



FastAPI

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About the Tutorial

FastAPI is a modern Python web framework, very efficient in building APIs. FastAPI has been developed by Sebastian Ramirez in Dec. 2018. FastAPI 0.68.0 is the currently available version. The latest version requires Python 3.6 or above. It is one of the fastest web frameworks of Python.

Audience

This tutorial is designed for developers who want to learn how to build REST APIs using Python.

Prerequisites

Before you proceed, make sure that you understand the basics of procedural and object-oriented programming in Python. Knowledge of REST architecture is an added advantage.

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1. FastAPI – Introduction

FastAPI is a modern Python web framework, very efficient in building APIs. It is based on Python's type hints feature that has been added since Python 3.6 onwards. It is one of the fastest web frameworks of Python.

- As it works on the functionality of Starlette and Pydantic libraries, its performance is amongst the best and on par with that of NodeJS and Go.
- In addition to offering high performance, FastAPI offers significant speed for development, reduces human-induced errors in the code, is easy to learn and is completely production-ready.
- FastAPI is fully compatible with well-known standards of APIs, namely OpenAPI and JSON schema.

FastAPI has been developed by **Sebastian Ramirez** in Dec. 2018. FastAPI 0.68.0 is the currently available version.

FastAPI – Environment Setup

To install FastAPI (preferably in a virtual environment), use **pip** installer.

```
pip3 install fastapi
```

FastAPI depends on **Starlette** and **Pydantic** libraries, hence they also get installed.

Installing Uvicorn using PIP

FastAPI doesn't come with any built-in server application. To run FastAPI app, you need an ASGI server called **uvicorn**, so install the same too, using pip installer. It will also install uvicorn's dependencies - asgiref, click, h11, and typing-extensions

```
pip3 install uvicorn
```

With these two libraries installed, we can check all the libraries installed so far.

```
pip3 freeze

asgiref==3.4.1
click==8.0.1
colorama==0.4.4
fastapi==0.68.0
h11==0.12.0
importlib-metadata==4.6.4
pydantic==1.8.2
starlette==0.14.2
typing-extensions==3.10.0.0
uvicorn==0.15.0
zipp==3.5.0
```

2. FastAPI – Hello World

Getting Started

The first step in creating a FastAPI app is to declare the application object of FastAPI class.

```
from fastapi import FastAPI  
app = FastAPI()
```

This **app** object is the main point of interaction of the application with the client browser. The unicorn server uses this object to listen to client's request.

The next step is to create path operation. Path is a URL which when visited by the client invokes visits a mapped URL to one of the HTTP methods, an associated function is to be executed. We need to bind a view function to a URL and the corresponding HTTP method. For example, the **index()** function corresponds to '/' path with 'get' operation.

```
@app.get("/")  
async def root():  
    return {"message": "Hello World"}
```

The function returns a JSON response, however, it can return **dict**, **list**, **str**, **int**, etc. It can also return Pydantic models.

Save the following code as main.py

```
from fastapi import FastAPI  
app = FastAPI()  
  
@app.get("/")  
async def index():  
    return {"message": "Hello World"}
```

Start the uvicorn server by mentioning the file in which the FastAPI application object is instantiated.

```
uvicorn main:app --reload

INFO: Uvicorn running on http://127.0.0.1:8000 (Press CTRL+C
to quit)

INFO: Started reloader process [28720]
INFO: Started server process [28722]
INFO: Waiting for application startup.
INFO: Application startup complete.
```

Open the browser and visit <http://localhost:8000>. You will see the JSON response in the browser window.



3. FastAPI – OpenAPI

Enter the following URL in the browser to generate automatically the interactive documentation.

```
http://127.0.0.1:8000/docs
```

FastAPI uses Swagger UI to produce this documentation. The browser will display the following:

The screenshot shows a browser window titled "FastAPI - Swagger UI". The address bar contains the URL "127.0.0.1:8000/docs#/default/index_get". The main content area is titled "default". It shows a "GET / Index" operation. Under "Parameters", it says "No parameters". Under "Responses", there is a table with columns "Code", "Description", and "Links". A single row is shown for "200 Successful Response". The "Description" column contains the text "Successful Response". In the "Links" column, the text "No links" is displayed. Below the table, there is a "Media type" dropdown set to "application/json", with a note "Controls Accept header." and "Example Value | Schema" buttons. The "Example Value" button is highlighted, showing the value "string".

Click the '**try it out**' button and then '**Execute**' button that appears afterward.

The screenshot shows the FastAPI - Swagger UI interface. At the top, there's a browser header with the title 'FastAPI - Swagger UI' and the URL '127.0.0.1:8000/docs#/default'. Below the header, the main content area is titled 'Responses'.

Under 'Responses', there's a 'Curl' section containing a code snippet:

```
curl -X 'GET' \
'http://127.0.0.1:8000/' \
-H 'accept: application/json'
```

Below that is a 'Request URL' input field containing 'http://127.0.0.1:8000/'. Under 'Server response', there's a table with two columns: 'Code' and 'Details'.

| Code | Details |
|------|---|
| 200 | <p>Response body</p> <pre>{ "message": "Hello World" }</pre> <p>Response headers</p> <pre>content-length: 25 content-type: application/json date: Mon, 09 May 2022 07:02:41 GMT server: uvicorn</pre> |

At the bottom of the 'Server response' section, there's a 'Responses' table:

| Code | Description | Links |
|------|---------------------|----------|
| 200 | Successful Response | No links |

For the '200' row, under 'Description', there's a 'Media type' dropdown set to 'application/json'. Below it, a note says 'Controls Accept header.' and 'Example Value | Schema' buttons are shown. The 'Example Value' field contains the string '"string"'.

You can see the **Curl** command internally executed, the request URL, the response headers, and the JSON format of the server's response.

FastAPI generates a schema using **OpenAPI** specifications. The specification determines how to define API paths, path parameters, etc. The API schema defined by the OpenAPI standard decides how the data is sent

using JSON Schema. Visit <http://127.0.0.1:8000/openapi.json> from your browser. A neatly formatted JSON response as follows will be displayed:

```
{  
    "openapi": "3.0.2",  
    "info": {  
        "title": "FastAPI",  
        "version": "0.1.0"  
    },  
    "paths": {  
        "/": {  
            "get": {  
                "summary": "Index",  
                "operationId": "index__get",  
                "responses": {  
                    "200": {  
                        "description": "Successful Response",  
                        "content": {  
                            "application/json": {  
                                "schema": {}  
                            }  
                        }  
                    }  
                }  
            }  
        }  
    }  
}
```

FastAPI also supports another automatic documentation method provided by **Redoc** (<https://github.com/Redocly/redoc>).

Enter <http://localhost:8000/redoc> as URL in the browser's address bar.

The screenshot shows a web browser window titled "FastAPI - ReDoc". The address bar displays "127.0.0.1:8000/redoc". The main content area is titled "FastAPI (0.1.0)". It features a search bar and a "GET Index" button. Below this, a link says "Documentation Powered by ReDoc". On the right, there is a "Download OpenAPI specification:" button with a "Download" link. The left sidebar has sections for "Index" and "Responses". Under "Responses", there is a green box labeled "> 200 Successful Response". A large dark modal window is open, showing a "GET /" request. It displays a "Response samples" section with a "200" status code. Inside, it shows "Content type: application/json" and a "null" response body. There are "Copy", "Expand all", and "Collapse all" buttons at the bottom of the modal.

4. FastAPI – Uvicorn

Unlike the Flask framework, FastAPI doesn't contain any built-in development server. Hence we need **Uvicorn**. It implements **ASGI** standards and is lightning fast. ASGI stands for **Asynchronous Server Gateway Interface**.

The **WSGI** (Web Server Gateway Interface – the older standard) compliant web servers are not suitable for **asyncio** applications. Python web frameworks (such as FastAPI) implementing ASGI specifications provide high speed performance, comparable to web apps built with Node and Go.

Uvicorn uses **uvloop** and **httptools** libraries. It also provides support for HTTP/2 and WebSockets, which cannot be handled by WSGI. **uvloop** is similar to the built-in **asyncio** event loop. **httptools** library handles the http protocols.

The installation of Uvicorn as described earlier will install it with minimal dependencies. However, standard installation will also install **cython** based dependencies along with other additional libraries.

```
pip3 install uvicorn(standard)
```

With this, the **WebSockets** protocol will be supported. Also, **PyYAML** will be installed to allow you to provide a `.yaml` file.

As mentioned earlier, the application is launched on the Uvicorn server with the following command:

```
uvicorn main:app --reload
```

The **--reload** option enables the debug mode so that any changes in `app.py` will be automatically reflected and the display on the client browser will be automatically refreshed. In addition, the following command-line options may be used:

| | |
|----------------|---|
| --host TEXT | Bind socket to this host. [default 127.0.0.1] |
| --port INTEGER | Bind socket to this port. [default 8000] |
| --uds TEXT | Bind to a UNIX domain socket. |
| --fd INTEGER | Bind to socket from this file descriptor. |
| --reload | Enable auto-reload. |

| | |
|------------------------------------|---|
| --reload-dir PATH | Set reload directories explicitly, default current working directory. |
| --reload-include TEXT | Include files while watching. Includes '*.py' by default |
| -reload-exclude TEXT | Exclude while watching for files. |
| --reload-delay FLOAT | Delay between previous and next check default 0.25 |
| -loop [auto asyncio uvloop] | Event loop implementation. [default auto] |
| --http [auto h11 httptools] | HTTP protocol implementation. [default auto] |
| --interface auto asgi asgi wsgi | Select application interface. [default auto] |
| --env-file PATH | Environment configuration file. |
| --log-config PATH | Logging configuration file. Supported formats .ini, .json, .yaml. |
| --version | Display the unicorn version and exit. |
| --app-dir TEXT | Look for APP in the specified directory default current directory |
| --help | Show this message and exit. |

Instead of starting Uvicorn server from command line, it can be launched programmatically also.

Example

In the Python code, call `uvicorn.run()` method, using any of the parameters listed above:

```
import uvicorn
from fastapi import FastAPI
app = FastAPI()

@app.get("/")

```

```
async def index():
    return {"message": "Hello World"}

if __name__ == "__main__":
    uvicorn.run("main:app", host="127.0.0.1", port=8000, reload=True)
```

Now run this **app.py** as Python script as follows:

```
(fastapienv) C:\fastapienv>python app.py
```

Uvicorn server will thus be launched in debug mode.

5. FastAPI – Type Hints

FastAPI makes extensive use of the **Type** hinting feature made available in Python's version 3.5 onwards. As a matter of fact, Python is known to be a dynamically typed language. It also happens to be Python's distinct feature. In a Python code, a variable need not be declared to be belonging to a certain type, and its type is determined dynamically by the instantaneous value assigned to it. Python's interpreter doesn't perform type checks and hence it is prone to runtime exceptions.

In the following example, a **division()** function is defined with two parameters and returns their division, assuming that the parameters will be numeric.

```
>>> def division(a, b):
    return a/b
>>> division(10, 4)
2.5

>>> division(10, 2.5)
4.0
```

However, if one of the values passed to the function happen to be non-numeric, it results in `TypeError` as shown below:

```
>>> division("Python",5)

TypeError: unsupported operand type(s) for /: 'str' and 'int'
```

Even a basic coding environment such as IDLE indicates that the function requires two parameters but won't specify the types as they haven't been declared.

```
>>>
>>>
>>> def division(a,b):
        return a/b

>>> division(
        (a, b)
```

Python's new type hinting feature helps in prompting the user with the expected type of the parameters to be passed. This is done by adding a colon and data type after the parameter. We'll redefine the `division()` function as follows:

```
>>> def division(a:int,b:int):
        return a/b

>>> division()
        (a: int, b: int)
```

Note that while calling the function, Python hints at the expected type of each parameter to be passed. However, this doesn't prevent the `TypeError` from appearing if an incompatible value is passed. You will have to use a static type checker such as **MyPy** to check for compatibility before running.

