger: "2.0"
info:
  title: Generated Flask Server

paths:
  '/celebrity/{name}':
    get:
      operationId: api.get_celebrity
      parameters:
        - name: name
          description: Celebrity name
          in: path
          type: string
          required: true
      responses:
        200:
          description: Response to a celebrity query
          schema:
            type: object
            properties:
              message:
                type: string
              status:
                type: integer
```

Our URL mapping: http://localhost:8051/celebrity/Kevin

get_celebrity() function within api.py

get_celebrity(name) takes a name parameter

It will be defined in the path

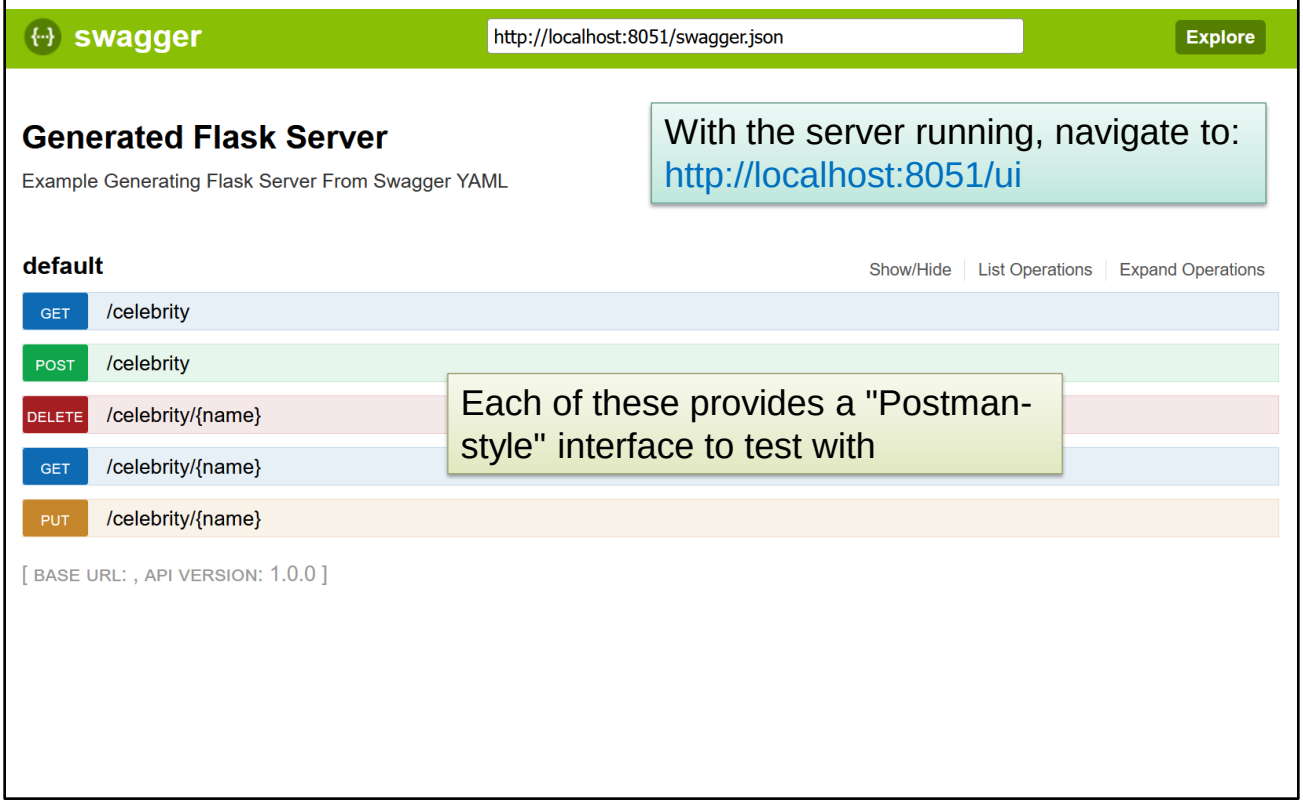
It returns an object with *message* & *status* props

See source file for more

ch03_adv_concepts/connexion_example

The first line of the document defines the format of the content. If it is swagger: "2.0" it will have one structure otherwise it could be openapi: "3.0.0" which will define a slightly different schema.

Generating a Solution with Connexion *(3 of 3)*



ch03_adv_concepts/connexion_example

Shown here is the autogenerated client for the Connexion example.

HATEOAS

- One problem with REST (or any service architecture) is that documentation is critical
- Every client must ask, "What are the valid URLs for this RESTful service?"
- To *promote looser coupling* between client and server and to provide a means for clients to *automatically discover* these services (resources), HATEOAS comes in
  - Stands for: Hypermedia As The Engine of Application State

To help promote loose coupling between the client and server (i.e., so that the client doesn't have to hard-code or have knowledge of various resource links), related resources can be embedded into GET requests. This can be done in a "links" property of the GET JSON response. The HATEOAS format is up to you; it doesn't have to be structured exactly like the example.

For more on this topic, check out: https://restcookbook.com/Basics/hateoas/

Sample HATEOAS Response

Server's GET Response

```
{
 "InvoiceNo": "536365",
 "StockCode": "85123A",
 "Quantity": 6,
 "Description": "LIGHT-HOLDER",
 "UnitPrice":2.55,
 "CustomerID": "17850",
 "Country": "United Kingdom",
 "links":[
   {
    "rel":"customer",
    "href":"https://hostname.com/customers/17850",
    "action":"GET",
    "types":["text/xml","application/json"]
   },
   {
    "rel":"customer",
    "href":"https://hostname.com/customers/17850",
    "action":"PUT",
    "types":["application/x-www-form-urlencoded"]
   },
   ...(see example in student files for more)...
  ]
}
```

A client must know the first request to make, but subsequent requests can be "discovered" in the "links"(or equivalent) section of the server's response

student_files/ch03_adv_concepts/hateoas.json

There are different formats for performing discovery. HATEOAS is only one.

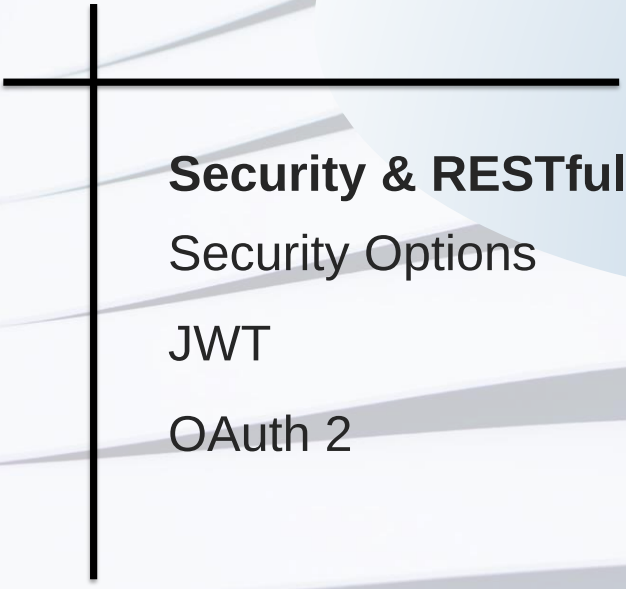
Also, in the works, is a way to define better support with JSON for linked actions. HAL and JSON-LD are two specifications that are evolving for this purpose.

Chapter 3 Summary

- Flexible APIs can provide filtering, sorting, and pagination features
  - These are commonly implemented using query string parameters
  - While a database might prefer limit and offset, the client doesn't need these
    - Simply provide a page attribute to allow pagination
- Caching can reduce the workload for both the API server and client
  - Client caching is easily controlled through Cache-Control
  - Other headers exist but often aren't necessary for APIs

Chapter 4 Authorization and Authentication

Chapter 4 Overview



Security & RESTful APIs

Security Options

JWT

OAuth 2

Securing RESTful APIs

- Most APIs require a level of security before resources can be accessed
- Several actively used authentication techniques exist
  - Basic Authentication
  - OAuth 1.0 (Digest Authentication)
  - Token (Bearer) Authentication (e.g., JSON Web Tokens, JWT)
  - API Keys
  - OAuth 2.0

There are several approaches that can be used when securing APIs. We'll discuss these in this chapter.

Basic Auth

- Basic authentication can be used as a challenge against unwanted visitors
  - It requires the use of a secure channel as credentials must be submitted in the HTTP request
  - Credentials are only encoded not encrypted so it should only be used with HTTPS

```
import requests
from requests.auth import HTTPBasicAuth
from bs4 import BeautifulSoup


page = 'https://jigsaw.w3.org/HTTP/Basic/'
auth = HTTPBasicAuth('guest', 'guest')
page_text = requests.get(page, auth=auth).text
soup = BeautifulSoup(page_text, 'html.parser')
print(soup.select('p')[2].text)
```

Python requests can handle basic auth queries

student_files/ch04_auth/01_basic_auth.py

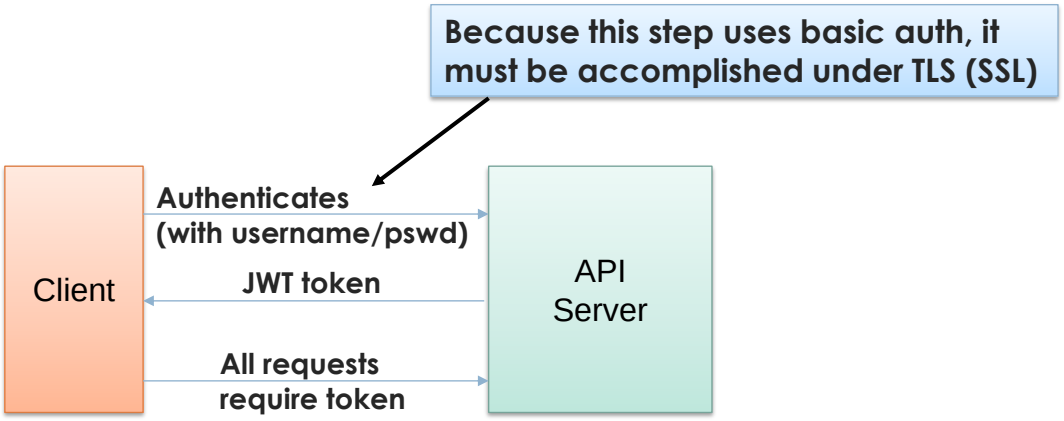
Basic authentication is secure only if you always make sure to use TLS (SSL).

In addition, basic auth always requires username and password to be sent and therefore raises the value of that request. In other words, if we are using OAuth 2, we are only sending a token each time. Compromise of that token while problematic, only gives the attacker access to that session, not the user's credentials or account info.

Compromise of a request that uses basic authentication exposes the user's username and password and potentially invalidates that user's account, possibly more. So careful consideration should be given to using basic auth in applications. Consideration as to how credentials are initially provided (like a web-based form, for example) or the cost to the user if the requests are compromised will need to be examined.

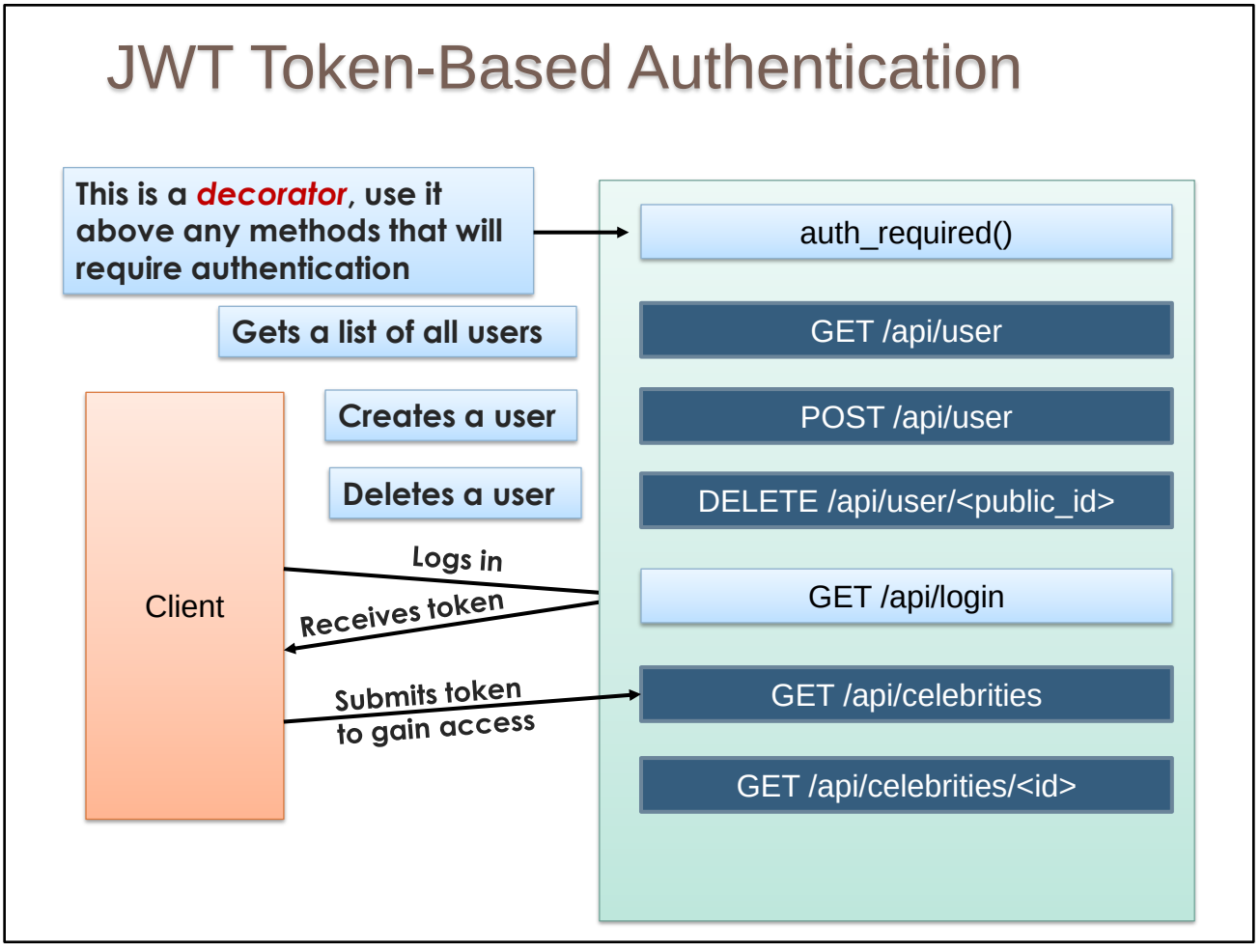
JSON Web Token-Based Authentication

- JSON Web Tokens (JWTs) can be a useful means for securing APIs



- JWTs only require authentication once, after that a token is used for authentication and authorization

JSON web tokens provide a means for identifying a user by examining a provided token. Because tokens are signed, they can't be tampered with by intercepting them. Because of the way the tokens are created, they can't be invalided. They can only be allowed to expire.



student_files/ch04_auth/02_celeb_auth.py

Our example exists in two files. The server is 02_celeb_auth.py while the client is 03_test_celeb_auth.py.

Our API has two sets of interfaces. One interface manages users while the other allows access to celebrity info.

The *auth_required* Decorator