Just as the formal parameters in the function's definition, it is possible to provide type hint for a function's return value. Just before the colon symbol in the function's definition statement (after which the function block starts) add an arrow (`->`) and the type.

```
>>> def division(a:int, b:int) ->float:
        return a/b

>>> division()
        (a: int, b: int) -> float
```

However, as mentioned earlier, if incompatible values are passed to the function, or returned by the function, Python reports `TypeError`. Use of MyPy static type checker can detect such errors. Install `mypy` package first.

```
pip3 install mypy
```

Save the following code as typecheck.py

```
def division(x:int, y:int) -> int:
    return (x//y)

a=division(10,2)
print (a)

b=division(5,2.5)
print (b)

c=division("Hello",10)
print (c)
```

Check this code for type errors using mypy.

```
C:\python37>mypy typechk.py

typechk.py:7: error: Argument 2 to "division" has incompatible
type "float"; expected "int"

typechk.py:10: error: Argument 1 to "division" has
incompatible type "str"; expected "int"

Found 2 errors in 1 file (checked 1 source file)
```

There are errors in second and third calls to the function. In second, value passed to **y** is **float** when **int** is expected. In third, value passed to **x** is **str** when **int** is expected. (Note that // operator returns integer division)

All standard data types can be used as type hints. This can be done with global variables, variables as function parameters, inside function definition etc.

```
x: int = 3
y: float = 3.14
```

```

nm: str = 'abc'

married: bool = False

names: list = ['a', 'b', 'c']

marks: tuple = (10, 20, 30)

marklist: dict = {'a': 10, 'b': 20, 'c': 30}

```

A new addition in newer versions of Python (version 3.5 onwards) standard library is the typing module. It defines special types for corresponding standard collection types. The types on typing module are **List**, **Tuple**, **Dict**, and **Sequence**. It also consists of **Union** and **Optional** types. Note that standard names of data types are all in small case, whereas ones in typing module have first letter in upper case. Using this feature, we can ask a collection of a particular type.

```

from typing import List, Tuple, Dict

# following line declares a List object of strings.

# If violated, mypy shows error

cities: List[str] = ['Mumbai', 'Delhi', 'Chennai']

# This is Tuple with three elements respectively

# of str, int and float type)

employee: Tuple[str, int, float] = ('Ravi', 25, 35000)

# Similarly in the following Dict, the object key should be str

# and value should be of int type, failing which

# static type checker throws error

marklist: Dict[str, int] = {'Ravi': 61, 'Anil': 72}

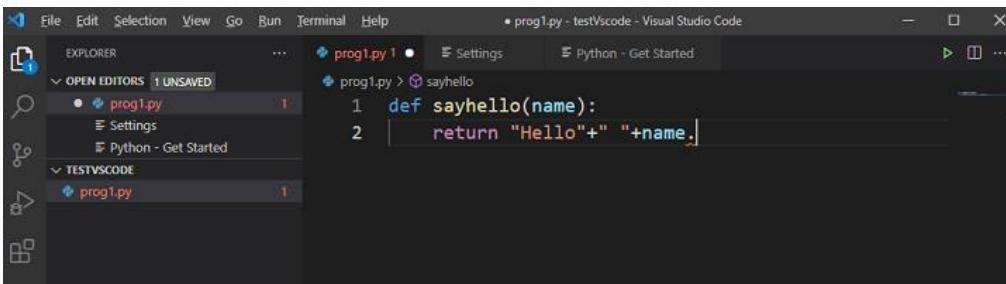
```

6. FastAPI – IDE Support

The Type Hinting feature of Python is most effectively used in almost all **IDEs** (Integrated Development Environments) such as **PyCharm** and **VS Code** to provide dynamic autocomplete features.

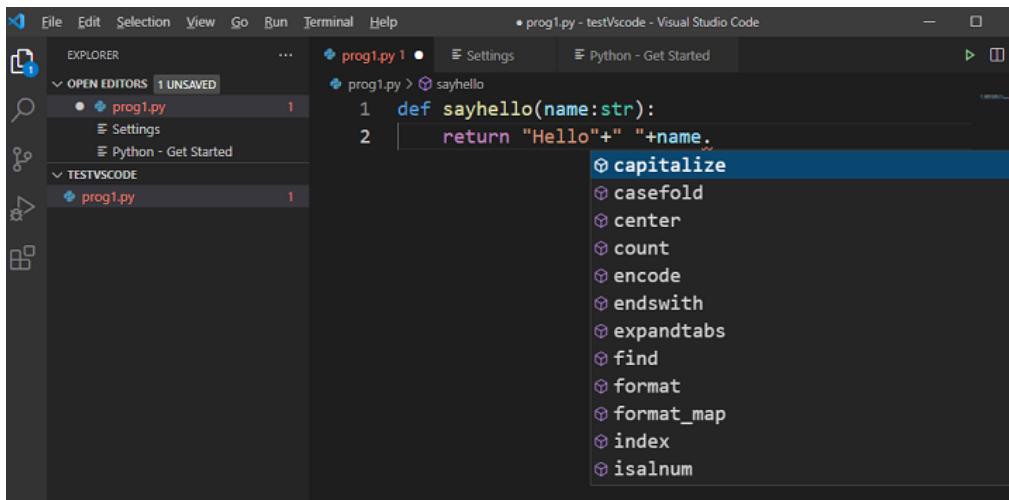
Let us see how VS Code uses the type hints to provide autocomplete suggestions while writing a code. In the example below, a function named as **sayhello** with name as an argument has been defined. The function returns a string by concatenating "Hello" to the name parameter by adding a space in between. Additionally, it is required to ensure that the first letter of the name be in upper case.

Python's **str** class has a **capitalize()** method for the purpose, but if one doesn't remember it while typing the code, one has to search for it elsewhere. If you give a dot after name, you expect the list of attributes but nothing is shown because Python doesn't know what will be the runtime type of name variable.



```
File Edit Selection View Go Run Terminal Help * prog1.py - testVscode - Visual Studio Code
EXPLORER OPEN EDITORS 1 UNSAVED prog1.py 1 Settings Python - Get Started
prog1.py > sayhello
1 def sayhello(name):
2     return "Hello"+ " "+name.
```

Here, type hint comes handy. Include **str** as the type of name in the function definition. Now when you press dot (.) after name, a drop down list of all string methods appears, from which the required method (in this case **capitalize()**) can be picked.



It is also possible to use type hints with a user defined class. In the following example a rectangle class is defined with type hints for arguments to the `__init__()` constructor.

```
class rectangle:
    def __init__(self, w:int, h:int) ->None:
        self.width=w
        self.height=h
```

Following is a function that uses an object of above rectangle class as an argument. The type hint used in the declaration is the name of the class.

```
def area(r:rectangle)->int:
    return r.width*r.height

r1=rectangle(10,20)
print ("area = ", area(r1))
```

In this case also, the IDE editor provides autocomplete support prompting list of the instance attributes. Following is a screenshot of **PyCharm** editor.

The screenshot shows the PyCharm IDE interface with the following details:

- File Menu:** File, Edit, View, Navigate, Code, Refactor, Run, Tools, VCS, Window, Help.
- Project Bar:** pythonProject1, main.py
- Project Tree:** Shows a folder named "pythonPro" containing "venv", "main.p", and "External Lib". A "Scratches" tab is also present.
- Code Editor:** Displays Python code for a `rectangle` class.

```
class rectangle:  
    def __init__(self, w:int, h:int) ->None:  
        self.width=w  
        self.height=h  
  
    def area(r:rectangle)->int:  
        return r.width*r.  
  
r1=rectangle(10,20)  
print ("area = ",
```
- Code Completion Pop-up:** A tooltip is open at the end of the line `return r.width*r.
` showing available methods and attributes for the `rectangle` object. The list includes:
 - width (rectangle)
 - height (rectangle)
 - __init__(self, w, h) (rectangle)
 - __eq__(self, o) (rectangle)
 - __ne__(self, o) (rectangle)
 - not (object)
 - par (expr)
 - __annotations__ (object)
 - __class__ (object)
 - __delattr__(self, name) (object)
 - __dict__ (object)
 - __dir__(self) (object)
- Status Bar:** Press Enter to insert Tab to replace Next Tip.

FastAPI makes extensive use of the type hints. This feature is found everywhere, such as path parameters, query parameters, headers, bodies, dependencies, etc. as well as validating the data from the incoming request. The OpenAPI document generation also uses type hints.

7. FastAPI – REST Architecture

RElational State Transfer (REST) is a software architectural style. REST defines how the architecture of a web application should behave. It is a resource based architecture where everything that the REST server hosts, (a file, an image, or a row in a table of a database), is a resource, having many representations.

REST recommends certain architectural constraints.

- Uniform interface
- Statelessness
- Client-server
- Cacheability
- Layered system
- Code on demand

REST constraints has the following advantages:

- Scalability
- Simplicity
- Modifiability
- Reliability
- Portability
- Visibility

REST uses HTTP verbs or methods for the operation on the resources. The POST, GET, PUT and DELETE methods perform respectively CREATE, READ, UPDATE and DELETE operations respectively.

8. FastAPI – Path Parameters

Modern web frameworks use routes or endpoints as a part of URL instead of file-based URLs. This helps the user to remember the application URLs more effectively. In FastAPI, it is termed a path. A path or route is the part of the URL trailing after the first '/'.

For example, in the following URL,

```
http://localhost:8000/hello/TutorialsPoint
```

the path or the route would be

```
/hello/TutorialsPoint
```

In FastAPI, such a path string is given as a parameter to the operation decorator. The operation here refers to the HTTP verb used by the browser to send the data. These operations include GET, PUT, etc. The operation decorator (for example, `@app.get("/")`) is immediately followed by a function that is executed when the specified URL is visited. In the below example:

```
from fastapi import FastAPI  
  
app = FastAPI()  
  
@app.get("/")  
async def index():  
    return {"message": "Hello World"}
```

Here, `("")` is the path, `get` is the operation, `@app.get("")` is the path operation decorator, and the `index()` function just below it is termed as path operation function.

Any of the following HTTP verbs can be used as operations.

| | |
|------|---|
| GET | Sends data in unencrypted form to the server. Most common method. |
| HEAD | Same as GET, but without the response body. |

| | |
|--------|--|
| POST | Used to send HTML form data to the server. Data received by the POST method is not cached by the server. |
| PUT | Replaces all current representations of the target resource with the uploaded content. |
| DELETE | Removes all current representations of the target resource given by a URL. |

The **async** keyword in the function's definition tells FastAPI that it is to be run asynchronously i.e. without blocking the current thread of execution. However, a path operation function can be defined without the **async** prefix also.

This decorated function returns a JSON response. Although it can return almost any of Python's objects, it will be automatically converted to JSON. Further in this tutorial, we shall see how such a function returns **Pydantic** model objects.

The URL's endpoint or path can have one or more variable parameters. They can be accepted by using Python's string formatting notation. In the above example URL <http://localhost:8000/hello/TutorialsPoint>, the last value may change in every client request. This variable parameter can be accepted in a variable as defined in the path and passed to the formal parameters defined in the function bound to the operation decorator.

Example

Add another path decorator with a variable parameter in the route, and bind **hello()** function to have name parameter. Modify the main.py as per the following.

```
import uvicorn
from fastapi import FastAPI
app = FastAPI()

@app.get("/")
async def index():
    return {"message": "Hello World"}

@app.get("/hello/{name}")
```

```
async def hello(name):  
    return {"name": name}
```

Start the Uvicorn server and visit <http://localhost:8000/hello/Tutorialspoint> URL. The browser shows the following JSON response.

```
{"name": "Tutorialspoint"}
```

Change the variable path parameter to something else such as <http://localhost:8000/hello/Python> so that the browser shows:

```
{"name": "Python"}
```

Check OpenAPI docs

Now if we check the OpenAPI documentation by entering the URL as <http://localhost:8000/docs>, it will show two routes and their respective view functions. Click the try out button below /hello/{name} button and give Tutorialspoint as the value of the name parameter's description and then click the Execute button.

The screenshot shows the FastAPI - Swagger UI interface. At the top, it displays "FastAPI - Swagger UI" and the URL "localhost:8000/docs#/default/hell...". Below this, the title "FastAPI" is shown with version "0.1.0" and "OAS3" status. A link to "/openapi.json" is also present.

The main section is titled "default". It lists two endpoints:

- GET / Index**
- GET /hello/{name} Hello**

For the second endpoint, a modal dialog is open, showing the parameter configuration:

| Name | Description |
|---------------------------|----------------|
| name * required (path) | Tutorialspoint |

Below the dialog is a large blue "Execute" button. The "Responses" section is partially visible below the dialog.

It will then show the **Curl** command, the **request URL** and the details of server's response with response body and response headers.

The screenshot shows the FastAPI Swagger UI interface. At the top, it says "FastAPI - Swagger UI". The URL in the address bar is "localhost:8000/docs#/default/hell...". The main content area is titled "Responses". It shows a "Curl" section with a code block:

```
curl -X 'GET' \
  'http://localhost:8000/hello/Tutorialspoint' \
  -H 'accept: application/json'
```

Below that is a "Request URL" section with the URL:

```
http://localhost:8000/hello/Tutorialspoint
```

Then there's a "Server response" section. It shows a table with two columns: "Code" and "Details". Under "Code", there's a row for "200". The "Details" column for "200" contains "Response body" with a JSON object:

```
{  
  "name": "Tutorialspoint"  
}
```

With "Edit" and "Download" buttons. Below that is "Response headers" with the following content:

```
content-length: 25  
content-type: application/json  
date: Tue, 10 May 2022 05:57:05 GMT  
server: uvicorn
```

At the bottom, there's another "Responses" section with a table for "200" status. The "Description" column says "Successful Response" and the "Links" column says "No links".

A route can have multiple parameters separated by "/" symbol.

```
from fastapi import FastAPI  
app = FastAPI()  
@app.get("/hello/{name}/{age}")  
async def hello(name,age):
```

```
return {"name": name, "age":age}
```

In this case, **/hello** is the route, followed by two parameters put in curly brackets. If the URL given in the browser's address bar is <http://localhost:8000/hello/Ravi/20>, The data of Ravi and 20 will be assigned to variables name and age respectively. The browser displays the following JSON response:

```
{"name":"Ravi","age":"20"}
```

Path Parameters with Types

You can use Python's type hints for the parameters of the function to be decorated. In this case, define name as str and age as int.

```
@app.get("/hello/{name}/{age}")
async def hello(name:str,age:int):
    return {"name": name, "age":age}
```

This will result in the browser displaying an HTTP error message in the JSON response if the types don't match. Try entering <http://localhost:8000/hello/20/Ravi> as the URL. The browser's response will be as follows:

```
{
  "detail": [
    {
      "loc": [
        "path",
        "age"
      ],
      "msg": "value is not a valid integer",
      "type": "type_error.integer"
    }
  ]
}
```

```
}
```

The reason is obvious as **age** being integer, can't accept a string value. This will also be reflected in the Swagger UI (OpenAPI) documentation.

The screenshot shows the FastAPI - Swagger UI interface at `localhost:8000/docs#/default/hello...`. The title bar indicates it's version 0.1.0 OAS3. The main section is titled "default". It lists a "GET / Index" operation. Below it is a detailed view of the "/hello/{name}/{age} Hello" operation. The "Parameters" table shows two required parameters: "name" (string, path) and "age" (integer, path). Both fields have input fields where "name" contains "name" and "age" contains "age". A "Try it out" button is visible to the right of the parameters table. The "Responses" section is currently collapsed.

9. FastAPI – Query Parameters

A classical method of passing the request data to the server is to append a query string to the URL. Assuming that a Python script (hello.py) on a server is executed as **CGI**, a list of key-value pairs concatenated by the ampersand (&) forms the query string, which is appended to the URL by putting a question mark (?) as a separator. For example:

<http://localhost/cgi-bin/hello.py?name=Ravi&age=20>

The trailing part of the URL, after (?), is the query string, which is then parsed by the server-side script for further processing.

As mentioned, the query string is a list of parameter=value pairs concatenated by & symbol. FastAPI automatically treats the part of the endpoint which is not a path parameter as a query string and parses it into parameters and its values. These parameters are passed to the function below the operation decorator.

Example

```
from fastapi import FastAPI  
  
app = FastAPI()  
  
@app.get("/hello")  
async def hello(name:str,age:int):  
    return {"name": name, "age":age}
```

Start the Uvicorn server and this URL in the browser:

<http://localhost:8000/hello?name=Ravi&age=20>

You should get the same JSON response. However, checking the tells you that FastAPI has detected that /hello endpoint has no path parameters, but query parameters.

The screenshot shows a browser window titled "FastAPI - Swagger UI" at the URL "localhost:8000/docs#/default/hello...". The main content is a "GET /hello Hello" operation. Below it, there's a "Parameters" section with two fields: "name" (string, query) and "age" (integer, query). A "Try it out" button is visible to the right of the parameters.

Click the **Try it out** button, enter "Ravi" and "20" as values, and press the **Execute** button. The documentation page now shows Curl command, request URL, and the body and headers of HTTP response.

The screenshot shows the FastAPI Swagger UI interface. At the top, it displays the URL `localhost:8000/docs#/default/hello...`. The main content area is titled "Responses". It includes sections for "Curl" (containing a command-line example), "Request URL" (containing the URL `http://localhost:8000/hello?name=Ravi&age=20`), and "Server response". The "Server response" section details a "200" status code. Under "Response body", there is a JSON object with fields "name" and "age". Below the JSON is a "Response headers" section listing "content-length", "content-type", "date", and "server". The "Responses" section at the bottom lists a "200" status code with a "Successful Response" description and a "No links" link.

Example

You can use Python's type hints for the parameters of the function to be decorated. In this case, define name as str and age as int.

```
from fastapi import FastAPI
app = FastAPI()
```

```
@app.get("/hello/{name}")
async def hello(name:str,age:int):
    return {"name": name, "age":age}
```

Try entering `http://localhost:8000/docs` as the URL. This will open the Swagger UI (OpenAPI) documentation. The parameter 'name' is a path parameter and 'age' is a query parameter.

The screenshot shows the FastAPI - Swagger UI interface. At the top, it displays the URL `localhost:8000/docs#/default/hell...`. Below this, there is a search bar with the text `/hello/{name} Hello`. A blue button labeled `GET` is next to the search bar. To the right of the search bar is a `Try it out` button. Underneath the search bar, there is a section titled `Parameters`. It contains two entries: `name` (string, path) and `age` (integer, query). Both fields have their respective values (`name` and `age`) entered into them. The entire interface is set against a dark background.

10. FastAPI – Parameter Validation

It is possible to apply **validation conditions** on path parameters as well as query parameters of the URL. In order to apply the validation conditions on a path parameter, you need to import the Path class. In addition to the default value of the parameter, you can specify the maximum and minimum length in the case of a string parameter.

```
from fastapi import FastAPI, Path
app = FastAPI()

@app.get("/hello/{name}")
async def hello(name:str=Path(...,min_length=3,
max_length=10)):
    return {"name": name}
```

If the browser's URL contains the parameter with a length less than 3 or more than 10, as in (<http://localhost:8000/hello/Tutorialspoint>), there will be an appropriate error message such as:

```
{
  "detail": [
    {
      "loc": [
        "path",
        "name"
      ],
      "msg": "ensure this value has at most 10 characters",
      "type": "value_error.any_str.max_length",
      "ctx": {
        "limit_value": 10
      }
}
```

```

    }
]
}

```

The OpenAPI docs also shows the validations applied:

The screenshot shows the FastAPI - Swagger UI interface. At the top, it displays the URL `localhost:8000/docs#/default/hell...`. Below this, the operation is defined as a `GET` request to `/hello/{name}` with the description "Hello". Under the "Parameters" section, there is a table with one row. The row has two columns: "Name" and "Description". The "Name" column contains "name * required" with a red asterisk. The "Description" column contains "string (path) maxLength: 10 minLength: 3". To the right of the table is a "Try it out" button.

Validation rules can be applied on numeric parameters too, using the operators as given below:

- **gt**: greater than
- **ge**: greater than or equal
- **lt**: less than
- **le**: less than or equal

Let us modify the above operation decorator to include age as a path parameter and apply the validations.

```

from fastapi import FastAPI, Path
app = FastAPI()
@app.get("/hello/{name}/{age}")

```

```
async def hello(*, name: str=Path(...,min_length=3 ,  
max_length=10), age: int = Path(..., ge=1, le=100)):  
    return {"name": name, "age":age}
```

In this case, validation rules are applied for both the parameters name and age. If the URL entered is <http://localhost:8000/hello/hi/110>, then the JSON response shows following explanations for validation failure:

```
{  
    "detail": [  
        {  
            "loc": [  
                "path",  
                "name"  
            ],  
            "msg": "ensure this value has at least 3 characters",  
            "type": "value_error.any_str.min_length",  
            "ctx": {  
                "limit_value": 3  
            }  
        },  
        {  
            "loc": [  
                "path",  
                "age"  
            ],  
            "msg": "ensure this value is less than or equal to 100",  
            "type": "value_error.number.not_le",  
            "ctx": {  
                "limit_value": 100  
            }  
        }  
    ]  
}
```

```

    }
]
}

```

The swagger UI documentation also identifies the constraints.

GET /hello/{name}/{age} Hello

Parameters

| Name | Description |
|------------------------|---|
| name * required | string (path) maxLength: 10 minLength: 3 |
| age * required | integer (path) maximum: 100 minimum: 1 |

Try it out

The query parameters can also have the validation rules applied to them. You have to specify them as the part of arguments of Query class constructor.

Let us add a query parameter called **percent** in the above function and apply the validation rules as **ge=0** (i.e., greater than or equal to 0) and **lt=100** (less than or equal to 100)

```
from fastapi import FastAPI, Path, Query

@app.get("/hello/{name}/{age}")

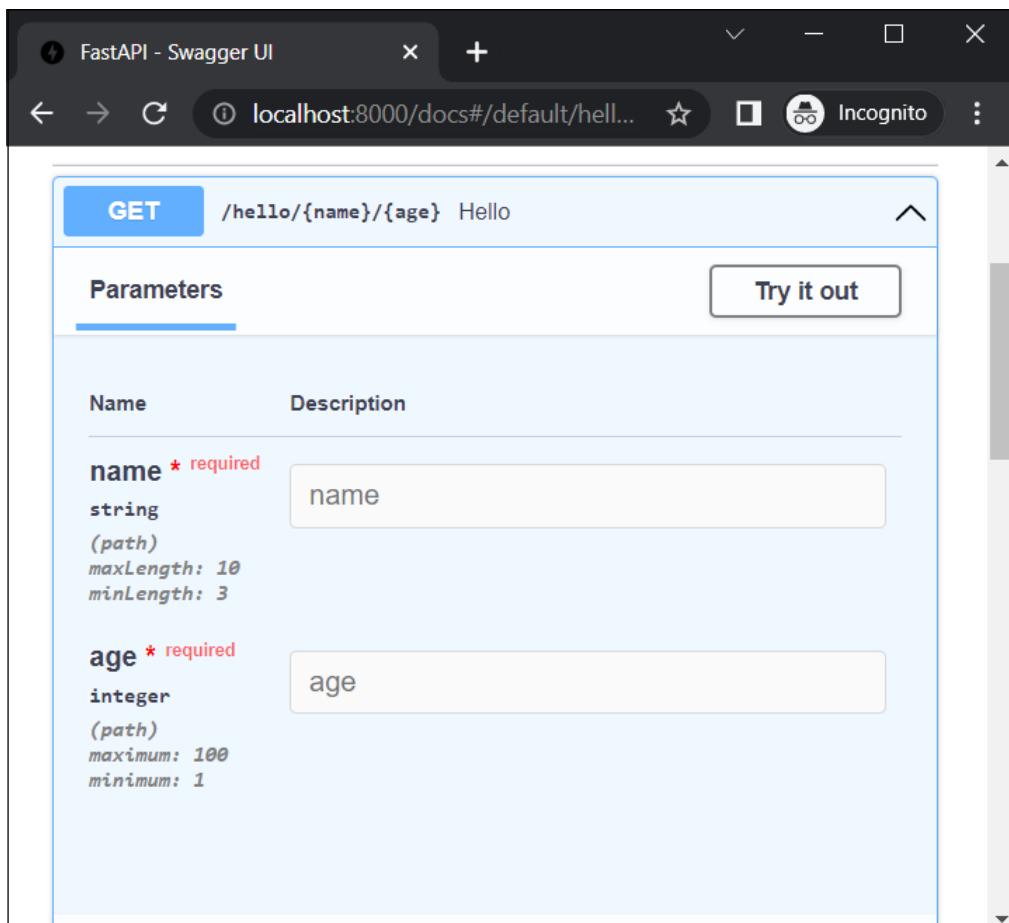
async def hello(*, name: str=Path(...,min_length=3 ,
max_length=10), \
                age: int = Path(..., ge=1, le=100), \
                percent:float=Query(..., ge=0, le=100)):

    return {"name": name, "age":age}
```

If the URL entered is <http://localhost:8000/hello/Ravi/20?percent=79>, then the browser displays following JSON response:

```
{"name": "Ravi", "age": 20}
```

FastAPI correctly identifies percent as a query parameter with validation conditions applied. It is reflected in the OpenAPI documentation as follows:



The screenshot shows the FastAPI - Swagger UI interface in a web browser. The URL is `localhost:8000/docs#/default/hello`. The page displays a **GET** method for the endpoint `/hello/{name}/{age}`. Below the method, there is a **Parameters** section. It contains two parameters: **name** (string, path, required) and **age** (integer, path, required). Each parameter has a description and a text input field. A **Try it out** button is located in the top right corner of the parameters section.

While the client can send the path and query parameters to the API server using GET method, we need to apply POST method to send some binary data as a part of the HTTP request. This binary data may be in the form of an object of any Python class. It forms the request body. FastAPI uses Pydantic library for this purpose.

11. FastAPI – Pydantic

Pydantic is a Python library for data parsing and validation. It uses the type hinting mechanism of the newer versions of Python (version 3.6 onwards) and validates the types during the runtime. Pydantic defines **BaseModel** class. It acts as the base class for creating user defined models.

Following code defines a Student class as a model based on BaseModel.

```
from typing import List
from pydantic import BaseModel

class Student(BaseModel):
    id: int
    name :str
    subjects: List[str] = []
```

The attributes of the **Student** class are declared with type hints. Note that the subjects attribute is of List type defined in typing module and of built-in list type.