```
def auth_required(orig_func):

    def wrapper(*args, **kwargs):
        token = None
        if 'x-access-token' in request.headers:
            token = request.headers['x-access-token']

        if not token:
            return jsonify({'message': 'Token is missing!'}), 401

        try:
            data = jwt.decode(jwt=token,
                              key=app.config['SECRET_KEY'],
                              algorithms=['HS256'])

            current_user = User.query.filter_by(public_id=data.get('public_id')).first()
        except Exception as err:
            print('Token is invalid--> ', err)
            return jsonify({'message': 'Token is invalid!'}), 401

        return orig_func(current_user, *args, **kwargs)
    return wrapper
```

The decorator is placed above any functions requiring authentication

Failure to authenticate will result in messages regarding the token

If the token is present, it is decoded using the jwt.decode() method

The decoded token should contain a public id of the user, which is used to query the database to obtain the user (if they exist)

student_files/ch04_auth/02_celeb_auth.py (server)

A little background on decorators can be found in the appendix.

This decorator should be placed above any function that will require authentication. It will look for the presence of the token under the key of "x-access-token" header. If it is not found or incorrect, a message will be returned. Otherwise, if it is present, it will be decoded using the jwt module's decode() method. The decoded token will result in a dictionary containing the user's public_id. This can be queried in the database to obtain the user object. With the user object, the originally desired function will be called and the current_user object will be injected into it. So, all functions that are decorated by this decorator must provide *current_user* as the first argument.

Testing JWT API Authentication

```
login_response = requests.get(f'{base_url}{path}/login', auth=credentials).json()
token = login_response.get('token')
```

The client logs in with credentials and gets a token in return

The token is added into the headers on each subsequent request

```
r = requests.get(f'{base_url}{path}/celebrities', headers={'x-access-token': token}).json())
```

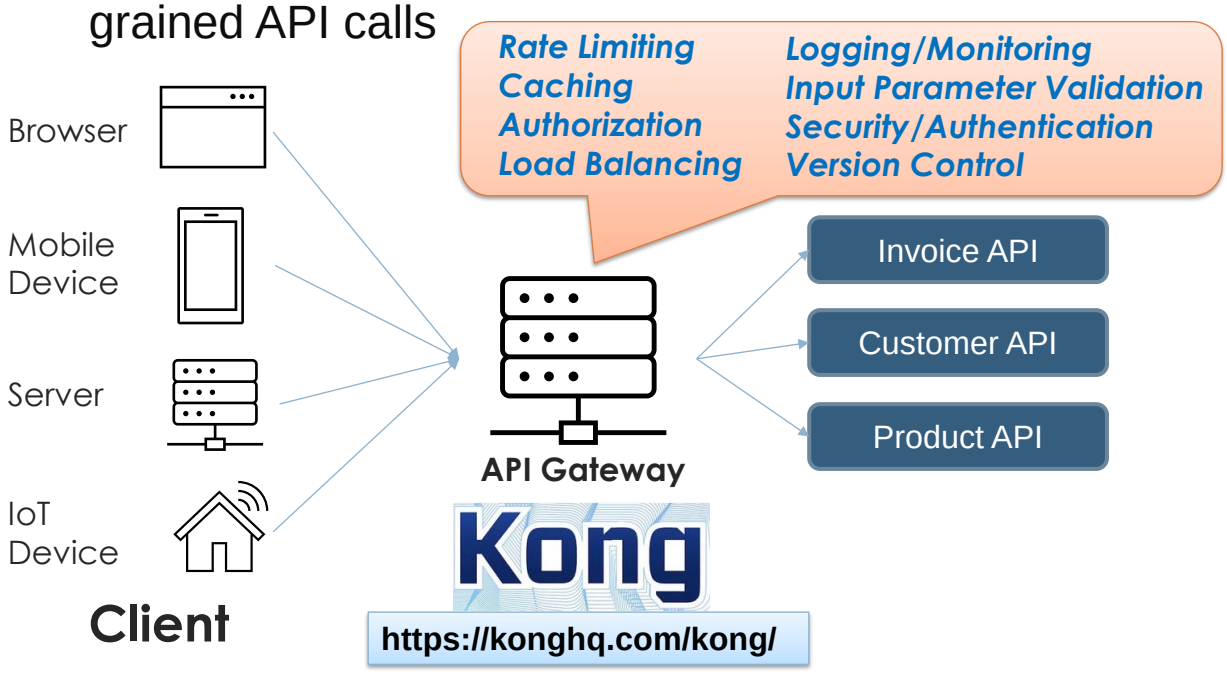
The test client (not shown) performs the following steps:

- Access celebrities without a token
- Access celebrities with an invalid token
- Authenticate (/api/login) as an admin
- Receives a token
- Access celebrites (with token) successfully
- Creates a new user (Sally) (not an admin)
- Logs in with the new user
- Retrieves a single celebrity successfully
- Attempts to delete a user (fails)
- Log in as admin user
- Deletes Sally

student_files/ch04_auth/03_test_celeb_auth.py (client)

API Gateway

- An API Gateway serves as a single point of entry when a client may need to interact with numerous fine-grained API calls

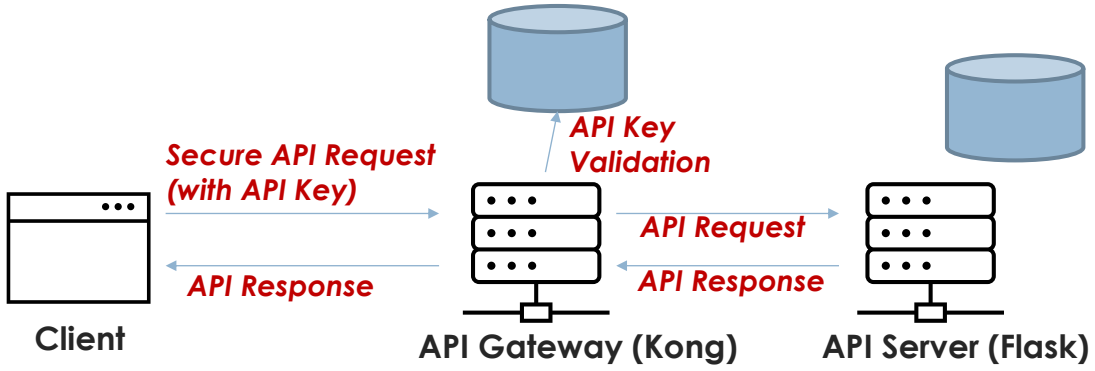


API gateways assist with providing a single interface in front of a microservices architecture thus simplifying client knowledge of the API network.

There are numerous options now for open-source API gateways. While KONG is the most popular and well-known, others such as Apache APISIX, Tyk (AWS), and Ocelot (for .NET) also exist.

API Keys

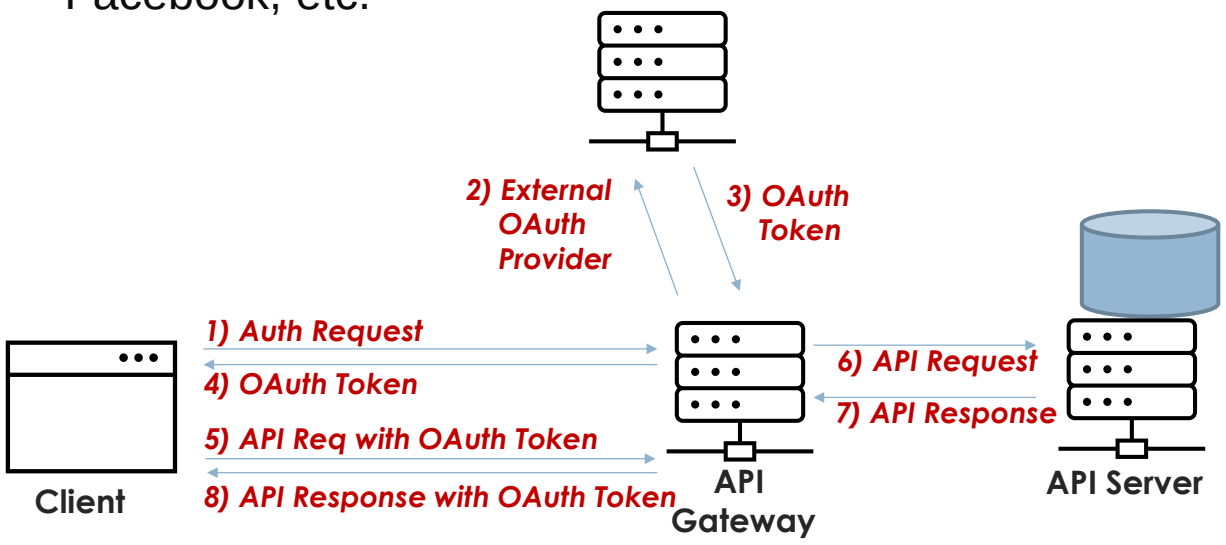
- API keys provide a means to link API access to a specific client
  - Usually, a client registers for an API key
  - The key is submitted for every GET request which identifies the client
  - Resource access and rate limits can then be applied
  - Common within public (non-private) APIs
  - API keys are not suitable for POST, PUT, PATCH, or DELETE



The use of an API key has become common particularly with publicly visible API services. Keys alone are typically not used to secure services. Instead, they are used as a tracking mechanism to control access and limit usage of the API.

OAuth 2

- OAuth provides token-based identity verification services from an external provider such as Google, Facebook, etc.



OAuth 2 is an authentication protocol that allows a client to communicate with a server once the client has been verified by a designated third-party provider. Once the provider verifies the client, it sends a token back to the client (via the API gateway or server) to be used for all subsequent requests made to the API host. OAuth 1 and OAuth 2 are completely different from each other.

Using an OAuth verifier provides easy access to services without the need to pass credentials. OAuth tokens must be provided in order to gain access to the API server. Tokens have an expiration (usually an hour).

Security Best Practices

- APIs should always send and receive over SSL (TLS)
- APIs that allow POST, PUT, PATCH and DELETE should use stronger forms of authentication, such as OAuth 2 or OpenID Connect
- Place API keys in the Authorization: header instead of the query string (as is too commonly done)