We can populate an object of Student class with a dictionary with matching structure as follows:

```
>>> data = {
    'id': 1,
    'name': 'Ravikumar',
    'subjects': ["Eng", "Maths", "Sci"],
}
>>> s1=Student(**data)
>>> print (s1)
id=1 name='Ravikumar' subjects=['Eng', 'Maths', 'Sci']
>>> s1
Student(id=1, name='Ravikumar', subjects=['Eng', 'Maths', 'Sci'])
```

```
>>> s1.dict()
{'id': 1, 'name': 'Ravikumar', 'subjects': ['Eng', 'Maths', 'Sci']}
```

Pydantic will automatically get the data types converted whenever possible. For example, even if the id key in the dictionary is assigned a string representation of a number (such as '123'), it will coerce it into an integer. But whenever not possible, an exception will be raised.

```
>>> data = {
    'id': [1,2],
    'name': 'Ravikumar',
    'subjects': ["Eng", "Maths", "Sci"],
}
>>> s1=Student(**data)
Traceback (most recent call last):
  File "<pyshell#13>", line 1, in <module>
    s1=Student(**data)
  File "pydantic\main.py", line 406, in
pydantic.main.BaseModel.__init__
pydantic.error_wrappers.ValidationError: 1 validation error
for Student
  id
    value is not a valid integer (type=type_error.integer)
```

Pydantic also contains a Field class to declare metadata and validation rules for the model attributes. First modify the Student class to apply Field type on "name" attribute as follows:

```
from typing import List
from pydantic import BaseModel, Field

class Student(BaseModel):
    id: int
    name :str = Field(None, title="The description of the
item", max_length=10)
```

```
subjects: List[str] = []
```

Populate the data as shown below. The name here is exceeding the **max_length** stipulated. Pydantic throws **ValidationError** as expected.

```
>>> data = {
    'id': 1,
    'name': 'Ravikumar Sharma',
    'subjects': ["Eng", "Maths", "Sci"],
}
>>> s1=Student(**data)
Traceback (most recent call last):
  File "<pyshell#28>", line 1, in <module>
    s1=Student(**data)
  File "pydantic\main.py", line 406, in
pydantic.main.BaseModel.__init__
  pydantic.error_wrappers.ValidationError: 1 validation error
  for Student
    name
      ensure this value has at most 10 characters
      (type=value_error.any_str.max_length; limit_value=10)
```

Pydantic models can be used to map with ORM models like **SQLAlchemy** or **Peewee**.

12. FastAPI – Request Body

We shall now use the Pydantic model object as a request body of the client's request. As mentioned earlier, we need to use POST operation decorator for the purpose.

```
import uvicorn
from fastapi import FastAPI
from typing import List
from pydantic import BaseModel, Field
app = FastAPI()
class Student(BaseModel):
    id: int
    name :str = Field(None, title="name of student", max_length=10)
    subjects: List[str] = []

@app.post("/students/")
async def student_data(s1: Student):
    return s1
```

As it can be seen, the **student_data()** function is decorated by **@app.post()** decorator having the URL endpoint as "/students/". It receives an object of Student class as Body parameter from the client's request. To test this route, start the Uvicorn server and open the Swagger UI documentation in the browser by visiting <http://localhost:8000/docs>

The documentation identifies that "/students/" route is attached with **student_data()** function with POST method. Under the schemas section the Student model will be listed.

The screenshot shows a browser window titled "FastAPI - Swagger UI" with the URL "localhost:8000/docs". The main content area is titled "default". Below it, a green button labeled "POST" is followed by the endpoint "/students/ Student Data". To the right of the endpoint is a dropdown arrow. Below this, a section titled "Schemas" contains three expandable nodes: "HTTPValidationError >", "Student >", and "ValidationError >". Each node has an expand/collapse arrow at its end.

Expand the node in front of it to reveal the structure of the model

The screenshot shows the FastAPI Swagger UI interface. At the top, it displays the title "FastAPI - Swagger UI" and the URL "localhost:8000/docs". Below this, the main content area is titled "default". A green button labeled "POST" is highlighted, indicating the current operation. To its right, the endpoint path is shown as "/students/ Student Data".

Below the endpoint details, there is a section titled "Schemas". Under this section, there is a link labeled "HTTPValidationError >".

The most prominent part of the screenshot is the "Student" schema definition, which is expanded. It includes the following fields:

- id***: integer, title: Id
- name**: string, title: name of student, maxLength: 10
- subjects**: Subjects > [...]

The entire screenshot is framed by a dark border, and a vertical scrollbar is visible on the right side of the content area.

Click the **Try it out** button to fill in the test values in the request body.

The screenshot shows the FastAPI - Swagger UI interface in a browser window. The URL is `localhost:8000/docs#/default`. A green header bar indicates a **POST** method and the endpoint `/students/ Student Data`. Below this, under the **Parameters** section, it says "No parameters". In the **Request body** section, the type is set to `application/json`. A blue-bordered box displays a sample JSON object:

```
{  
    "id": 10,  
    "name": "Rajesh",  
    "subjects": ["Maths", "Science"]  
}
```

At the bottom of the interface is a large blue **Execute** button.

Click the **Execute** button and get the server's response values.

The screenshot shows the FastAPI Swagger UI interface. At the top, it says "Responses". Below that, under "Curl", is a code block for a POST request to the "/students/" endpoint. The "Request URL" is listed as "http://localhost:8000/students/". Under "Server response", there's a "Code" section with "Details" and a "200" status row. The "Response body" is a JSON object with fields: id: 10, name: "Rajesh", subjects: ["Maths", "Science"]. The "Response headers" include: content-length: 56, content-type: application/json, date: Wed, 29 Sep 2021 06:47:32 GMT, and server: uvicorn.

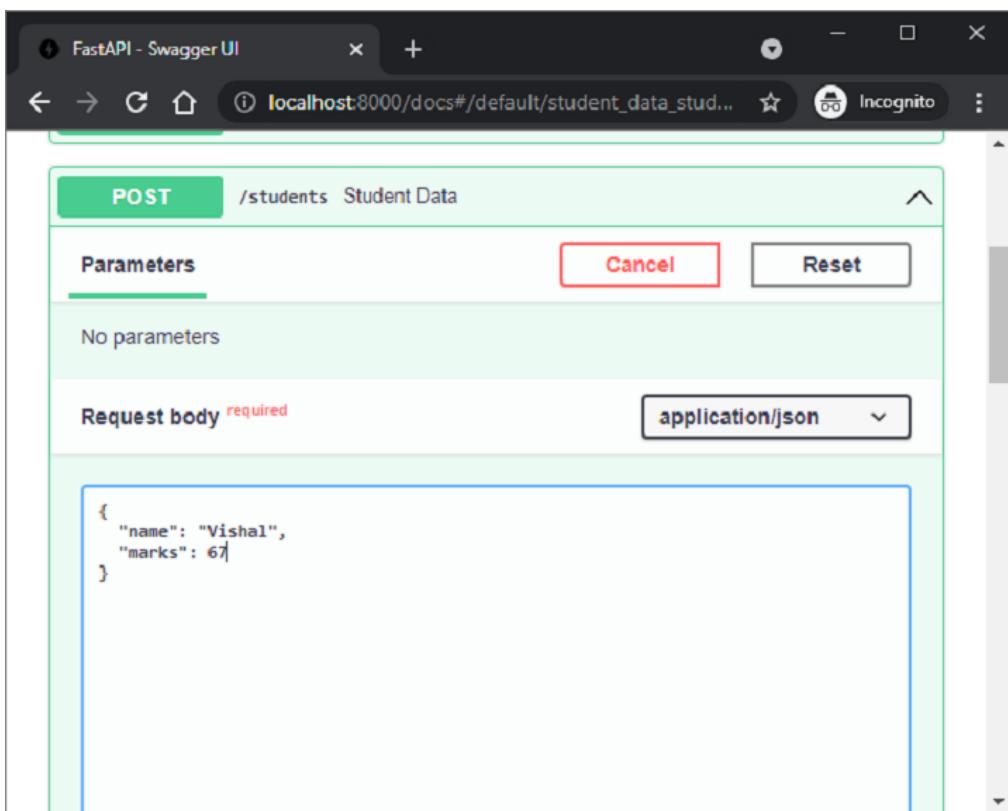
While a Pydantic model automatically populates the request body, it is also possible to use singular values to add attributes to it. For that purpose, we need to use Body class objects as the parameters of the operation function to be decorated.

First, we need to import Body class from **fastapi**. As shown in the following example, declare 'name' and 'marks' as the Body parameters in the definition of **student_data()** function below the **@app.post()** decorator.

```
import uvicorn
from fastapi import FastAPI, Body
```

```
@app.post("/students")
async def student_data(name:str=Body(...),
marks:int=Body(...)):
    return {"name":name,"marks": marks}
```

If we check the Swagger UI documentation, we should be able to find this POST method associated to `student_data()` function and having a request body with two parameters.



It is also possible to declare an operation function to have path and/or query parameters along with request body. Let us modify the `student_data()` function to have a path parameter 'college', 'age' as query parameter and a Student model object as body parameter.

```
@app.post("/students/{college}")
async def student_data(college:str, age:int, student:Student):
```

```
retval={"college":college, "age":age, **student.dict()}

return retval
```

The function adds values of college and age parameters along with the dictionary representation of Student object and returns it as a response. We can check the API documentation as follows:

The screenshot shows the FastAPI - Swagger UI interface. A POST request is selected for the endpoint `/students/{college}`. The "Parameters" section shows two fields: `college` (path, required, string type) and `age` (query, required, integer type). The "Request body" section is set to `application/json` and contains the following JSON example:

```
{ "id": 0, "name": "string", "subjects": [] }
```

As it can be seen, **college** is the path parameter, **age** is a query parameter, and the **Student** model is the request body.

13. FastAPI – Templates

By default, FastAPI renders a JSON response to the client. However, it can be cast to a HTML response. For this purpose, FastAPI has **HTMLResponse** class defined in **fastapi.responses** module. We need to add **response_class** as an additional parameter to operation decorator, with **HTMLResponse** object as its value.

In the following example, the `@app.get()` decorator has `"/hello/"` endpoint and the **HTMLResponse** as **response_class**. Inside the `hello()` function, we have a string representation of a HTML code of Hello World message. The string is returned in the form of HTML response.

```
from fastapi.responses import HTMLResponse
from fastapi import FastAPI
app = FastAPI()
@app.get("/hello/")
async def hello():
    ret='''  

<html>
<body>
<h2>Hello World!</h2>
</body>
</html>
...
    return HTMLResponse(content=ret)
```

On examining the API docs, it can be seen that the server's response body is in HTML.

The request URL (<http://localhost:8000/hello/>) should also render the message in the browser. However, rendering a raw HTML response is very tedious. Alternately, it is possible to render prebuilt HTML pages as templates. For that we need to use a web template library.

Web template library has a template engine that merges a static web page having place holder variables. Data from any source such as database is merged to dynamically generate and render the web page. FastAPI doesn't have any prepackaged template library. So one is free to use any one that suits his needs. In this tutorial, we shall be using **jinja2**, a very popular web template library. Let us install it first using pip installer.

```
pip3 install jinja2
```

FastAPI's support for Jinja templates comes in the form of **jinja2Templates** class defined in fastapi.templates module.

```
from fastapi.templating import Jinja2Templates
```

To declare a template object, the folder in which the html templates are stored, should be provided as parameter. Inside the current working directory, we shall create a '**templates**' directory.

```
templates = Jinja2Templates(directory="templates")
```

A simple web page '**hello.html**' to render Hello World message is also put in '**templates**' folder.

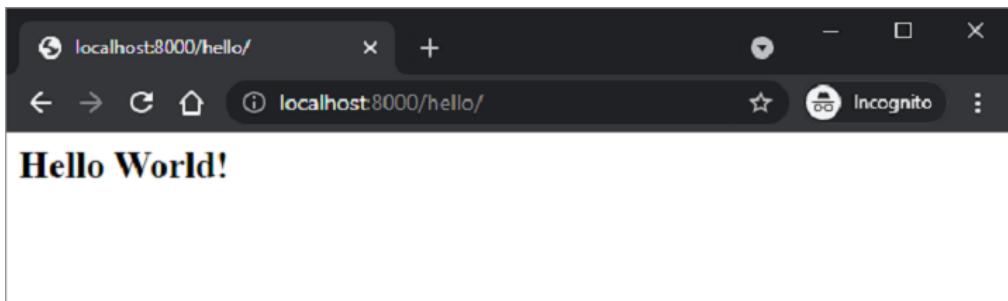
```
<html>
<body>
<h2>Hello World!</h2>
</body>
</html>
```

We are now going to render html code from this page as HTMLResponse. Let us modify the hello() function as follows:

```
from fastapi.responses import HTMLResponse
from fastapi.templating import Jinja2Templates
from fastapi import FastAPI, Request
app = FastAPI()
templates = Jinja2Templates(directory="templates")

@app.get("/hello/", response_class=HTMLResponse)
async def hello(request: Request):
    return templates.TemplateResponse("hello.html",
    {"request": request})
```

Here, **templateResponse()** method of template object collects the template code and the request context to render the http response. When we start the server and visit the <http://localhost:8000/hello/> URL, we get to see the **Hello World** message in the browser, which is in fact the output of **hello.html**



As mentioned earlier, jinja2 template allows certain place holders to be embedded in the HTML code. The jinja2 code elements are put inside the curly brackets. As soon as the HTML parser of the browser encounters this, the template engine takes over and populates these code elements by the variable data provided by the HTTP response. Jinja2 provides following code elements:

- **{% %}** – Statements
- **{{ }}** – Expressions to print to the template output
- **{# #}** – Comments which are not included in the template output
- **# # #** – Line statements

The **hello.html** is modified as below to display a dynamic message by substituting the name parameter.

```
<html>
<body>
<h2>Hello {{name}} Welcome to FastAPI</h2>
</body>
</html>
```

The operation function **hello()** is also modified to accept name as a path parameter. The **TemplateResponse** should also include the JSON representation of "**name":name**" along with the request context.

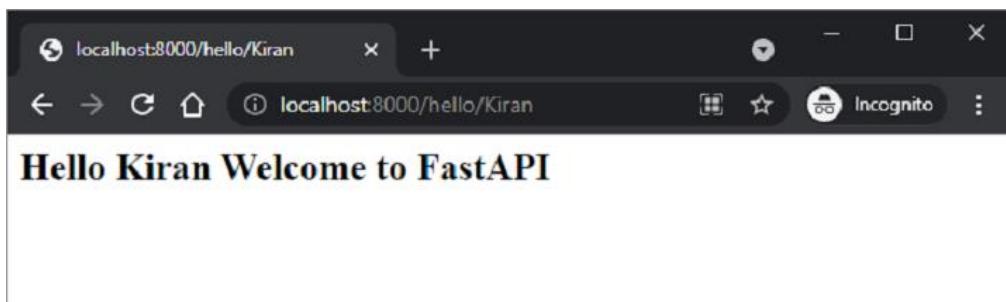
```
from fastapi.responses import HTMLResponse
from fastapi.templating import Jinja2Templates
from fastapi import FastAPI, Request
```

```
app = FastAPI()

templates = Jinja2Templates(directory="templates")

@app.get("/hello/{name}", response_class=HTMLResponse)
async def hello(request: Request, name:str):
    return templates.TemplateResponse("hello.html",
    {"request": request, "name":name})
```

Restart the server and go to <http://localhost:8000/hello/Kiran>. The browser now fills the jinja2 place holder with the path parameter in this URL.



14. FastAPI – Static Files

Often it is required to include in the template response some resources that remain unchanged even if there is a certain dynamic data. Such resources are called static assets. Media files (.png, .jpg etc), JavaScript files to be used for executing some front end code, or stylesheets for formatting HTML (.CSS files) are the examples of static files.

In order to handle static files, you need a library called **aiofiles**

```
pip3 install aiofiles
```

Next, import **StaticFiles** class from the **fastapi.staticfiles** module. Its object is one of the parameters for the **mount()** method of the FastAPI application object to assign "static" subfolder in the current application folder to store and serve all the static assets of the application.

```
app.mount(app.mount("/static",
StaticFiles(directory="static"), name="static")
```

Example

In the following example, FastAPI logo is to be rendered in the hello.html template. Hence, "fa-logo.png" file is first placed in static folder. It is now available for using as **src** attribute of **** tag in HTML code.

```
from fastapi import FastAPI, Request
from fastapi.responses import HTMLResponse
from fastapi.templating import Jinja2Templates
from fastapi.staticfiles import StaticFiles

app = FastAPI()

templates = Jinja2Templates(directory="templates")

app.mount("/static", StaticFiles(directory="static"),
name="static")
```

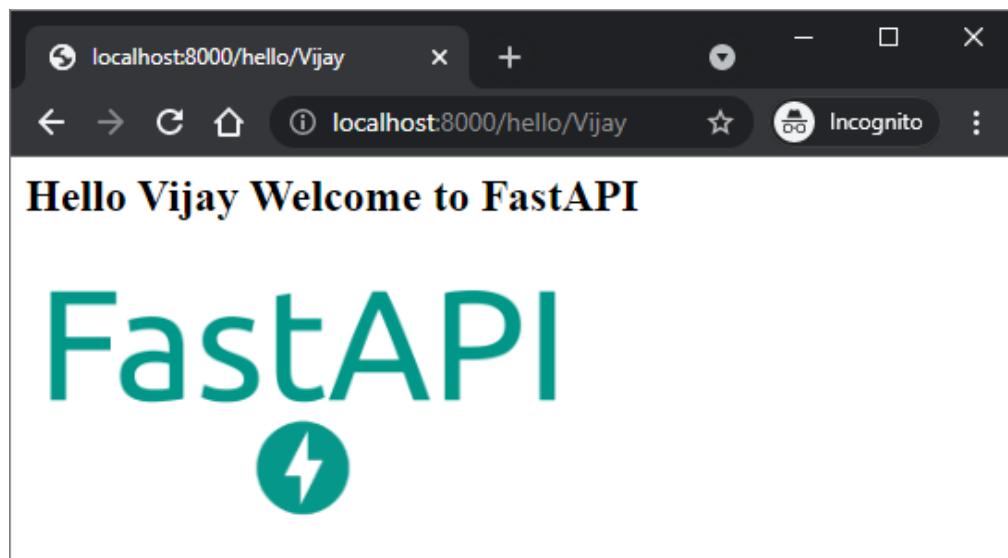
```
@app.get("/hello/{name}", response_class=HTMLResponse)
async def hello(request: Request, name:str):
    return templates.TemplateResponse("hello.html",
    {"request": request, "name":name})
```

The HTML code of **\templates\hello.html** is as follows:

```
<html>
<body>
<h2>Hello {{name}} Welcome to FastAPI</h2>

</body>
</html>
```

Run the Uvicorn server and visit the URL as <http://localhost:8000/hello/Vijay>. The Logo appears in the browser window as shown.



Example

Here is another example of a static file. A JavaScript code `hello.js` contains a definition of `myfunction()` to be executed on the `onload` event in following HTML script (`\templates\hello.html`)

```
<html>
  <head>
    <title>My Website</title>
    <script src="{{ url_for('static', path='hello.js') }}></script>
  </head>
  <body onload="myFunction()">
    <div id="time" style="text-align:right; width=100%"></div>
    <h1><div id="ttl">{{ name }}</div></h1>
  </body>
</html>
```

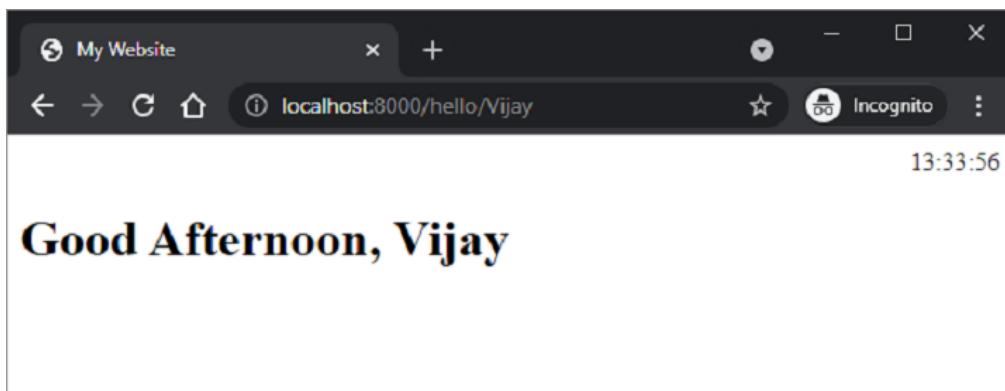
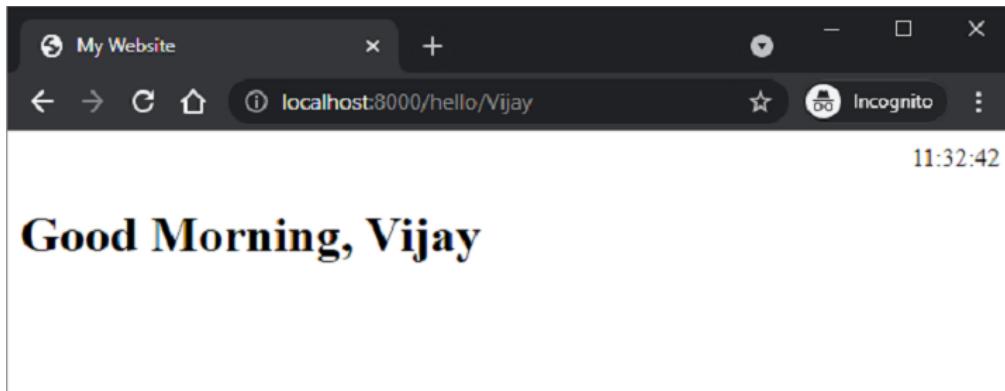
The `hello.js` code is as follows: (`\static\hello.js`)

```
function myFunction() {
  var today = new Date();
  var h = today.getHours();
  var m = today.getMinutes();
  var s = today.getSeconds();
  var msg="";
  if (h<12)
  {
    msg="Good Morning, ";
  }
  if (h>=12 && h<18)
  {
    msg="Good Afternoon, ";
  }
  if (h>=18)
  {
```

```
    msg="Good Evening, ";  
}  
  
var x=document.getElementById('ttl').innerHTML;  
document.getElementById('ttl').innerHTML = msg+x;  
document.getElementById('time').innerHTML = h + ":" + m +  
":" + s;  
}
```

The function detects the value of current time and assigns appropriate value to **msg** variable (good morning, good afternoon or good evening) depending on the time of the day.

Save **/static/hello.js**, modify **\templates\hello.html** and restart the server. The browser should show the current time and corresponding message below it.



15. FastAPI – HTML Form Templates

Let us add another route "**/login**" to our application which renders a html template having a simple login form. The HTML code for login page is as follows:

```
<html>
  <body>
    <form action="/submit" method="POST">
      <h3>Enter User name</h3>
      <p><input type='text' name='nm' /></p>
      <h3>Enter Password</h3>
      <p><input type='password' name='pwd' /></p>
      <p><input type='submit' value='Login' /></p>
    </form>
  </body>
</html>
```

Note that the action parameter is set to "/submit" route and action set to POST. This will be significant for further discussion.

Add **login()** function in the **main.py** file as under:

```
@app.get("/login/", response_class=HTMLResponse)
async def login(request: Request):
    return templates.TemplateResponse("login.html",
    {"request": request})
```

The URL <http://localhost:8000/login> will render the login form as follows:

A screenshot of a web browser window titled "localhost:8000/login/". The page displays a login form with two text input fields labeled "Enter User name" and "Enter Password", and a "Login" button.

Enter User name

Enter Password

Login

16. FastAPI – Accessing Form Data

Now we shall see how the HTML form data can be accessed in a FastAPI operation function. In the above example, the /login route renders a login form. The data entered by the user is submitted to **/submit** URL with POST as the request method. Now we have to provide a view function to process the data submitted by the user.