```
Authorization: Bearer zY%^33GhibW2%11Qy#1a8Z
```

Chapter 4 Summary

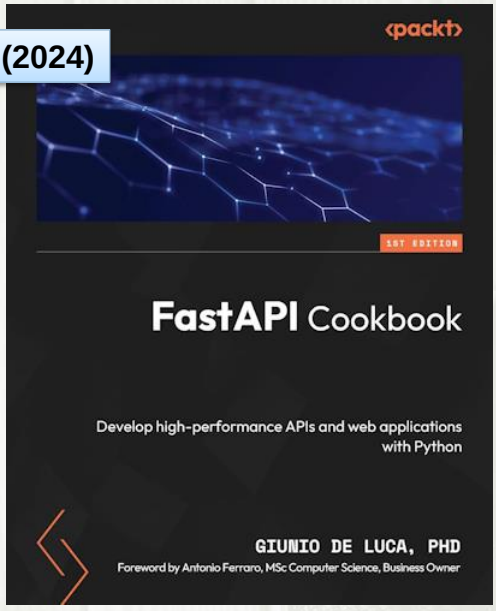
- As a minimum, all APIs should implement transport security using TLS (SSL)
- Use API keys for public APIs that primarily support GET operations to monitor client usage metrics
- Apply stronger forms of authentication for full-service APIs
  - Use OAuth 1 or 2 for most needs

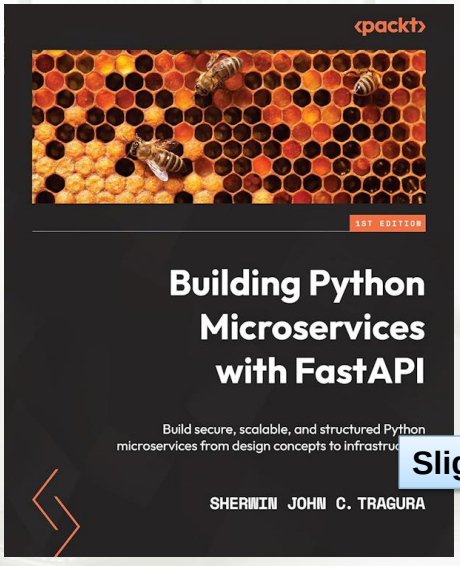
What Did We Learn?

- REST vs Web Services
- JSON Syntax
- Key REST Components
- Design Principles
- RESTful Methods
- Endpoints and Resources
- Python Requests
- FastAPI
- Routes
- Postman
- Swagger
- Database Integration
- Object Serialization
- PUT vs PATCH
- Error Handling
- Pagination
- Caching
- Rate-Limits
- Versioning
- Data Compression
- HATEOAS
- Options for Securing Services
- OAuth
- API Keys
- Considerations for Security

Recommended Sources

For those who like the cookbook style (2024)





Slightly older but still good (2022)

Other Resources

Comparing Flask and FastAPI (2021)

https://christophergs.com/python/2021/06/16/python-flask-fastapi/

FastAPI Tutorial

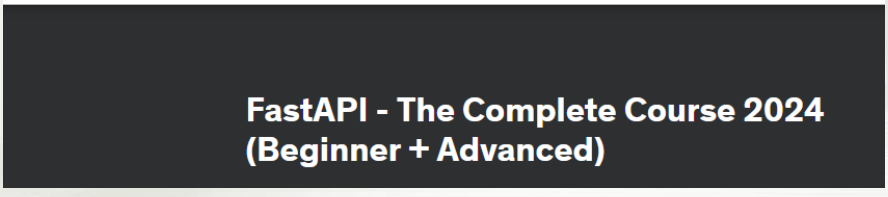
https://fastapi.tiangolo.com/tutorial/

Awesome FastAPI - Useful collection of resources

https://github.com/mjhea0/awesome-fastapi

udemy

https://www.udemy.com/course/fastapi-the-complete-course/

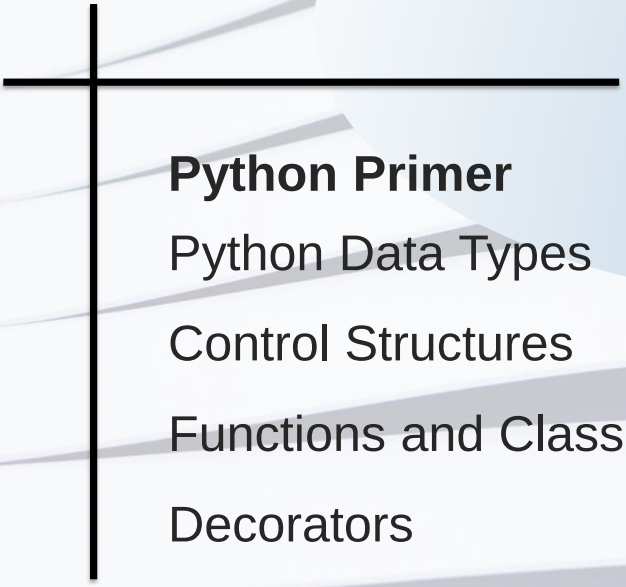


Questions

Questions?

Appendix
Python Primer

Appendix Overview



Python Primer

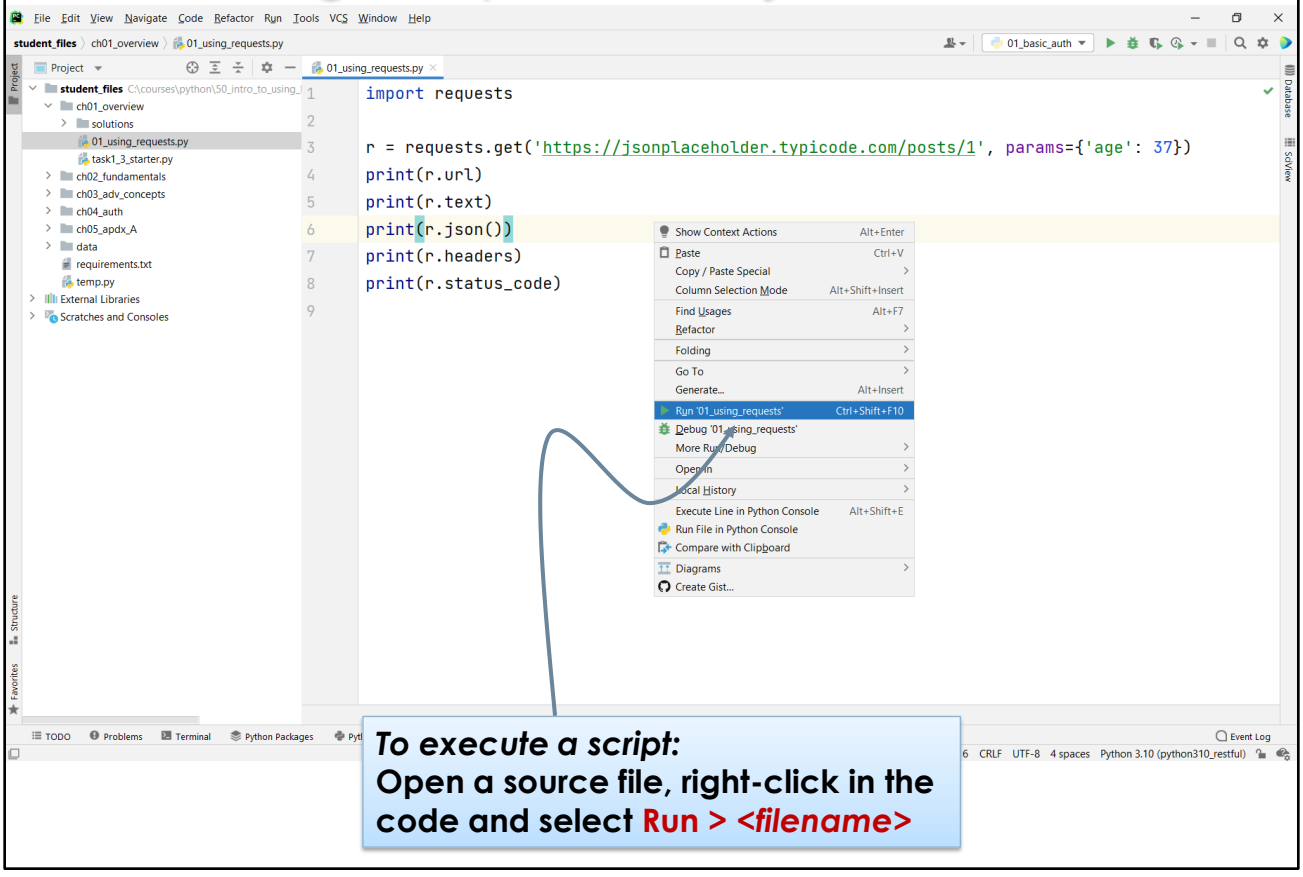
Python Data Types

Control Structures

Functions and Classes

Decorators

Running Scripts with PyCharm



To work with PyCharm, launch the program and select Open... from the options on the right and then locate the student_files directory.

Usually, a good first step is to verify the correct interpreter is selected for use. Do this by visiting File > Settings > Project: student_files > Project Interpreter and examining the interpreter option.

To execute a script, you will first need to wait until the IDE has "scanned" the environment. You may see a message "3 processes running" in the footer. Wait until this completes, then attempt to run the script.

Providing Command-Line Arguments

- When a script is run from a command-line, additional arguments can be retrieved
  - Import the sys module, use the argv list (array)

```
import sys

pet1, pet2 = 'dog', 'cat'

if len(sys.argv) >= 3:
    pet1 = sys.argv[1]
    pet2 = sys.argv[2]

print('My', pet1, 'chases my', pet2)
```

  - When running this script:

```
python example01.py
python example01.py cat bird
```

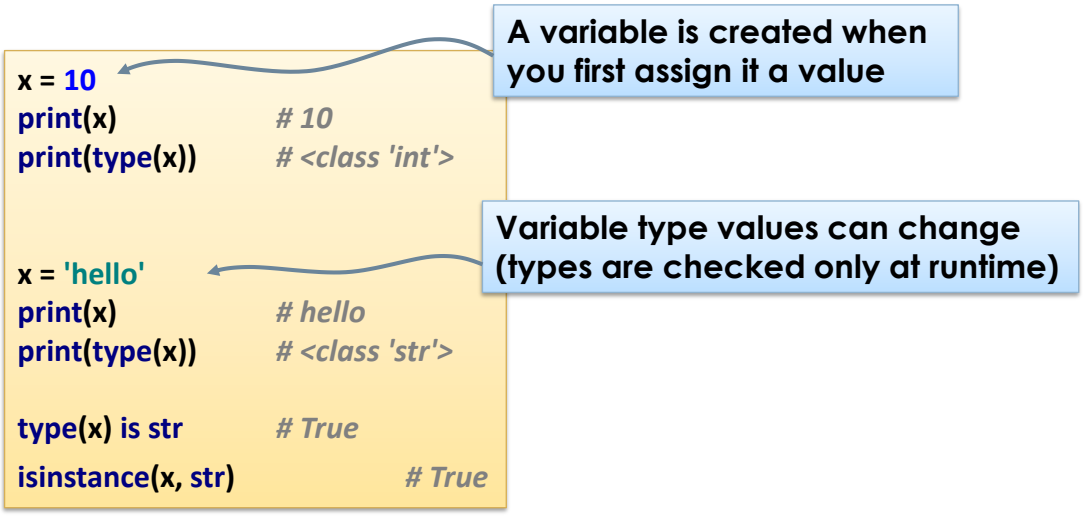
argv[0] argv[1] argv[2]

```
My dog chases my cat
My cat chases my bird
```

student_files/ch05_apdx_A/example01.py

Python Data Types

- Python has many built-in data types



- type() provides insight about what *kind* a variable is at runtime
  - Use isinstance() in practice to verify a variable's type

Converting Values

- Sometimes values need to be converted from one format to another
  - int or float *to String (str)*

```
s1 = str(55)          # '55'
s2 = str(3.14)        # '3.14'
```

  - String or float *to int*

```
i1 = int('37')        # 37
i2 = int(3.14)        # 3
```

  - int or String *to float*

```
f1 = float(55)        # 55.0
f2 = float('3.14')    # 3.14
```

Values that can't be converted will generate an exception called a *ValueError*

```
int('hello')
```

yields…

```
ValueError: invalid literal for int() with base 10: 'hello'
```

Exceptions such as ValueErrors can be properly dealt with using exception handling (not discussed in this primer).

Strings

- Strings are immutable sequences of Unicode characters
  - Type: str
  - Formal notation:

```
my_str = str('Python is great!')
my_str = 'Python is great!'
```

```
my_str = 'Python is fun'      my_str = 'Python is very fun'
```

Creates a new string object

  - Strings support both single and double quotes

PEP 8 does not have a preference

```
my_str = 'Python\'s great fun'
my_str = "Python is great fun"
my_str = """Python is so much fun"""
```

Triple quoted strings can span multiple lines. A common use for triple quoted strings is for documentation (called a docstring).

In Python 3, strings are Unicode characters. Some characters must be escaped to use them. Escape characters include:

\\	backslash
\'	single quote (as shown in the slide)
\"	double quote
\b	backspace character (ascii)
\n	linefeed
\r	carriage return
\t	tab

Conditional Control Structures

- Python has only one conditional control

There may be zero or more elif branches

The else is optional

```
if test:
    <one or more statements>
elif test2:
    <one or more statements>
else:
    <one or more statements>
```

Beginning and ending of blocks are determined by indentations (use 4 spaces)

```
if test:
    print('If test is true, this will execute')
    print('So will this!')
print('This will always execute!')
```

Sequences

- In Python, sequences (str, list, and tuple types) are ordered collections of objects

```
dirs = ['North', 'South', 'East', 'West']
```

- All sequences have some common features:
  - Random access and slicing

```
dirs[2]     # 'East'
dirs[-2:]   # ['East', 'West']
```

  - Concatenation (of the same type)

```
dirs + ['NW', 'NE', 'SW', 'SE']
```

  - Length (size)

```
len(dirs), len(dirs[0])
```

  - Membership

```
if 'East' in dirs:
    print(dirs.index('East'))
```

Sequences exhibit similar behaviors such as the ability to be randomly accessed, perform slicing, support membership checks, and have their size (length) returned through the len() function.

In addition, sequences also support a min() and max() function.
Examples of min() and max():

```
max([1973, 2001, 2015, 2013, 1994])
min([1973, 2001, 2015, 2013, 1994])
```

Lists Are Python's Arrays

- Lists are mutable, ordered collections of objects

```
my_list = []
my_list = list()
```

Empty lists

List created using the type name

```
my_list = [1, 3, 5]
my_list = [3.3, 'hello', Person()]
my_list = list('hello')
```

```
some_list = list(other_sequence)
```

- Lists may contain duplicates

```
my_list = [3.3, 'hello', Person(), 3.3, Person()]
```

- Adding items to a list

```
my_list = [1, 2, 3]
my_list.append(10)
my_list.insert(1, 'hello')
```

1, 'hello', 2, 3, 10

student_files/ch05_apdx_A/example02.py

Lists may be created using literal notation with square brackets [ ]. While literal notation is common, occasionally lists are created using the list() type name.

Use append() to add items onto the end of the list.

To add a value into the middle of a list, use insert(position, value), keeping in mind that sequences are zero-based in Python.

Tuples Are Python's Fixed Arrays

- Tuples are *immutable*, ordered collections of objects

```
my_tuple = ()
```
Empty tuple

```
my_tuple = tuple()
```
Tuple created using the type name

```
my_tuple = (1, 3, 5)
my_tuple = (3.3, 'hello', Person())
my_tuple = tuple('hello')
```
```
some_tuple = tuple(sequence)
```

```
my_tuple = (1,)
```
Tuple with one element

- Modifying a tuple causes an error, like this:

```
contact = ('John', 'Smith', ['123 Main St', 'Los Angeles', 'CA'])
contact[0] = 'Jonathan'
```
TypeError: 'tuple' object does not support item assignment

Tuples do not have append(), insert(), or other methods that attempt to modify the data as this would violate the concept of a tuple.

Iterative Control Structures

```
while test:
     <one or more statements>
```

This will execute the contents of the indented block as long as test is True

```
for one_item in iterable:
    <one or more statements>
```

This will take one item from the iterable at a time, process it within the indented block, and then get the next item.

- Performance note:
  - For larger iterations, the for-loop performs better than the while-loop and should usually be preferred
  - *for* executes at the C-level, *while* executes in the PVM

Note: Both the while and for loops have a second part, an else block. However, because this block is extremely rare to use, it has been left out of our discussion here.

Examples Using the *for* Loop

```
seasons = ['Spring', 'Summer', 'Fall', 'Winter']

for season in seasons:
    if season.lower().startswith('s'):
        print(f'{season} has {len(season)} characters.')
```

```
Spring has 6 characters.
Summer has 6 characters.
```

```
records = [
    ('John',  'Smith',   43, 'jsbrony@yahoo.com'),
    ('Ellen', 'James',   32, 'jamestel@google.com'),
    ('Sally', 'Edwards', 36, 'steclone@yahoo.com'),
    ('Keith', 'Cramer',  29, 'kcramer@sintech.com')
]
```

```
for record in records:
    print(f'{record[0]} {record[1]}, {record[2]} {record[3]}')
```