FastAPI has a Form class to process the data received as a request by submitting an HTML form. However, you need to install the **python-multipart** module. It is a streaming multipart form parser for Python.

```
pip3 install python-multipart
```

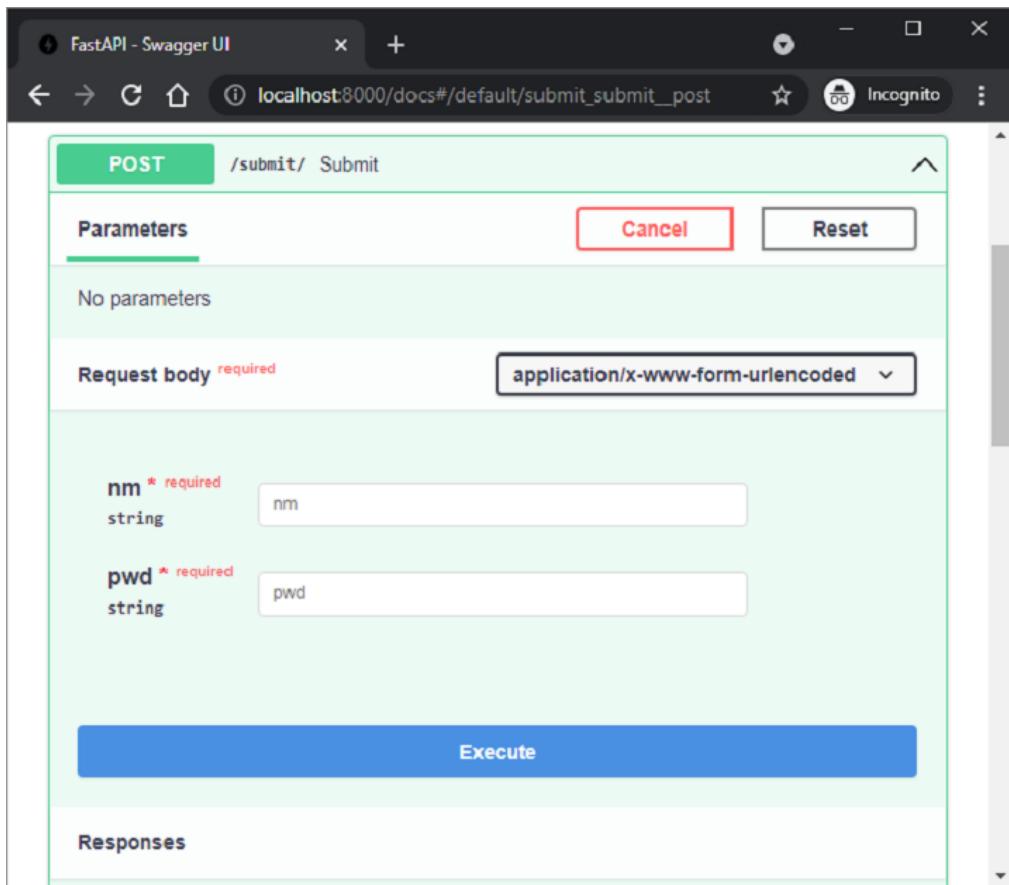
Add **Form** class to the imported resources from FastAPI

```
from fastapi import Form
```

Let us define a **submit()** function to be decorated by `@app.post()`. In order to receive the form data, declare two parameters of Form type, having the same name as the form attributes.

```
@app.post("/submit/")
async def submit(nm: str = Form(...), pwd: str = Form(...)):
    return {"username": nm}
```

Press submit after filling the text fields. The browser is redirected to /submit URL and the JSON response is rendered. Check the Swagger API docs of the **/submit** route. It correctly identifies **nm** and **pwd** as the request body parameters and the form's "media type" as **application/x-www-form-urlencoded**.



It is even possible to populate and return Pydantic model with HTML form data. In the following code, we declare User class as a Pydantic model and send its object as the server' response.

```
from pydantic import BaseModel  
  
class User(BaseModel):  
    username:str  
    password:str  
  
    @app.post("/submit/", response_model=User)  
    async def submit(nm: str = Form(...), pwd: str = Form(...)):  
        return User(username=nm, password=pwd)
```

17. FastAPI – Uploading Files

First of all, to send a file to the server you need to use the HTML form's **enctype** as **multipart/form-data**, and use the input type as the file to render a button, which when clicked allows you to select a file from the file system.

```
<html>
  <body>
    <form action="http://localhost:8000/uploader"
method="POST" enctype="multipart/form-data">
      <input type="file" name="file" />
      <input type="submit"/>
    </form>
  </body>
</html>
```

Note that the form's action parameter to the endpoint <http://localhost:8000/uploader> and the method is set to POST.

This HTML form is rendered as a template with following code:

```
from fastapi import FastAPI, File, UploadFile, Request
import uvicorn
import shutil

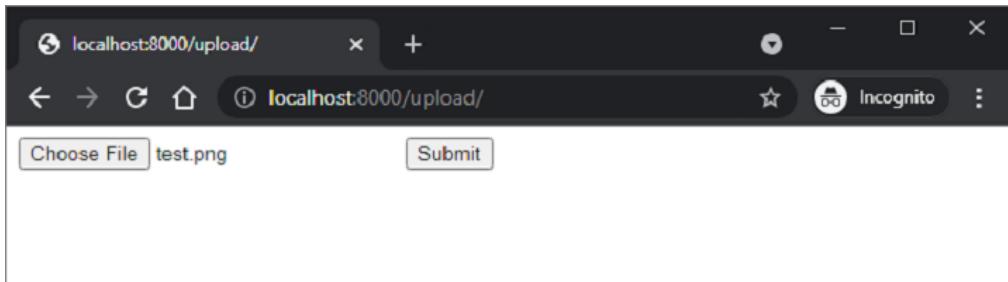
from fastapi.responses import HTMLResponse
from fastapi.templating import Jinja2Templates

app = FastAPI()

templates = Jinja2Templates(directory="templates")
```

```
@app.get("/upload/", response_class=HTMLResponse)
async def upload(request: Request):
    return templates.TemplateResponse("uploadfile.html",
    {"request": request})
```

Visit <http://localhost:8000/upload/>. You should get the form with **Choose File** button. Click it to open the file to be uploaded.



The upload operation is handled by **UploadFile** function in FastAPI

```
from fastapi import FastAPI, File, UploadFile
import shutil

@app.post("/uploader/")
async def create_upload_file(file: UploadFile = File(...)):
    with open("destination.png", "wb") as buffer:
        shutil.copyfileobj(file.file, buffer)

    return {"filename": file.filename}
```

We shall use **shutil** library in Python to copy the received file in the server location by the name **destination.png**

18. FastAPI – Cookie Parameters

A **cookie** is one of the HTTP headers. The web server sends a response to the client, in addition to the data requested, it also inserts one or more cookies. A **cookie** is a very small amount of data, that is stored in the client's machine. On subsequent connection requests from the same client, this cookie data is also attached along with the HTTP requests.

The cookies are useful for recording information about client's browsing. Cookies are a reliable method of retrieving stateful information in otherwise stateless communication by HTTP protocol.

In FastAPI, the cookie parameter is set on the response object with the help of **set_cookie()** method

```
response.set_cookie(key, value)
```

Example

Here is an example of **set_cookie()** method. We have a JSON response object called content. Call the **set_cookie()** method on it to set a cookie as **key="username"** and **value="admin"**:

```
from fastapi import FastAPI
from fastapi.responses import JSONResponse

app = FastAPI()

@app.post("/cookie/")
def create_cookie():
    content = {"message": "cookie set"}
    response = JSONResponse(content=content)
    response.set_cookie(key="username", value="admin")
    return response
```

To read back the cookie on a subsequent visit, use the **Cookie** object in the FastAPI library.

```
from fastapi import FastAPI, Cookie
app = FastAPI()
@app.get("/readcookie/")
async def read_cookie(username: str = Cookie(None)):
    return {"username": username}
```

Inspect these two endpoints in the Swagger API. There are these two routes **"/cookies"** and **"readcookie"**. Execute the **create_cookie()** function bound to **"/cookies"**. The response is just the content, although the cookie is set.

The screenshot shows the FastAPI - Swagger UI interface. At the top, it displays the URL `localhost:8000/docs#/default/create_cookie_coo...`. The main area is focused on the `/cookie/ Create Cookie` endpoint, which is a `POST` method. The **Parameters** section indicates "No parameters". Below this are **Execute** and **Clear** buttons. The **Responses** section includes a **Curl** command:

```
curl -X 'POST' \
  'http://localhost:8000/cookie/' \
  -H 'accept: application/json' \
  -d ''
```

It also shows the **Request URL** as `http://localhost:8000/cookie/`. Under the **Server response** section, for **Code 200**, the **Response body** is shown as:

```
{
  "message": "cookie set"
}
```

With **Copy** and **Download** buttons next to it.

When the **read_cookie()** function is executed, the cookie is read back and appears as the response. Also, note that the documentation identifies the user name as a cookie parameter.

GET /readcookie/ Read Cookie

Parameters

| Name | Description |
|----------|--------------------------------|
| username | username string (cookie) |

Responses

Curl

```
curl -X 'GET' \
'http://localhost:8000/readcookie/' \
-H 'accept: application/json'
```

Request URL

```
http://localhost:8000/readcookie/
```

Server response

Code Details

200 Response body

```
{ "username": "admin" }
```

Download

Response headers

```
content-length: 20
content-type: application/json
date: Tue, 02 Nov 2021 13:06:48 GMT
```

19. FastAPI – Header Parameters

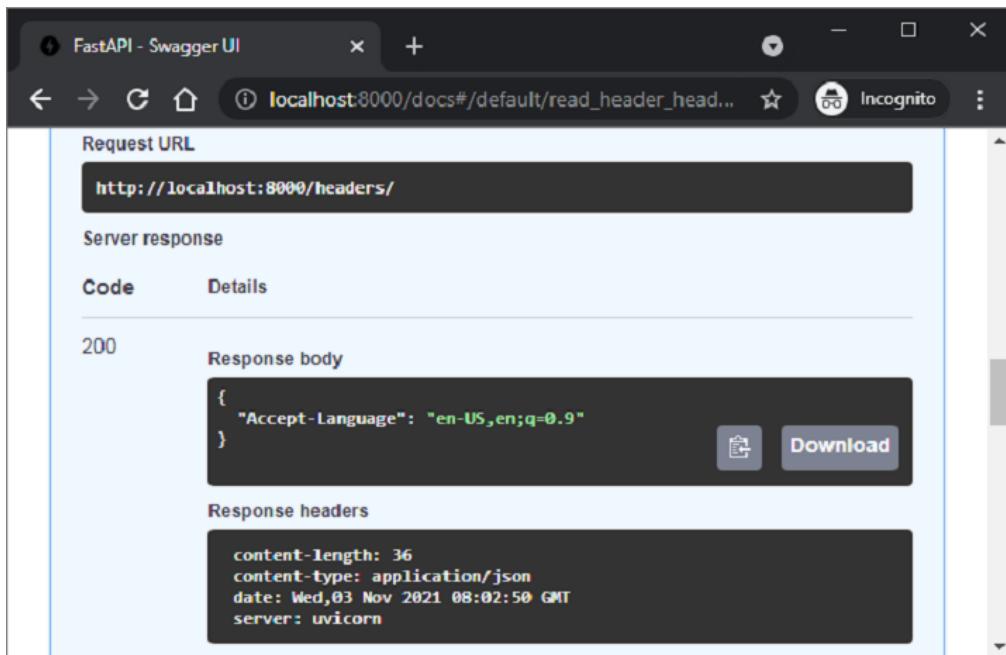
In order to read the values of an **HTTP header** that is a part of the client request, import the Header object from the FastAPI library, and declare a parameter of Header type in the operation function definition. The name of the parameter should match with the HTTP header converted in **camel_case**.

In the following example, the "accept-language" header is to be retrieved. Since Python doesn't allow "-" (dash) in the name of identifier, it is replaced by "_" (underscore)

```
from typing import Optional
from fastapi import FastAPI, Header

app = FastAPI()
@app.get("/headers/")
async def read_header(accept_language: Optional[str] = Header(None)):
    return {"Accept-Language": accept_language}
```

As the following Swagger documentation shows, the retrieved header is shown as the response body.

A screenshot of a web browser window titled "FastAPI - Swagger UI". The URL bar shows "localhost:8000/docs#/default/read_header_head...". The main content area displays a "Request URL" of "http://localhost:8000/headers/". Below it, a "Server response" section shows a "Code" of 200 and "Details". The "Response body" contains a JSON object: { "Accept-Language": "en-US,en;q=0.9" }. There are "Copy" and "Download" buttons next to it. The "Response headers" section lists: content-length: 36, content-type: application/json, date: Wed,03 Nov 2021 08:02:50 GMT, and server: uvicorn.

You can push custom as well as predefined headers in the response object. The operation function should have a parameter of **Response** type. In order to set a custom header, its name should be prefixed with "X". In the following case, a custom header called "X-Web-Framework" and a predefined header "Content-Language" is added along with the response of the operation function.

```
from fastapi import FastAPI
from fastapi.responses import JSONResponse

app = FastAPI()

@app.get("/rspheader/")
def set_rsp_headers():
    content = {"message": "Hello World"}
    headers = {"X-Web-Framework": "FastAPI", "Content-Language": "en-US"}
    return JSONResponse(content=content, headers=headers)
```

The newly added headers will appear in the response header section of the documentation.

The screenshot shows the FastAPI Swagger UI interface. At the top, the URL is `localhost:8000/docs#/default/set_rsp_headers_rs...`. The request URL is `http://localhost:8000/rspheader/`. The response code is 200, labeled "Response body". The JSON content is:

```
{  "message": "Hello World"}
```

With "Download" and "Copy" buttons. Below that, the "Response headers" section lists:

```
content-language: en-US
content-length: 25
content-type: application/json
date: Wed,03 Nov 2021 08:13:27 GMT
server: uvicorn
x-web-framework: FastAPI
```

20. FastAPI – Response Model

An operation function returns A JSON response to the client. The response can be in the form of Python primary types, i.e., numbers, string, list or dict, etc. It can also be in the form of a Pydantic model. For a function to return a model object, the operation decorator should declare a **response_model** parameter.

With the help of `response_model`, FastAPI Converts the output data to a structure of a model class. It validates the data, adds a JSON Schema for the response, in the OpenAPI path operation.

One of the important advantages of `response_model` parameter is that we can format the output by selecting the fields from the model to cast the response to an output model.

Example

In the following example, the POST operation decorator receives the request body in the form of an object of the student class (a subclass of `BaseModel`). As one of the fields in this class, i.e. `marks` (a list of marks) is not needed in the response, we define another model called `percent` and use it as the `response_model` parameter.

```
from typing import List
from fastapi import FastAPI
from pydantic import BaseModel, Field

app = FastAPI()

class student(BaseModel):
    id: int
    name :str = Field(None, title="name of student", max_length=10)
    marks: List[int] = []
    percent_marks: float

class percent(BaseModel):
```

```

id:int

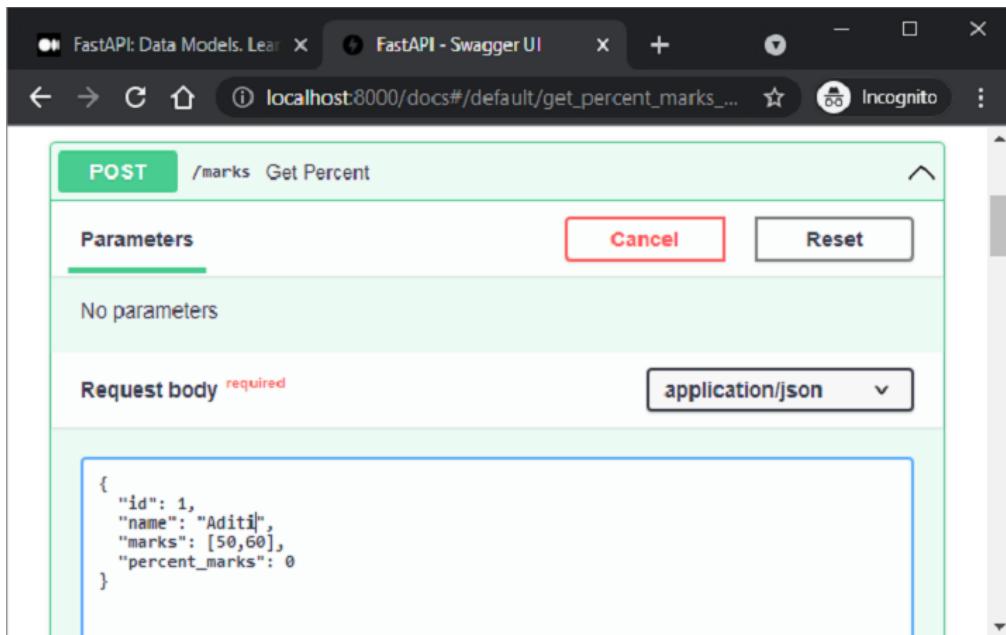
name :str = Field(None, title="name of student", max_length=10)

percent_marks: float

@app.post("/marks", response_model=percent)
async def get_percent(s1:student):
    s1.percent_marks=sum(s1.marks)/2
    return s1

```

If we check the Swagger documentation, it shows that the "/marks" route gets an object of student class as the request body. Populate the attributes with appropriate values and execute the **get_percent()** function.



The server response is cast to the percent class as it has been used as the response_model.

The screenshot shows a browser window with the title "FastAPI - Swagger UI". The URL in the address bar is "localhost:8000/docs#/default/get_percent_marks...". The page displays the following information:

- Curl**: A code block containing a curl command to post data to the /marks endpoint:

```
curl -X 'POST' \
  'http://localhost:8000/marks' \
  -H 'accept: application/json' \
  -H 'Content-Type: application/json' \
  -d '{'
  "id": 1,
  "name": "string",
  "marks": [50,60],
  "percent_marks": 0
}'
```
- Request URL**: A text input field containing "http://localhost:8000/marks".
- Server response**: A table with two columns: "Code" and "Details".

| Code | Details |
|------|--|
| 200 | Response body <pre>{ "id": 1, "name": "string", "percent_marks": 55 }</pre> Copy Download |

21. FastAPI – Nested Models

Each attribute of a **Pydantic** model has a type. The type can be a built-in Python type or a model itself. Hence it is possible to declare nested JSON "objects" with specific attribute names, types, and validations.

Example

In the following example, we construct a customer model with one of the attributes as product model class. The product model in turn has an attribute of supplier class.

```
from typing import Tuple
from fastapi import FastAPI
from pydantic import BaseModel
app = FastAPI()

class supplier(BaseModel):
    supplierID:int
    supplierName:str

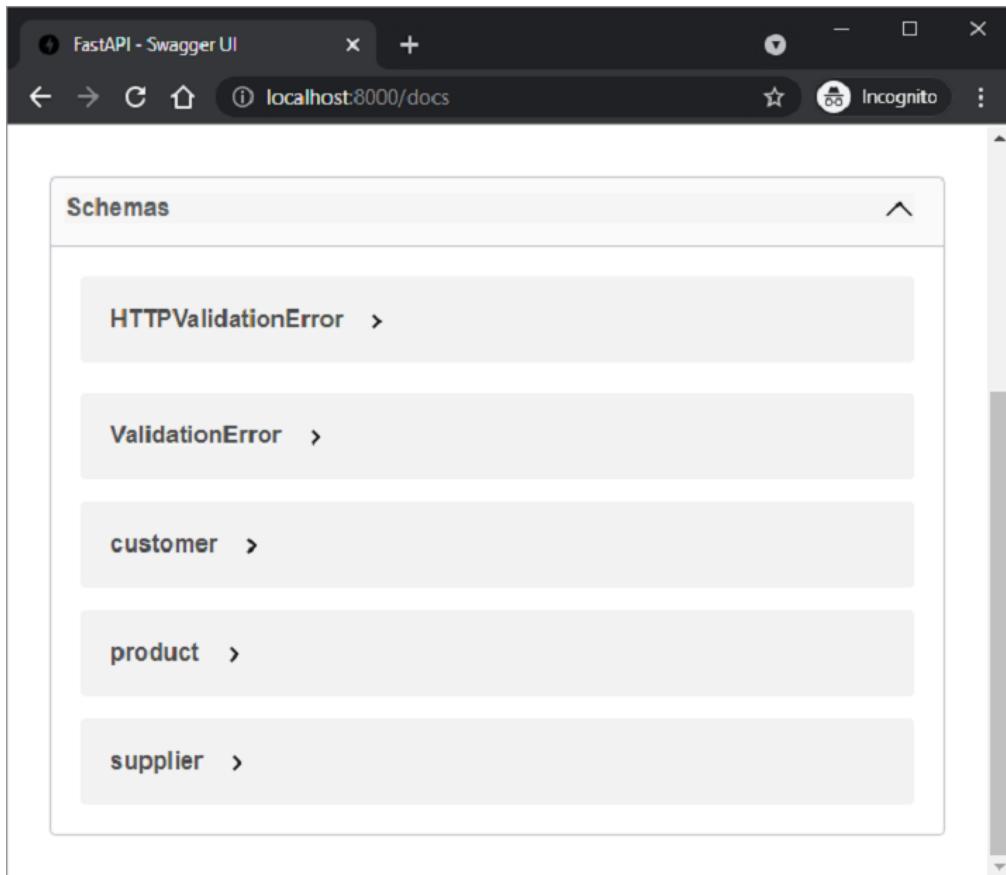
class product(BaseModel):
    productID:int
    prodname:str
    price:int
    supp:supplier

class customer(BaseModel):
    custID:int
    custname:str
    prod:Tuple[product]
```

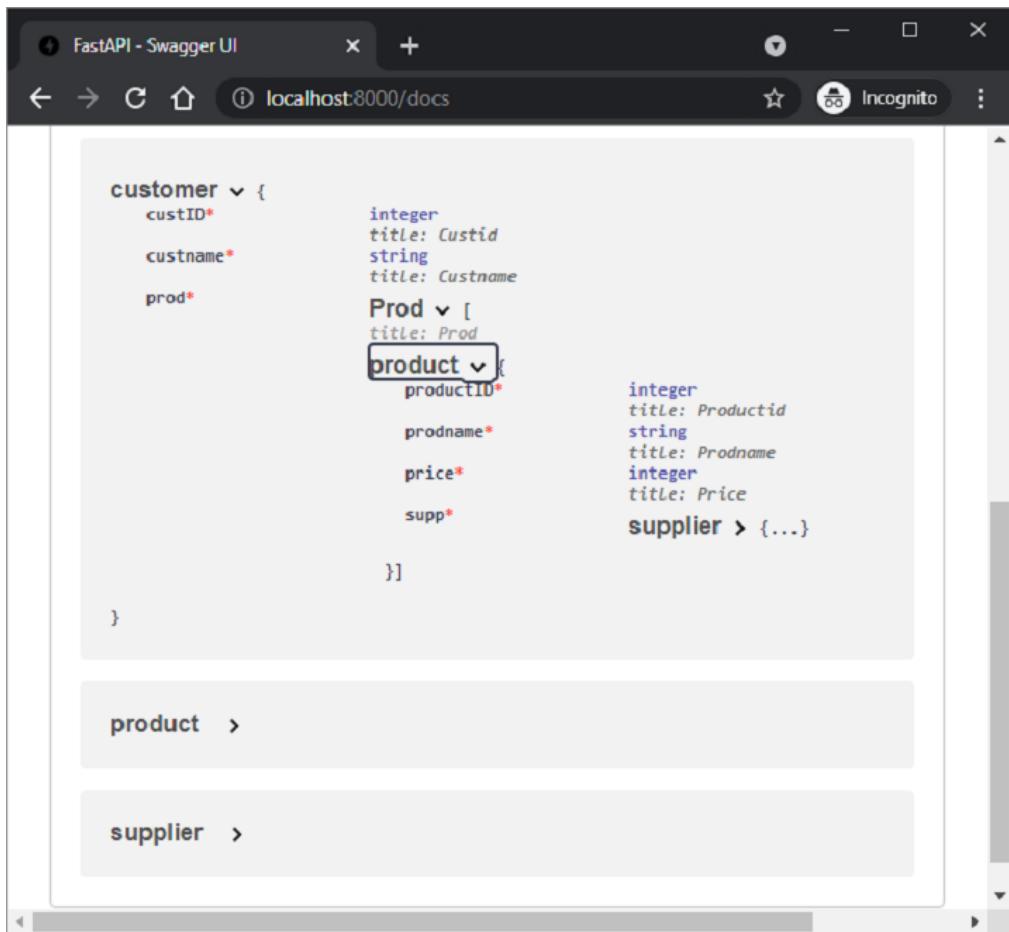
The following POST operation decorator renders the object of the customer model as the server response.

```
@app.post('/invoice')
async def getInvoice(c1:customer):
    return c1
```

The swagger UI page reveals the presence of three schemas, corresponding to three BaseModel classes.



The Customer schema when expanded to show all the nodes looks like this:



An example response of "**/invoice**" route should be as follows:

```
{  
    "custID": 1,  
    "custname": "Jay",  
    "prod": [  
        {  
            "productID": 1,  
            "prodname": "LAPTOP",  
            "price": 40000,  
            "supp": {  
                "supplierID": 1,  
                "supplierName": "Dell"  
            }  
        }  
    ]  
}
```

```
    }  
}  
]  
}
```

22. FastAPI – Dependencies

The built-in dependency injection system of FastAPI makes it possible to integrate components easier when building your API. In programming, **Dependency injection** refers to the mechanism where an object receives other objects that it depends on. The other objects are called dependencies. Dependency injection has the following advantages:

- reuse the same shared logic
- share database connections
- enforce authentication and security features

Assuming that a FastAPI app has two operation functions both having the same query parameters id, name and age.

```
from fastapi import FastAPI
app = FastAPI()

@app.get("/user/")
async def user(id: str, name: str, age: int):
    return {"id": id, "name": name, "age": age}

@app.get("/admin/")
async def admin(id: str, name: str, age: int):
    return {"id": id, "name": name, "age": age}
```

In case of any changes such as adding/removing query parameters, both the route decorators and functions need to be changed.

FastAPI provides **Depends** class and its object is used as a common parameter in such cases. First import **Depends** from FastAPI and define a function to receive these parameters:

```
async def dependency(id: str, name: str, age: int):
    return {"id": id, "name": name, "age": age}
```

Now we can use the return value of this function as a parameter in operation functions

```
@app.get("/user/")
async def user(dep: dict = Depends(dependency)):
    return dep
```

For each new Request, FastAPI calls the dependency function using the corresponding parameters, returns the result, and assigns the result to your operation.