```
John Smith, 43 jsbrony@yahoo.com
Ellen James, 32 jamestel@google.com
Sally Edwards, 36 steclone@yahoo.com
Keith Cramer, 29 kcramer@sintech.com
```

student_files/ch05_apdx_A/example02.py

Python's for and while loops are the only iterative control structures. There is not a classic 3 part for( ) loop as in C++, Java, and other languages. Both while and for support the break and continue statements.

Iterating *(continued)*

- All of these can iterate the *records* data structure

```
for record in records:
    print('{0} {1}, {2} {3}'.format(*record))


for (first, last, age, email) in records:
    print(f'{first} {last}, {age} {email}')


for first, last, age, email in records:
    print('{first} {last}, {age} {email}'.format(first=first,
                                                 last=last,
                                                 age=age,
                                                 email=email))
```

student_files/ch05_apdx_A/example02.py

Each of these produces the same output as the one on the previous slide. The last, while a bit cumbersome, can be useful when the string is a variable that's already defined elsewhere and can't be changed.

Primer on Dictionaries

- Dictionaries are collections of name/value pairs
  - They are unordered, mutable, iterable
  - Support len() function and in operator
  - Keys are hashable (immutable), values can be any type

```
d = { key1: value1, key2: value2, ... }
```

```
my_dict = {}
my_dict = dict()
my_dict = { 'pet1': 'dog', 'pet2': 'fish' }
my_dict = dict(pet1='dog', pet2='fish')

my_dict['pet3'] = 'cat'
print(my_dict['pet2'])
```

empty dicts

No quotes on keys here

adding / changing values

accessing values

Dictionaries are useful data structures as they provide a means to store any kind of data yet access that data via a key. Because dictionary keys must be unique, attempting to add an entry to a dictionary that has the same key in existence will replace the value with the new value.

Dictionaries became ordered in Python 3.6.

Accessing Dictionaries

```
d1 = {'Smith': 43, 'James': 32, 'Edwards': 36, 'Cramer': 29}
```

- Direct access can generate a KeyError

```
d1['Smith']          # returns 43
d1['Green']          # generates a KeyError
```

- Use exception handling to deal with a KeyError

```
try:
   value = d1['Green']     # generates a KeyError
except KeyError:
   value = 0
```

- dict.get(key) to retrieve values also:

```
d1.get('Edwards')          # returns 36
d1.get('Green')            # returns None
```

- dict.get(key, default) is safest

```
d1.get('Cramer', 0)        # returns 29
d1.get('Green', 0)         # returns 0
```

student_files/ch05_apdx_A/example03.py

Accessing a dictionary in a for loop will return the keys. It is the same effect as d1.keys(), which is arguably more understandable but also more verbose.

Iterating Dictionaries

```
d1 = {'Smith': 43, 'James': 32, 'Edwards': 36, 'Cramer': 29}
```

- Iterating a dictionary directly returns keys:

```
for item in d1:
    print (item)
```

```
Smith
James
Edwards
Cramer
```

- Iterating a dictionary's values:

```
for val in d1.values():
    print(val)
```

```
43
32
36
29
```

- Accessing both key and value simultaneously:

```
for key, val in d1.items():
    print(f'Key: {key}, Value: {val}')
```

returns a (view of) list of tuples

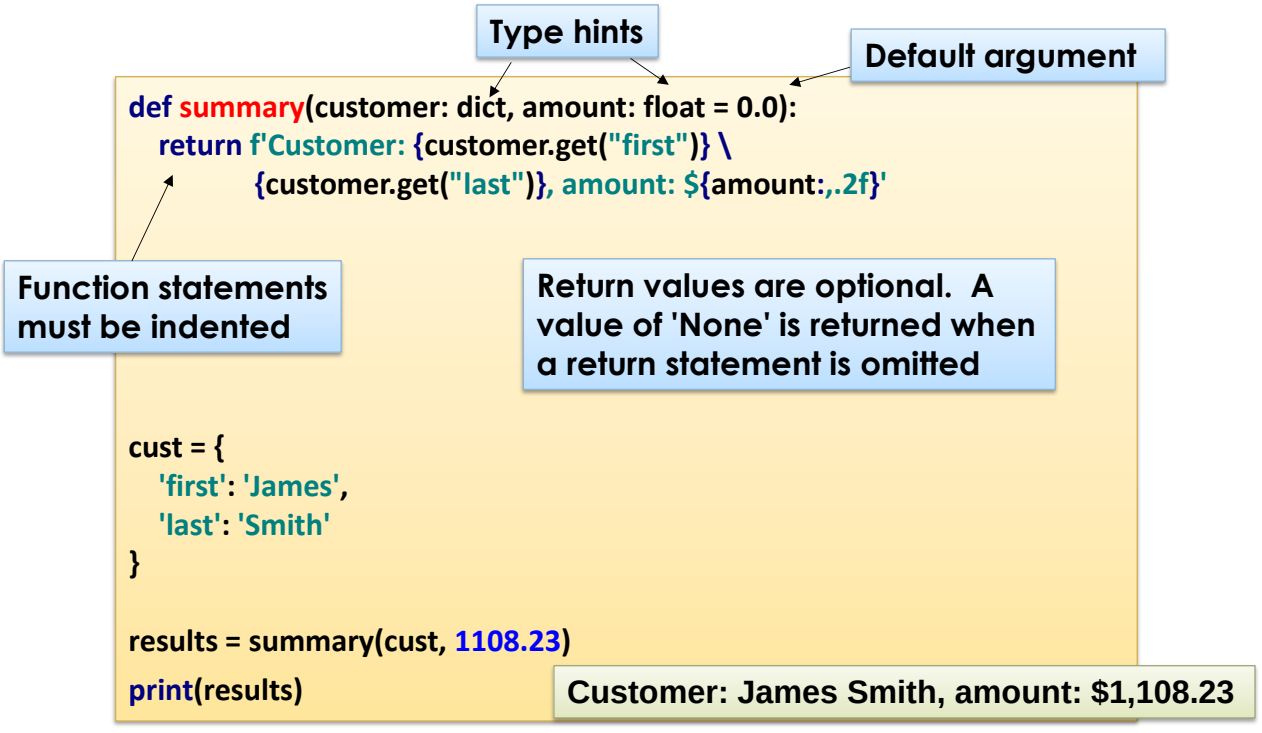
student_files/ch05_apdx_A/example03.py

The above example indicates how a dictionary is used within a `for` control. It always returns the keys.

The items() method returns a "view" object instead of a copy of a list of tuples.

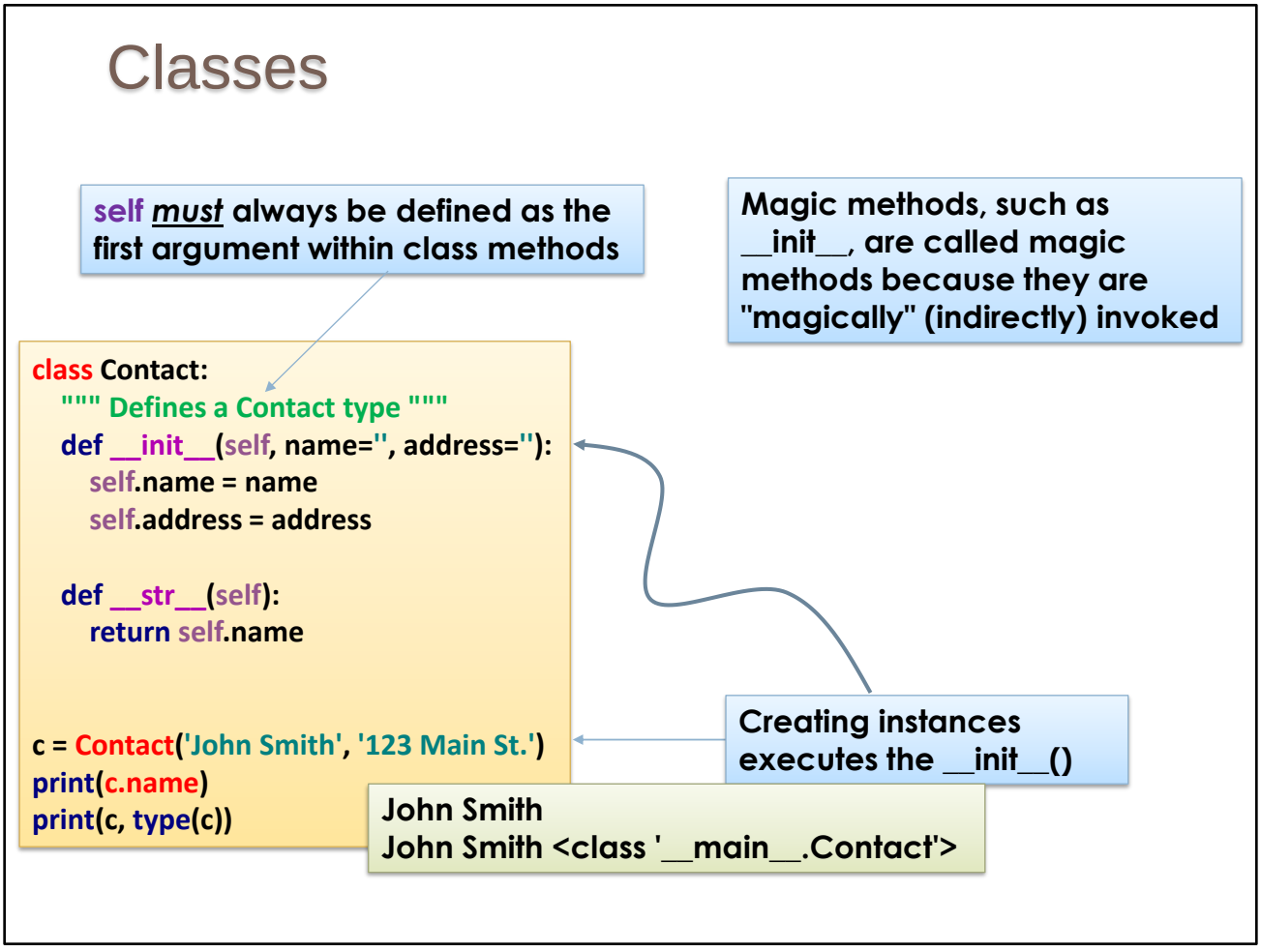
Defining and Calling Functions

- Functions must be defined before they can be called



student_files/ch05_apdx_A/example04.py

Functions must be declared (or imported) before they can be called. Parameters passed into the function must also match what is declared in the function.

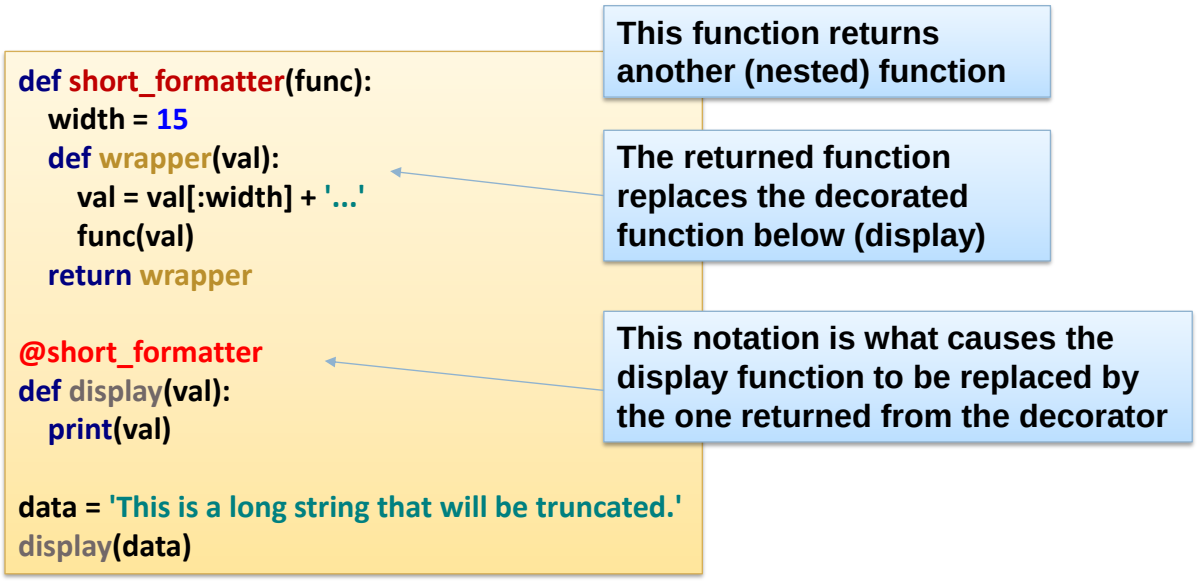


student_files/ch05_apdx_A/example05.py

When an instance (object) is created the constructor is called. In Python, the constructor is always called. Its purpose is to initialize variables and/or code.

The __init__() (constructor essentially) must always define a variable called **self**. Self represents the current object being constructed. In this example, the object called 'c' is being created. In the constructor, the 'c' object is what self is referring to. While theoretically self can be renamed to something else, in Python we ***never*** do this.

Decorators *(in brief)*



student_files/ch05_apdx_A/example06.py

In the example above, the original function (display) is passed into another function called short_formatter(). Short_formatter() returns a nested function called wrapper(). The returned wrapper function replaces the originally passed function (display). Now, any calls to display() are actually calls to wrapper(). Decorators give the library/framework builder control over your code.

Introduction to API Development Using Python

Exercise Workbook

Task 1-1
Setting Up Your Environment

Overview

This task establishes your development environment by setting up a virtual environment, and IDE, and the Python interpreter.

Determine Your Python Command

Every Python environment is just a little different from the next. To perform this task, you need to know which Python is the correct one to use for this course. Open a command window (Windows) or a terminal (Linux/OS X). Find the correct version of Python you intend to use by typing in the following commands:

```
python -V

python3 -V

python3.12 -V
```

(repeat this using 3.11, 3.10, or 3.9 as needed)

One of these commands should work for you. If not, you will need to check your PATH environment variable and double-check the location that Python was installed.

Remember what works for you as it will be used throughout the course!

In this course, replace any Python command-line references (e.g., python, python3, etc.) with the version you just determined works for you!

Create and Activate a Virtual Environment

In this step, we will create a virtual environment to work within. This way, anything we install will only go into the virtual environment and won't affect any of your current Python environments.

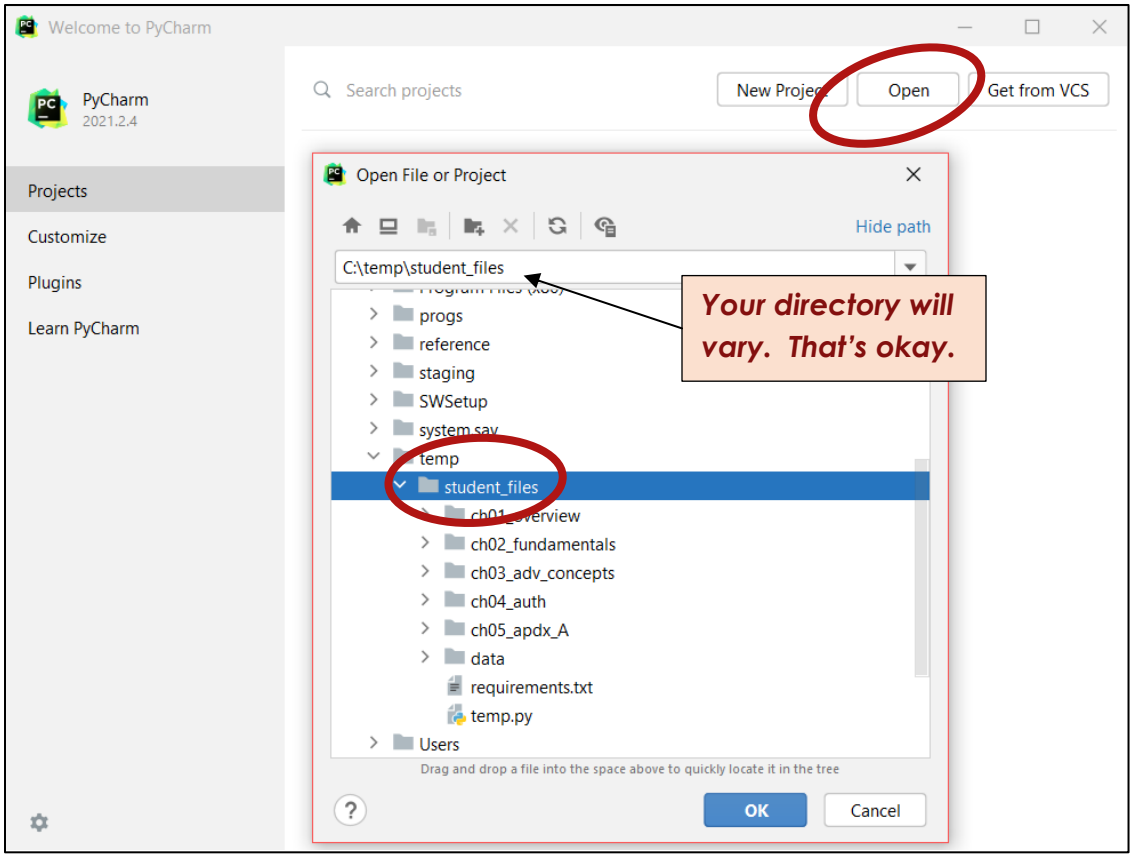
There are two ways to create the virtual environment:

1. Via PyCharm (easier, and our preferred way)
2. Manually from the command line

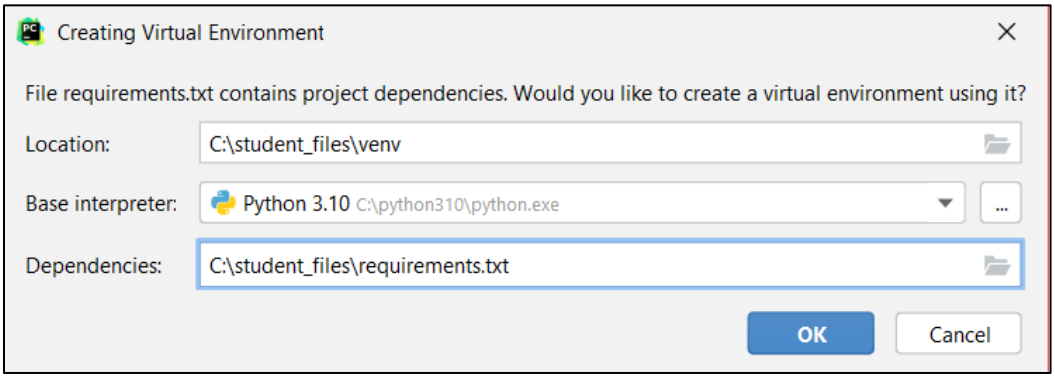
If technique #1 from above doesn't work, skip down to the star shown below and perform a manual creation of the virtual environment.

Creating the Virtual Environment using PyCharm

Launch PyCharm. In the Welcome dialog, select "Open" and browse to your student_files directory (which should be extracted from the provided zip file already).



PyCharm should offer to create a virtual environment for you *AND* should offer to run the file called ***requirements.txt***. Use the defaults that are provided and **click Ok**--*you don't need to match the paths shown below*.



That should be it for this step.

Note: If PyCharm doesn't ask to create a virtual environment for you automatically, double-click the *requirements.txt* file within your student_files folder and choose the option to install dependencies mentioned in the yellow bar that should appear at the top of the editor. If no yellow bar appears, you may have to manually run the requirements.txt file from a Terminal within PyCharm. Ask the instructor for help on how to do this.

Alternatively, Create the Virtual Environment Manually

If PyCharm isn't used to create the virtual environment for you, or PyCharm failed to do this properly, follow this next section instead.

In the same terminal window from step 1, create a directory for your virtual environment. You can create this directory anywhere. A nice possible location for this virtual environment is in a *virtualenv* directory in your home. If you don't have a location to place virtual environments on your system, type the following:

On Windows: **`cd /D %userprofile%`**

On Linux/OS X: **`cd ~`**

Create a directory here called **`virtualenvs`** by typing:

```
mkdir virtualenvs
```

Change into this new directory.

```
cd virtualenvs
```

Now create the Python virtual environment and activate it by typing:

python -m venv api_env

On Windows: **cd api_env\Scripts**
.\activate (or just **activate**)

On Linux/OS X: **cd api_env/bin**
source ./activate

Verify that you have activated the python environment by typing:

On Windows: **where python**

On Linux/OS X: **which python**

Check that the response shows your new virtual Python interpreter listed first.

We are about to install any needed dependencies for the course. Before doing that, you will need to ensure that the student files have been placed on your machine (already extracted from the provided zip file). Take note of the location of your student files. We'll refer to this location as your <student_files_home>.

cd <student_files_home> (this should be your location of the student files)

Install the dependencies:

(from the student_files directory)

pip install -r requirements.txt

Below is a sample screenshot (with slightly different directories used) of what to expect when running this command:

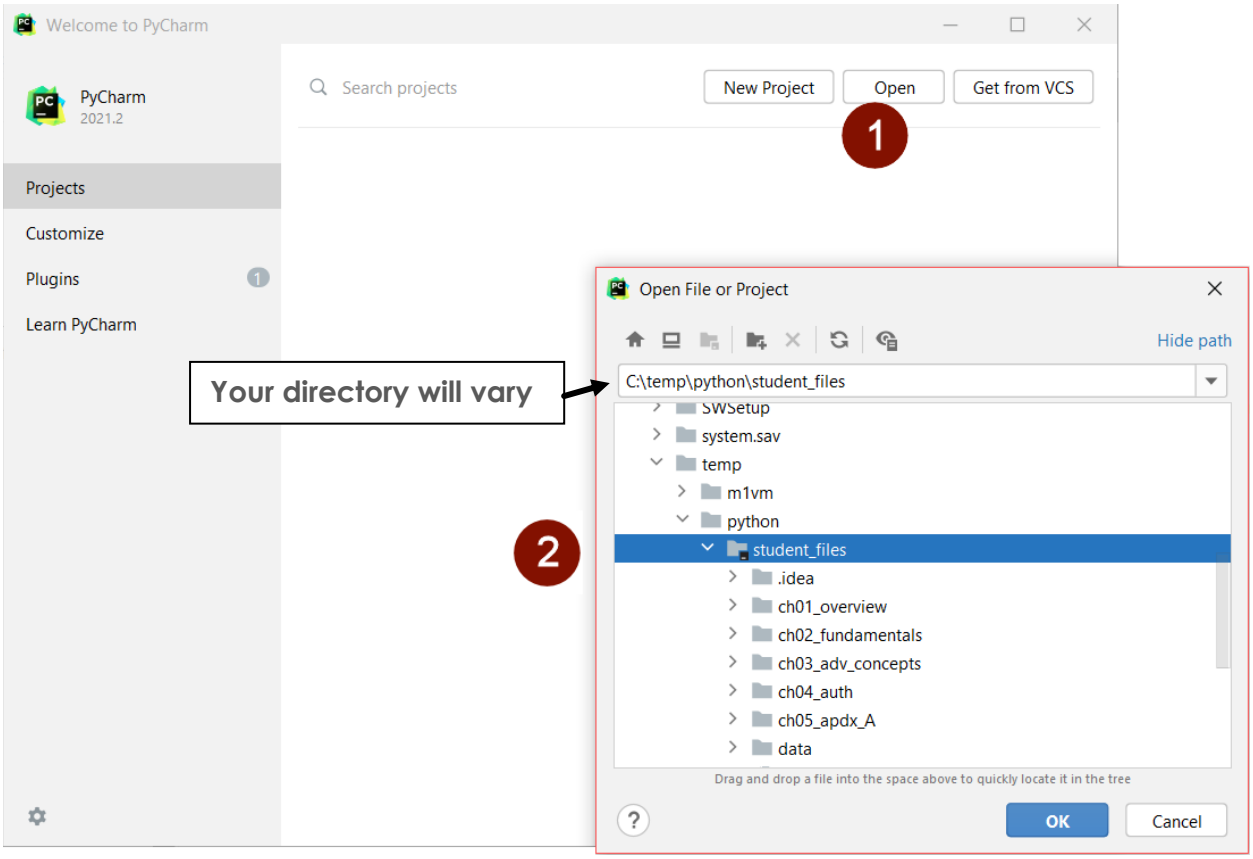
```
(api_env) >pip -V
pip 21.2.4 from c:\virtualenvs\api_env\lib\site-packages\pip (python 3.10)

(api_env) c:\student_files>pip install -r requirements.txt
Collecting Flask==2.0.2
  Using cached Flask-2.0.2-py3-none-any.whl (95 kB)
Collecting SQLAlchemy==1.4.29
  Using cached SQLAlchemy-1.4.29-cp310-cp310-win_amd64.whl (1.5 MB)
Collecting requests==2.27.1
  Using cached requests-2.27.1-py2.py3-none-any.whl (63 kB)
Collecting flask-restx==0.5.1
  Using cached flask_restx-0.5.1-py2.py3-none-any.whl (5.3 MB)
Collecting Flask-sqlalchemy==2.5.1
  Using cached Flask_SQLAlchemy-2.5.1-py2.py3-none-any.whl (17 kB)
Collecting flask-marshmallow==0.14.0
  Using cached flask_marshmallow-0.14.0-py2.py3-none-any.whl (10 kB)
Collecting marshmallow-sqlalchemy==0.27.0
  Using cached marshmallow_sqlalchemy-0.27.0-py2.py3-none-any.whl (15 kB)
Collecting beautifulsoup4==4.10.0
  Using cached beautifulsoup4-4.10.0-py3-none-any.whl (97 kB)
Collecting prettytable
  Using cached prettytable-3.2.0-py3-none-any.whl (26 kB)
Collecting click>=7.1.2
  Downloading click-8.0.4-py3-none-any.whl (97 kB)
     |████████████████████████████████| 97 kB 420 kB/s
Collecting itsdangerous>=2.0
  Downloading itsdangerous-2.1.2-py3-none-any.whl (15 kB)
```

Setup the IDE

Note: This step may be skipped entirely if PyCharm automatically installed the packages for you when you launched the IDE in step 2.

After the packages finish installing (should be relatively quick), **launch PyCharm** if you haven't already.

In the Welcome screen, locate the student_files directory, select this directory and then click **Open**. In some cases, the project may open directly skipping this step. That is okay.

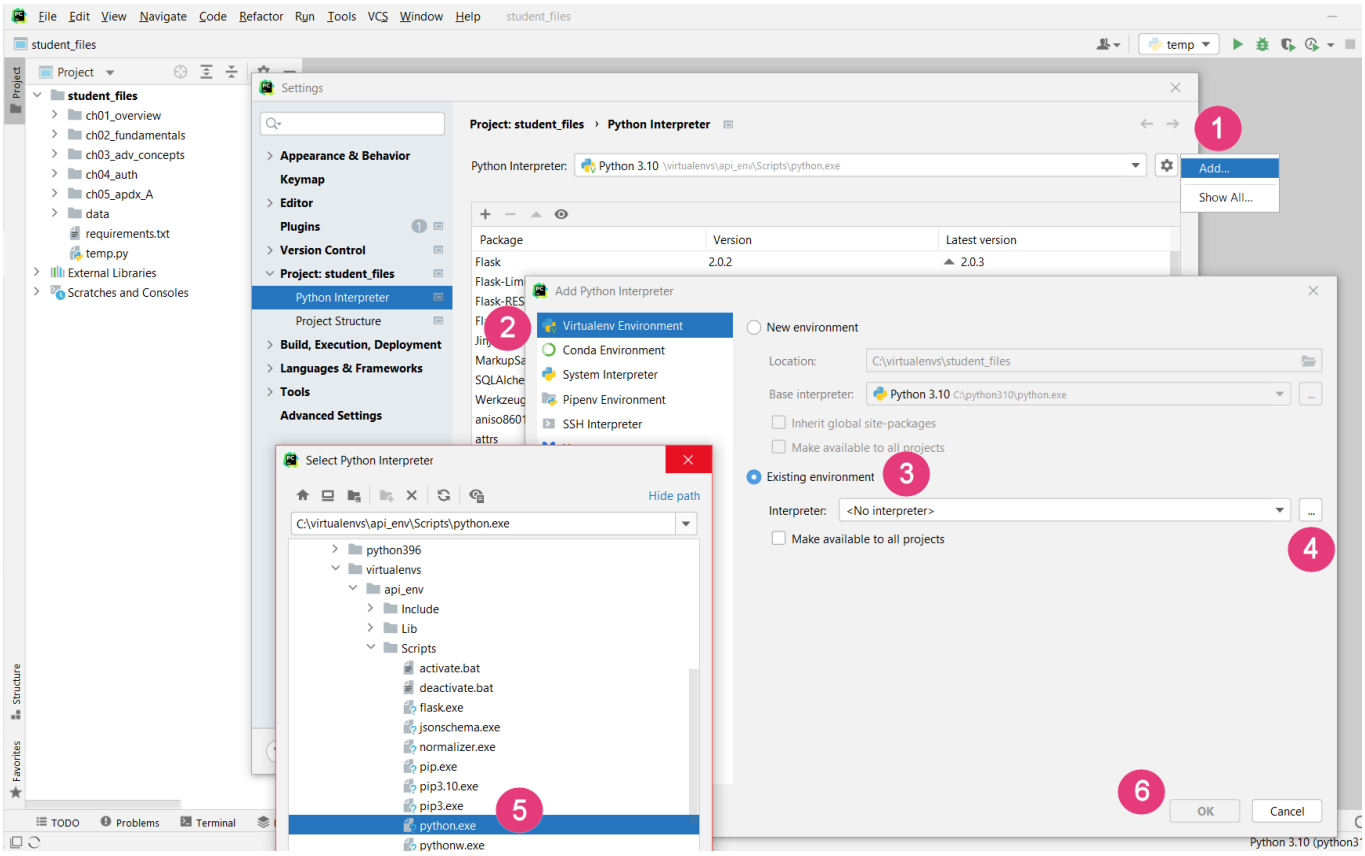


Proceed to the settings to establish which interpreter to use.

OS X: **`PyCharm > Preferences`**

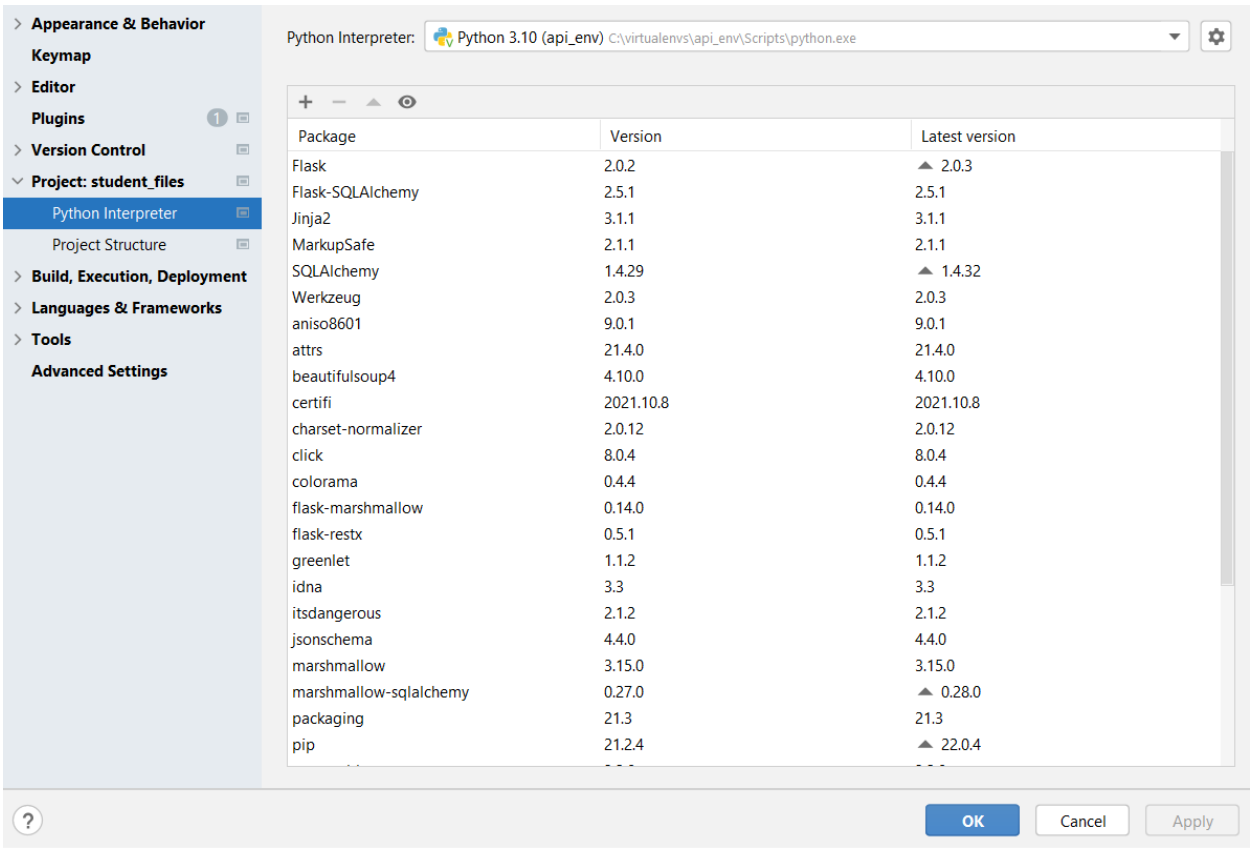
Windows: **`File > Settings`**

Expand the **`Project: student_files`** item. Select **`Project Interpreter`**. On the right side, we'll have to point PyCharm to the newly created virtual environment. Do this as shown below:



1- Select the setting (cog wheel) symbol
2- Leave selected "Virtualenv Environment" option
3- Select "Existing Environment" button
4- Select the ... button (far to the right)
5- Browse to the new Interpreter location (*python.exe* on Windows, *python* or *python3.x* on OS X)
6- Click OK twice.

You should see numerous packages listed here now (See next screen shot)



Test out the new environment by running the file in ch01_overview called **task1_1_starter.py**. To run it, right-click in the source code and select **Run task1_1_starter**.

That's it! If it runs, you're done!

Task 1-3
Creating a Client Using Requests

Overview

This simple task will utilize the Python requests module to make a request and view the results of the URLs encountered in Task1-2.

Work from the provided starter file, task1_3_starter.py, found in the ch01_overview directory.

Create a for-loop. Retrieve the Data.

Create a for-loop to iterate over the URLs. Make a request to the specific URL using the requests module.

```
for url in urls:
    r = requests.get(url)
```

Display the Responses

Display the results from the request using

```
for url in urls:
    r = requests.get(url)

    print(r.url)
    print('-'*len(r.url))
    print(r.text)
```

That's it! Test it out!

Task 2-1
An Initial API

Overview

This task begins the development of our invoicing API. For this first version, you will create the code to initialize the FastAPI server and set up our first path parameter decorator. Begin by opening the **task2_1_starter.py** file within ch02_fundamentals.

Create the FastAPI Server

At the location of step 1 in the source file, instantiate the FastAPI server object.

```
app = FastAPI()
```

Define a Route

Define a single path parameter decorator for now. It will only handle "GET" HTTP requests. It will map to: ***/api/invoices/{invoice_num}***. Place this decorator above the retrieve_invoice() function.

```
@app.get('/api/invoices/{invoice_num}')
def retrieve_invoice(invoice_num):
```

Retrieve a Matching Invoice Number

Within the retrieve_invoice() function, write a list comprehension that builds a list (called results here) by iterating through the list of invoices (called data) and checking for any invoice numbers (invoice_num) that match the invoice id (row[0]). Do this as follows:

```
results = [row[1:] for row in data if invoice_num == row[0]]
```

Check for No Invoice Found

Below the statement from the previous step, check to see if any results were found. If not, respond by raising an HTTPException with a status_code of 404.

```
results = [row[1:] for row in data if invoice_num == row[0]]

if not results:
    raise HTTPException(status_code=404,
                        detail='Invoice not found')
```

Complete the Return Statement

At the location where the return statement exists, complete it by returning the results found in step 3. Do this by providing a dictionary in the return.

```
return {'results': results}
```

Complete the uvicorn.run() Statement

Finish the task by passing the **app** object into the uvicorn.run() statement:

```
uvicorn.run(app, host='localhost', port=8000)
```

That's it! Test it out within your browser for now by starting the server and navigating your browser to: **`http://localhost:8000/api/invoices/536365.`**

Task 2-2
An API Client

Overview

This task will allow us to interact with our invoice API via a Python-based client. We'll work from the provided task2_2_starter.py file.

Prompt the User for an Invoice Number

Use a simple prompt to ask the user to supply an invoice number. There are many ways to retrieve an input from the user. Below represents only one possible way. Feel free to create your own, otherwise, use the technique shown below:

```
default = '536365'
invoice_num = click.prompt('Enter invoice number to retrieve',
                           default=default)
```

Construct the URL to Access Our FastAPI Server

We need to combine the provided base_url, path, and user's input to create the URL. A Python f-string can do this.

```
default = '536365'
invoice_num = click.prompt('Enter invoice number to retrieve',
                           default=default)


url = f'{base_url}{path}{invoice_num}'
```

Make a Request and Convert the Response

Time to make an HTTP GET request using the requests module and the URL created in step 2. Convert the returned response to JSON using the .json() method:

```
default = '536365'
invoice_num = click.prompt('Enter invoice number to retrieve',
                           default=default)


url = f'{base_url}{path}{invoice_num}'


results = requests.get(url).json()
```

Display the Retrieved Results

Use json.dumps() to take the returned dictionary and output it as a string.

```
default = '536365'
invoice_num = click.prompt('Enter invoice number to retrieve',
                           default=default)


url = f'{base_url}{path}{invoice_num}'
results = requests.get(url).json()


print(json.dumps(results, indent=4))
```

That's it! Test it out by:

1. Making sure you are running the task2_1_starter.py server.
2. Running the task2_2_starter.py file after the server is already running.

Task 2-3
Creating the POST and Other Methods

Overview

This task will implement a method within the FastAPI server which handles creating new invoices. We will not complete this method for now as it will require us to incorporate the database (shortly). You will create a Pydantic model and stub out the PUT, DELETE, and GET (all) methods as well. You'll test your solution against the provided task2_3_client.py file.

Import Needed Items

Add the import needed to create a Pydantic model. This is the **BaseModel class**.

```
import uvicorn
from fastapi import FastAPI, HTTPException
from pydantic import BaseModel
```

Create the Invoice Model Class

Create the Invoice Model Class as defined on our working slide:

stock_code (str), quantity (int), description (str), invoice_date (str), unit_price (float), customer_id (str), and country (str)

```
app = FastAPI()


class Invoice(BaseModel):
    stock_code: str
    quantity: int
    description: str
    invoice_date: str
    unit_price: float
    customer_id: str
    country: str
```

Create the POST Method

Create the the APIs POST handling method. Call it create_invoice(). Be sure to add the decorator above it. It should also accept an Invoice object. Place this method below the already provided retrieve_invoice() method.

```
@app.post('/api/invoices')
def create_invoice(invoice: Invoice):
    return {'action': 'POST response', **invoice.model_dump()}
```

Create the GET (All) Path Parameter Function

Create the GET (all) HTTP path operation (function). It should provide the path parameter decorator. Call the function get_all_invoices() and have it return a simple dictionary, as shown:

```
@app.get('/api/invoices')
def get_all_invoices():
    return {'action': 'GET (all) response'}
```

Create the PUT Path Parameter Function

Create the PUT HTTP path operation (function). It should provide the path parameter decorator. Call the function update_invoice() and have it return a simple dictionary, as shown:

```
@app.put('/api/invoices/{invoice_num}')
def update_invoice():
    return {'action': 'PUT response'}
```

Create the DELETE Path Parameter Function

Create the DELETE HTTP path operation (function). It should provide the path parameter decorator. Call the function delete_invoice() and have it return a simple dictionary, as shown:

```
@app.delete('/api/invoices/{invoice_num}')
def delete_invoice():
    return {'action': 'DELETE response'}
```

That's it! Test it out by:

1. Ensuring no other servers are running. Be sure to stop them.
2. Starting the task2_3_starter.py server.
3. Using the provided client (task2_3_client.py) to access the server.

Task 2-4
Using Postman (Optional)

Overview

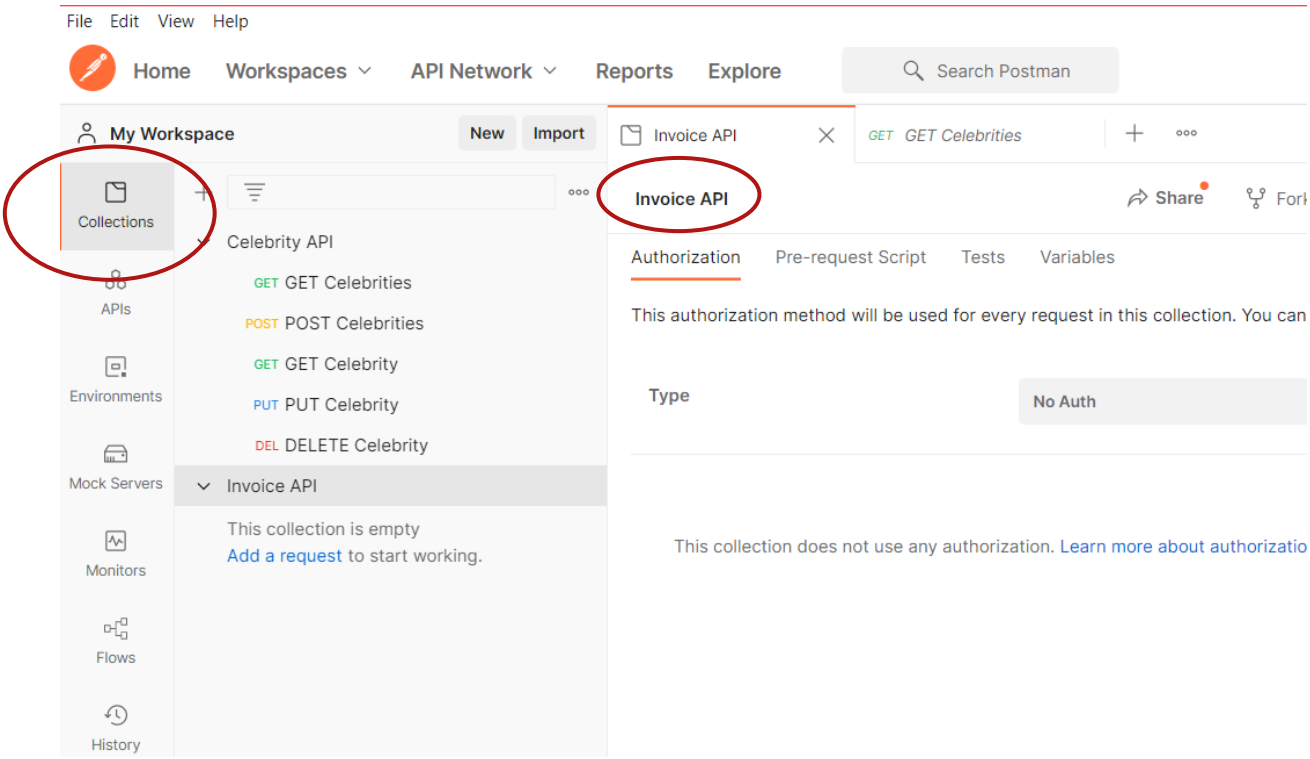
This task will use (or demonstrate the use of) Postman. If you don't have Postman installed on your working machine, this is okay. The exercise provides screen shots to demonstrate its capabilities.

You will need Postman desktop for this task as it is required for localhost testing. Open Postman desktop app if you have it.

Note: references in screenshots to port 8051 will be port 8000 instead.

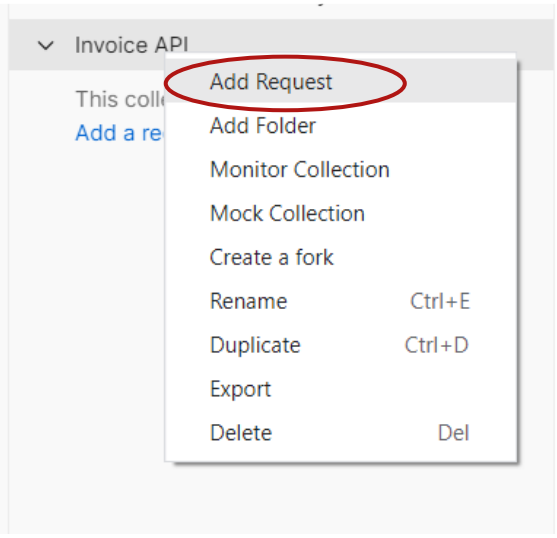
Create the Invoice Collection

Open the Postman desktop app. In the ***My Workspace*** section on the left, select ***Collections***. Then, in the field to the right, define the name ***Invoice API***. (See the screen shot).

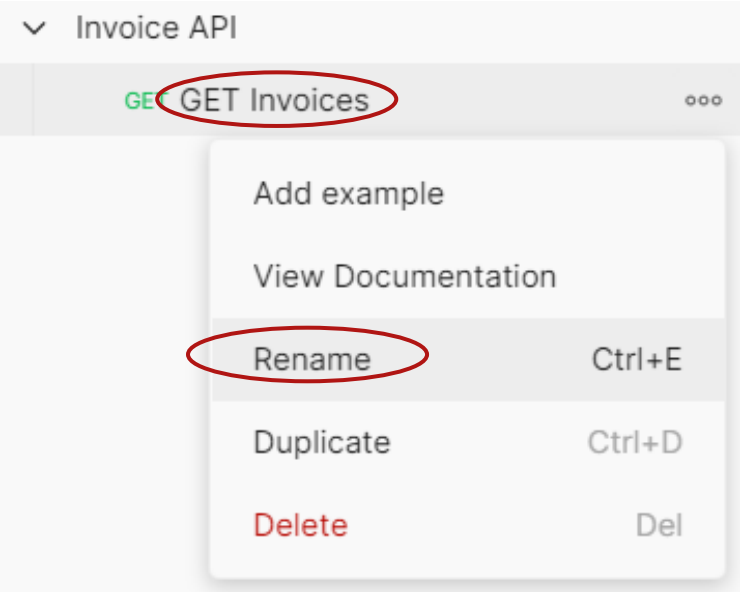


2 Add the Five Requests

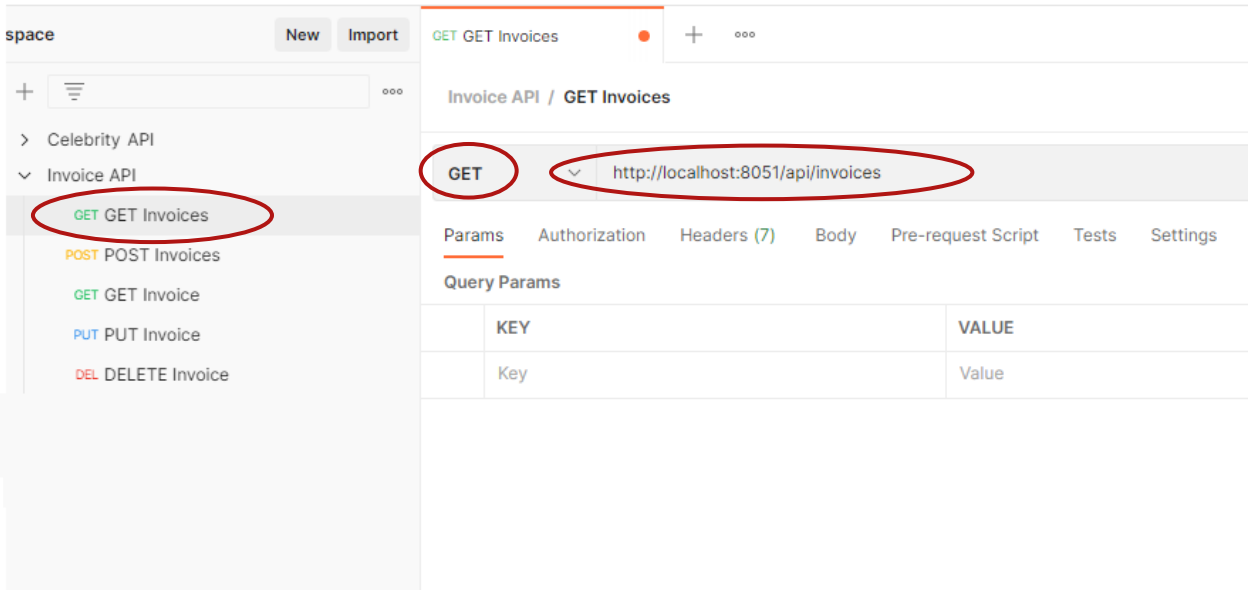
Next, add a request to the collection as shown below.



Give the request a new name.



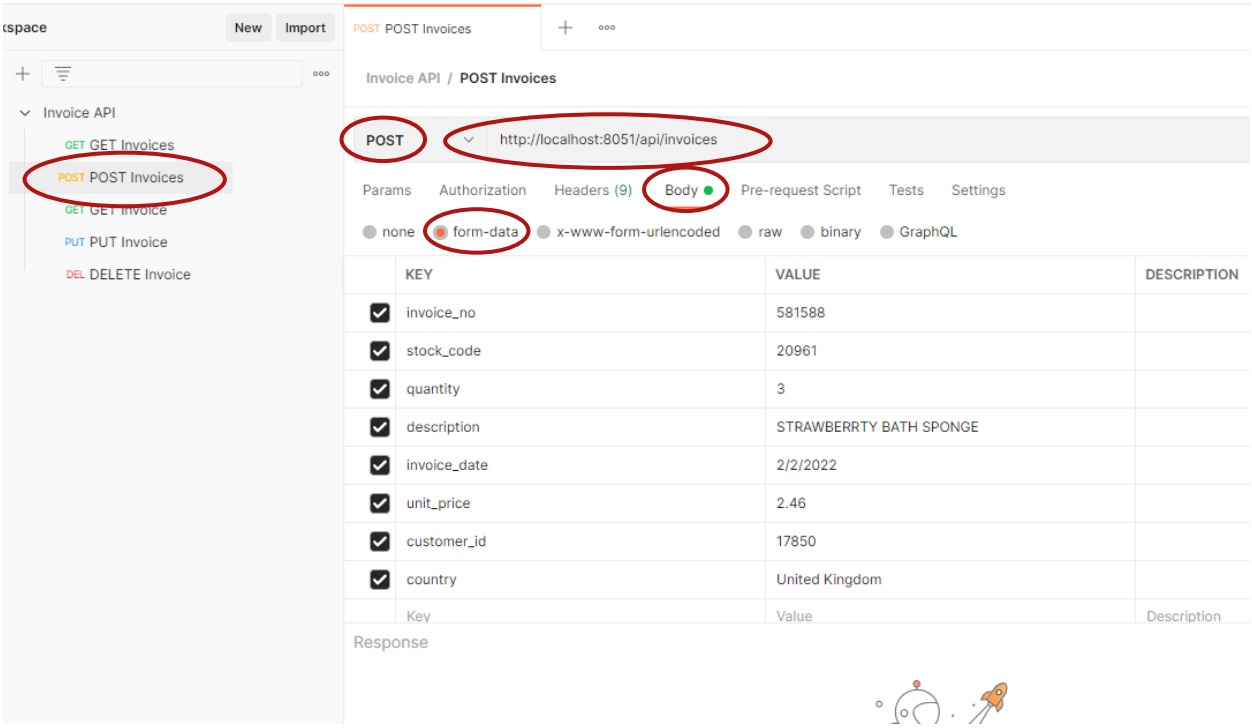
Supply the URL of **`http://localhost:8000/api/invoices`**.
Select the HTTP method type as shown.



Save the tab (request) using CTRL-S.

Do this again this time for the **POST** request next:

1. Create a new request.
2. Rename it.
3. Use the same URL from the previous step.
4. Be sure to select POST type.
5. Save the tab (request) using CTRL-S.

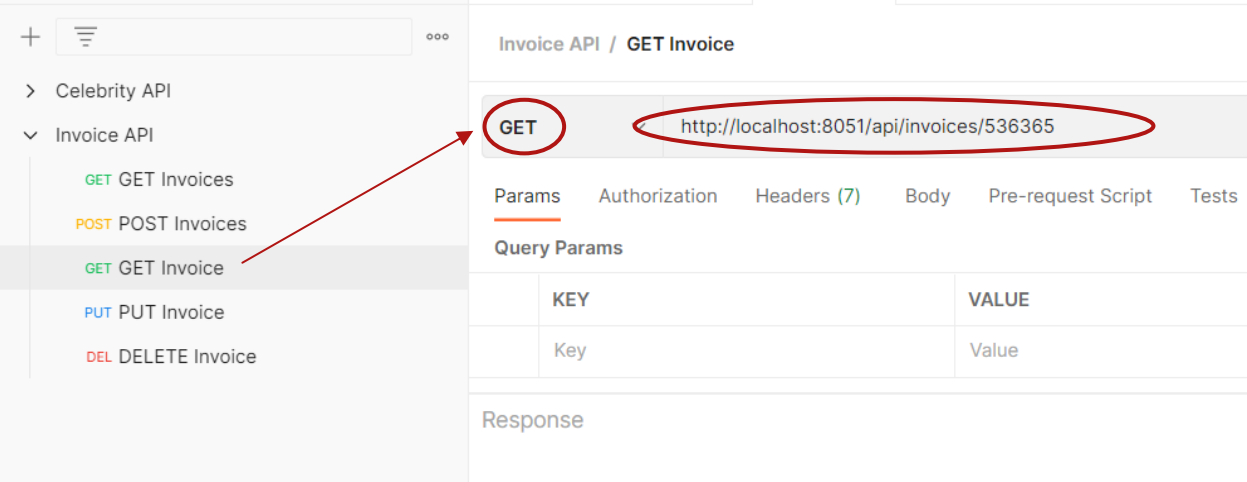


Add parameters by selecting the Body tab and then the form-data radio button as shown above. Add in values: **invoice_no**: 581588, **stock_code**: 20961, **quantity**: 3, **description**: STRAWBERRY BATH SPONGE, **invoice_date**: 2/2/2022, **unit_price**: 2.46, **customer_id**: 17850, **country**: United Kingdom.

Save the request again.

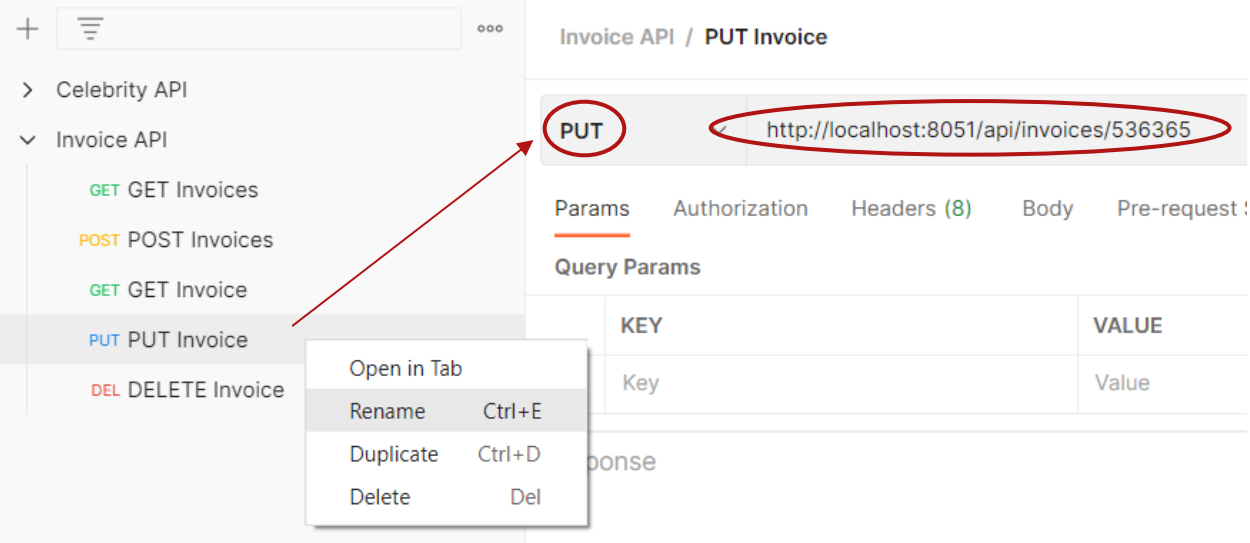
Now for the GET (singular) request:

1. Create a new request.
2. Rename it.
3. Select a specific invoice to test (see screen shot). We used **536365**.



Be sure to save the tab (request) with CTRL-S.

Implement the PUT and DELETE requests (as shown below) using the same technique as the GET (singular) shown above. Don't forget to save the new requests each time. For the PUT request, add the form parameters into the Body > Form Data section as we did for the PUT request.

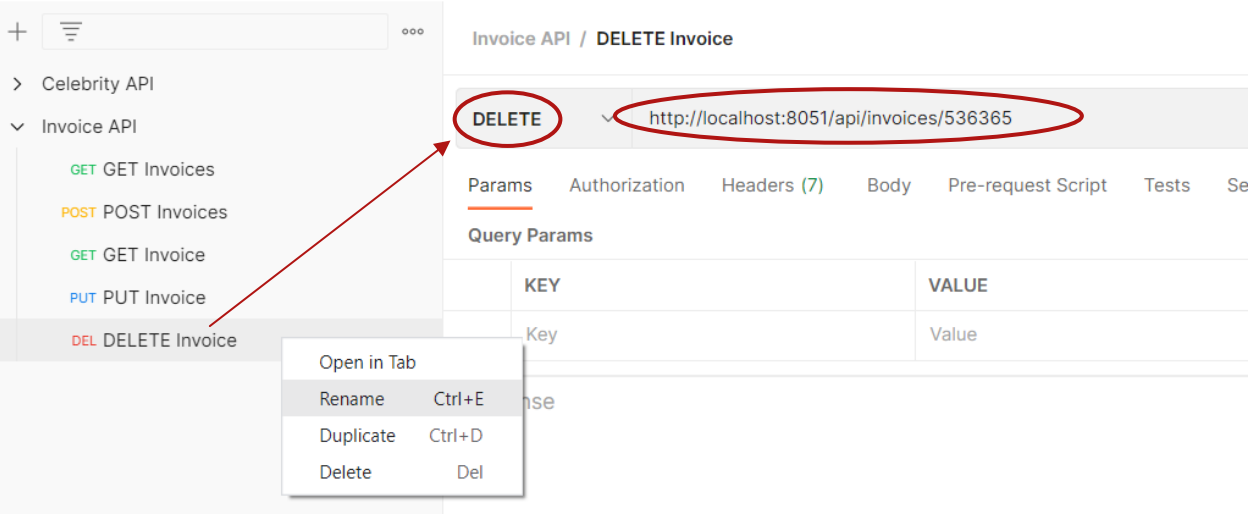


Again, for the PUT, add Body parameters as we did for the POST request (not pictured this time).

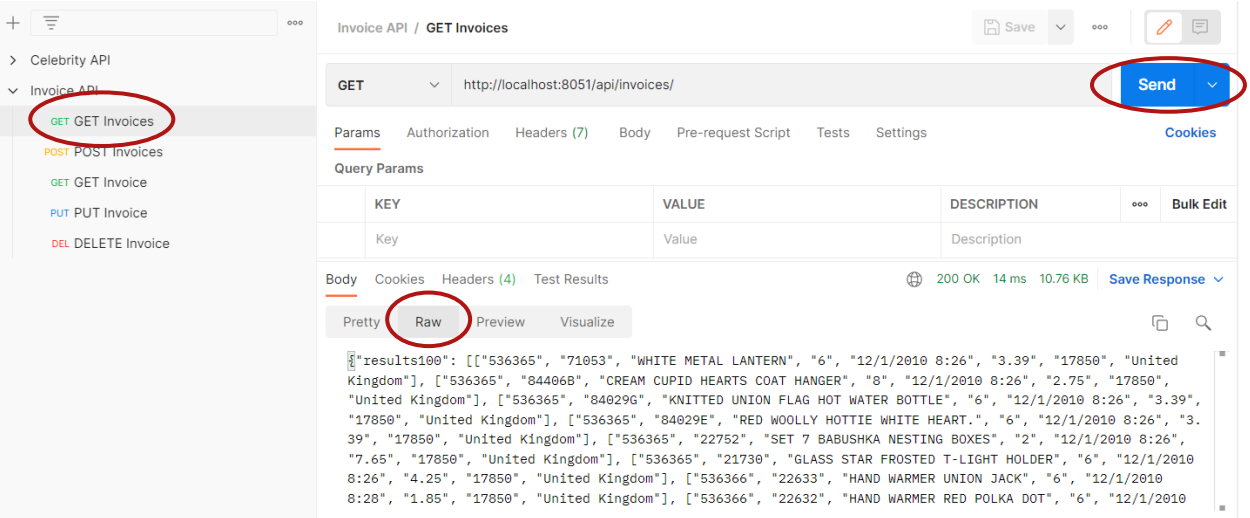
Add parameters by selecting the Body tab and then the form-data radio button as shown above. Add in values: **invoice_no**: 581588, **stock_code**: 20961, **quantity**: 3, **description**: STRAWBERRY BATH SPONGE, **invoice_date**: 2/2/2022, **unit_price**: 2.46, **customer_id**: 17850, **country**: United Kingdom.

Save the request again.

Create the DELETE request. No body parameters are needed in this case.



Test it out by running your task2_3_starter.py server. Then, for each request in the collection, select it. Press send and view the output results, as shown:



Task 2-5
Adding SQLAlchemy, Implementing POST and Get (Singular)

Overview

This task incorporates the database SQLAlchemy. You will SQLAlchemy into our on-going invoice API, create a database model object, write and test the create_invoice() (POST) method and the retrieve_invoice() (GET) method.

Create the Session Class

Create the SQLAlchemy Session class as shown:

```
engine = create_engine('sqlite:///' + str(db_url), echo=True)
Session = sessionmaker(bind=engine)
session = Session()
```

Create the Base Class

Create the SQLAlchemy Base class using declarative_base()

```
Session = sessionmaker(bind=engine)
session = Session()

Base = declarative_base()
```

Build the InvoiceModel Class

In the blank line provided, create the InvoiceModel class that inherits from Base. Add the following in the blank space provided:

```
class InvoiceModel(Base):
    __tablename__ = 'purchases'
```

Uncomment the lines of code that provide the Column definitions. Your class to this point should look like the following:

```
class InvoiceModel(Base):
    __tablename__ = 'purchases'
    id = Column(Integer, primary_key=True, autoincrement=True)
    invoice_num = Column('InvoiceNo', String(30))
    stock_code = Column('StockCode', String(30))
    quantity = Column(Integer)
    description = Column(String(150))
    invoice_date = Column('InvoiceDate', String(50))
    unit_price = Column('UnitPrice', Float)
    customer_id = Column('CustomerID', String(50))
    country = Column(String(50))
```

Continue Building InvoiceModel

Complete the __init__() of the InvoiceModel class. Do this by adding the following line and uncommenting the self.xxx = xxx lines as shown:

```
def __init__(self, invoice_num, stock_code, quantity,
             description, invoice_date,
             unit_price, customer_id, country):
```

The final version of our invoice model should look like this:

```
class InvoiceModel(Base):
    __tablename__ = 'purchases'
    id = Column(Integer, primary_key=True, autoincrement=True)
    invoice_num = Column('InvoiceNo', String(30))
    stock_code = Column('StockCode', String(30))
    quantity = Column(Integer)
    description = Column(String(150))
    invoice_date = Column('InvoiceDate', String(50))
    unit_price = Column('UnitPrice', Float)
    customer_id = Column('CustomerID', String(50))
    country = Column(String(50))

    def __init__(self, invoice_num, stock_code, quantity,
                 description, invoice_date,
                 unit_price, customer_id, country):
        super().__init__()
        self.invoice_num = invoice_num
        self.stock_code = stock_code
        self.quantity = quantity
        self.description = description
        self.invoice_date = invoice_date
        self.unit_price = unit_price
        self.customer_id = customer_id
        self.country = country

    def __str__(self):
        return f'({self.invoice_num}) {self.stock_code} Qty:
                 {self.quantity} - {self.description}'
```

```
    def to_dict(self) -> dict:
        return {'id': self.id, 'invoice_num': self.invoice_num,
                'stock_code': self.stock_code,
                'quantity': self.quantity,
                'description': self.description,
                'invoice_date': self.invoice_date,
                'unit_price': self.unit_price,
                'customer_id': self.customer_id,
                'country': self.country}

    __repr__ = __str__
```

Complete the retrieve_invoice() Method

Remove the pass statement from retrieve_invoice() and implement the following within it:

```
invoice = session.get(InvoiceModel, id)
if not invoice:
    raise HTTPException(status_code=404,
                        detail=f'Invoice not found.')
return invoice.to_dict()
```

The final version of retrieve_invoice() should look like the following:

```
@app.post('/api/invoices')
def create_invoice(invoice_request: Invoice):
    try:
        new_invoice_db =
                 InvoiceModel(**invoice_request.model_dump())
        session.add(new_invoice_db)
        session.commit()
        results = new_invoice_db.to_dict()
    except Exception as err:
        raise HTTPException(status_code=404,
                detail=f'Error creating invoice: {err.args[0]}')

    return results
```

Complete the create_invoice() Method

Remove the pass statement from create_invoice(). Add the following to the try block.

```
try:
    new_invoice_db =
                    InvoiceModel(**invoice_request.model_dump())
    session.add(new_invoice_db)
    session.commit()
    results = new_invoice_db.to_dict()
except Exception as err:
    raise HTTPException(status_code=404,
                detail=f'Error creating invoice: {err.args[0]}')

return results
```

That's it! Test it out by:

1. Ensuring no other servers are running
2. Starting the task2_5_starter.py server
3. Run the task2_5_client.py file to test the post operation

Task 2-6
Complete the Invoice API

Overview

This last task in the chapter completes our Invoice API. In this task, you will complete the remaining API methods: GET (all), PUT, and DELETE. Work from the provided task2_6_starter.py in the ch02_fundamentals folder.

Complete the GET (all) Method

Remove the existing return statement from the get_all_invoices() method. Replace it with the following version. This will retrieve all invoices using SQLAlchemy and the session's query() method. Unfortunately, this also returns TOO MANY results. If you wish, on the return invoices line, you can limit the size of the response by using return invoices[:100]. This is only temporary and we'll fix this in Task 3-1.

```
@app.get('/api/invoices')
def get_all_invoices():
    invoices = session.query(InvoiceModel).all()
    if not invoices:
        raise HTTPException(status_code=404,
                            detail=f'No invoices found.')
    return invoices[:100]
```

Complete the PUT Method Signature

The method entitled update_invoice() needs to be fixed to support a PUT operation. The path parameter and Invoice model should be provided as parameters for this function:

```
@app.put('/api/invoices/{id}')
def update_invoice(id: int, updated_invoice: Invoice):
```

Complete the PUT Method Body

Within the body of the update_invoice() method, remove the current return statement and replace it with the code below. Note, to simplify typing, the lines that update the invoice object have been provided so you merely need to uncomment them.

```
@app.put('/api/invoices/{id}')
def update_invoice(id: int, updated_invoice: Invoice):
    try:
        invoice = session.get(InvoiceModel, id)

        invoice.invoice_num = updated_invoice.invoice_num if
            updated_invoice.invoice_num else invoice.invoice_num
        invoice.stock_code = updated_invoice.stock_code if
            updated_invoice.stock_code else invoice.stock_code
        invoice.quantity = updated_invoice.quantity if
            updated_invoice.quantity else invoice.quantity
        invoice.description = updated_invoice.description if
            updated_invoice.description else invoice.description
        invoice.invoice_date = updated_invoice.invoice_date if
          updated_invoice.invoice_date else invoice.invoice_date
```

```
        invoice.unit_price = updated_invoice.unit_price if
            updated_invoice.unit_price else invoice.unit_price
        invoice.customer_id = updated_invoice.customer_id if
            updated_invoice.customer_id else invoice.customer_id
        invoice.country = updated_invoice.country if
            updated_invoice.country else invoice.country

        session.commit()

        results = invoice.to_dict()
    except Exception as err:
        raise HTTPException(status_code=404, detail=f'Error
updating invoice: {err.args[0]}')

    return results
```

Complete the DELETE Method Signature

The method entitled delete_invoice() needs to be fixed to support a DELETE operation. The id path parameter should be provided as a parameter for this function:

```
@app.delete('/api/invoices/{id}')
def delete_invoice(id: int):
```

Complete the DELETE Method Body

Within the body of the delete_invoice() method, remove the current return statement and replace it with the code below.

```
@app.delete('/api/invoices/{id}')
def delete_invoice(id: int):
    try:
        invoice = session.get(InvoiceModel, id)
        session.delete(invoice)
        session.commit()

        results = invoice.to_dict()
    except Exception as err:
        raise HTTPException(status_code=404, detail=f'Error
removing invoice: {err.args[0]}')

    return results
```

That's it! Test it out by running task2_6_starter.py as a server and then running the provided client, task2_6_client.py.

Task 3-1
Pagination

Overview

This task adds a pagination feature into the Invoice API service. To do this, you will only need to modify the get_all_invoices() method. We'll make use of the SQLAlchemy tool's Paginate object. Begin by working from your task3_1_starter.py file in the ch03_adv_concepts folder.

Define a Limit and Offset

In the get_all_invoices() method, add a parameter to define the **limit** as an int with a default value of 50. Include a **page** parameter as an int with a default value of 0.

```
@app.get('/api/invoices')
def get_all_invoices(limit: int = 50, page: int = 0):
```

Use the Page and Limit in the Database

Apply the page and limit values from the previous step to the database query by modifying the session.query() statement.

```
@app.get('/api/invoices')
def get_all_invoices(limit: int = 50, page: int = 0):
    if limit > 50:
        limit = 50
    invoices = session.query(InvoiceModel)
                      .limit(limit).offset(page * limit).all()
    if not invoices:
        raise HTTPException(status_code=404,
                            detail=f'No invoices found.')
    return invoices
```

That's it! Test it out by running task3_1_starter.py and then running task3_1_client.py.