You can use a class for managing dependencies instead of a function. Declare a class with id, name and age as attributes.

```
class dependency:
    def __init__(self, id: str, name: str, age: int):
        self.id = id
        self.name = name
        self.age = age
```

Use this class as the type of parameters.

```
@app.get("/user/")
async def user(dep: dependency = Depends(dependency)):
    return dep

@app.get("/admin/")
async def admin(dep: dependency = Depends(dependency)):
    return dep
```

Here, we used the dependency injection in the operation function. It can also be used as operation decoration. For example, we want to check if the value of query parameter age is less than 21. If yes it should throw an exception. So, we write a function to check it and use it as a dependency.

```
async def validate(dep: dependency = Depends(dependency)):  
    if dep.age < 18:  
        raise HTTPException(status_code=400, detail="You are  
not eligible")  
@app.get("/user/", dependencies=[Depends(validate)])  
async def user():  
    return {"message": "You are eligible"}
```

In FastAPI dependency management, you can use yield instead of return to add some extra steps. For example, the following function uses database dependency with yield.

```
async def get_db():  
    db = DBSession()  
    try:  
        yield db  
    finally:  
        db.close()
```

23. FastAPI – CORS

Cross-Origin Resource Sharing (CORS) is a situation when a frontend application that is running on one client browser tries to communicate with a backend through JavaScript code, and the backend is in a different "origin" than the frontend. The origin here is a combination of protocol, domain name, and port numbers. As a result, <http://localhost> and <https://localhost> have different origins.

If the browser with a URL of one origin sends a request for the execution of JavaScript code from another origin, the browser sends an **OPTIONS** HTTP request.

If the backend authorizes the communication from this different origin by sending the appropriate headers it will let the JavaScript in the frontend send its request to the backend. For that, the backend must have a list of "allowed origins".

To specify explicitly the allowed origins, import **CORSMiddleware** and add the list of origins to the app's middleware.

```
from fastapi import FastAPI  
from fastapi.middleware.cors import CORSMiddleware  
  
app = FastAPI()  
  
origins = [  
    "http://192.168.211.:8000",  
    "http://localhost",  
    "http://localhost:8080",  
]  
  
app.add_middleware(  
    CORSMiddleware,  
    allow_origins=origins,
```

```
allow_credentials=True,  
allow_methods=["*"],  
allow_headers=["*"],  
)  
  
@app.get("/")  
async def main():  
    return {"message": "Hello World"}
```

24. FastAPI – CRUD Operations

The REST architecture uses HTTP verbs or methods for the operation on the resources. The POST, GET, PUT and DELETE methods perform respectively CREATE, READ, UPDATE and DELETE operations respectively.

In the following example, we shall use a Python list as an in-memory database and perform the CRUD operations on it. First, let us set up a FastAPI app object and declare a Pydantic model called **Book**.

```
from fastapi import FastAPI
from pydantic import BaseModel

app = FastAPI()

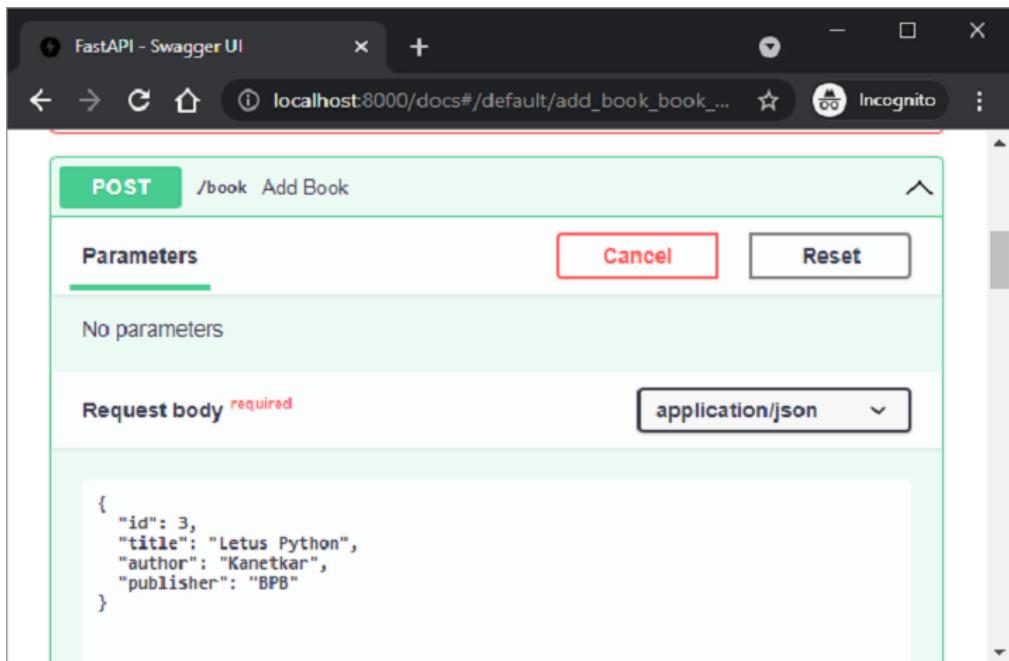
data = []

class Book(BaseModel):
    id: int
    title: str
    author: str
    publisher: str
```

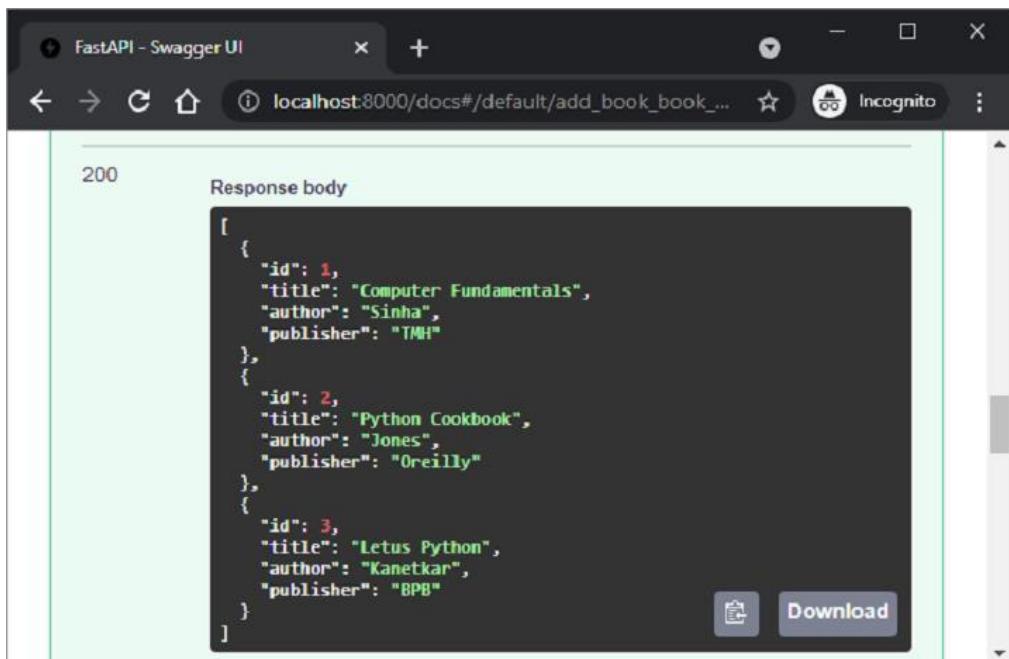
An object of this model is populated using the **@app.post()** decorator and it is appended to the list of books (data is declared for the list of books)

```
@app.post("/book")
def add_book(book: Book):
    data.append(book.dict())
    return data
```

In the Swagger UI, execute this operation function a couple of times and add some data.



The server's JSON response shows the list of books added so far.



To retrieve the list, define an operation function bound to the `@app.get()` decorator as follows:

```
@app.get("/list")
def get_books():
    return data
```

To retrieve a book with its id as a path parameter, define the get() operation decorator and get_book() function as below:

```
@app.get("/book/{id}")
def get_book(id: int):
    id = id - 1
    return data[id]
```

The **/list** route retrieves all the books.

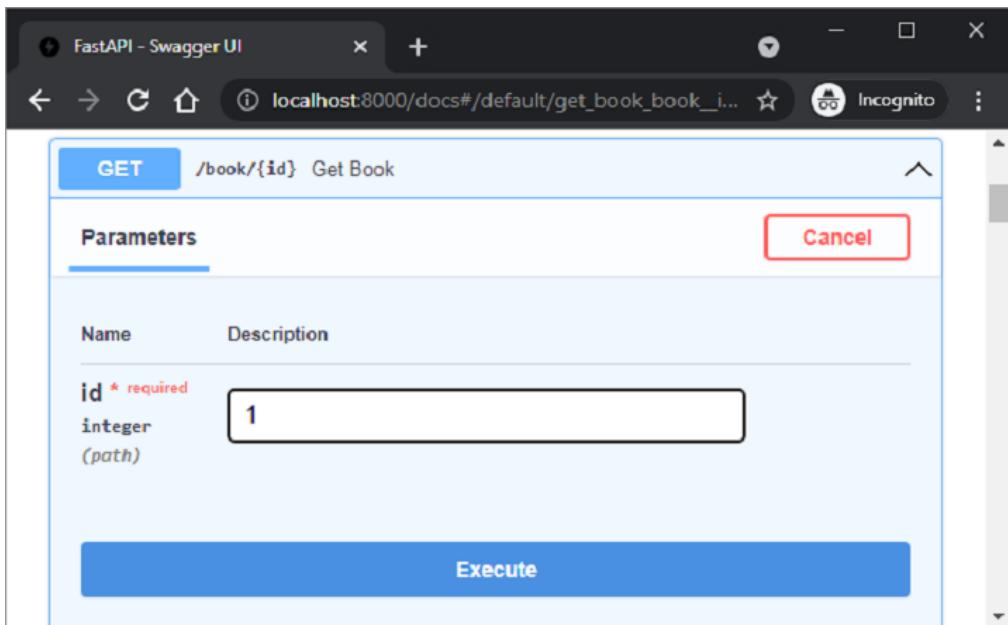
The screenshot shows the FastAPI Swagger UI interface. At the top, it says "FastAPI - Swagger UI". Below that, the URL is "localhost:8000/docs#/default/get_books_list_get".
Curl: A code block containing a curl command:

```
curl -X 'GET' \
'http://localhost:8000/list' \
-H 'accept: application/json'
```

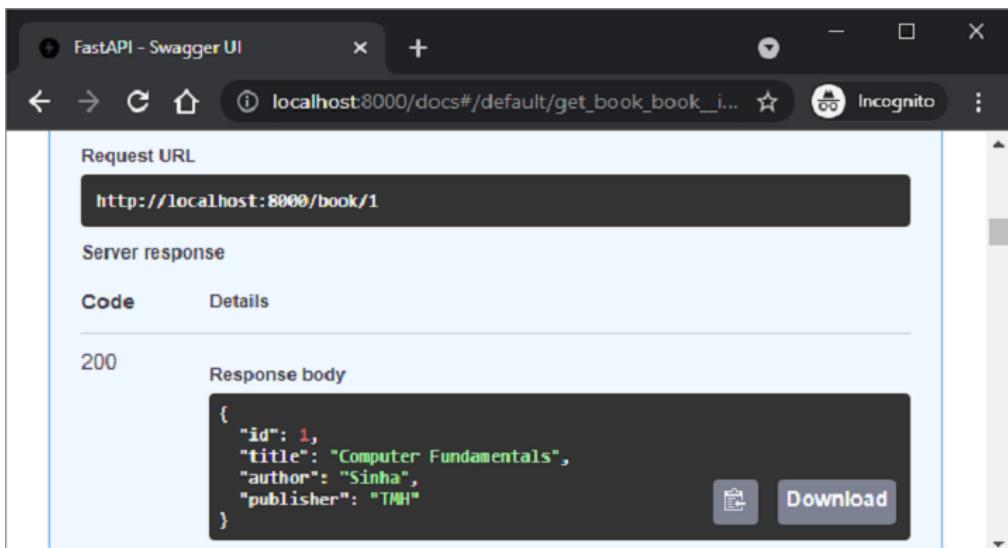
Request URL: A text input field containing "<http://localhost:8000/list>".
Server response:

| Code | Details |
|------|---|
| 200 | Response body [{ "id": 1, "title": "Computer Fundamentals", "author": "Sinha", "publisher": "TMH" }, { "id": 2, "title": "Python Cookbook", "author": "Jones", "publisher": "Oreilly" }, { "id": 3, "title": "Let us Python", "author": "Kanetkar", "publisher": "BPB" }] <div style="text-align: right;">Copy Download</div> |

On the other hand, use "id" as the path parameter in the "/book/1" route.



The book with "id=1" will be retrieved as can be seen in the server response of Swagger UI



Next, define `@app.put()` decorator that modifies an object in the data list. This decorator too has a path parameter for the id field.

```
@app.put("/book/{id}")
def add_book(id: int, book: Book):
```

```
data[id-1] = book  
return data
```

Inspect this operation function in the swagger UI. Give id=1, and change value of publisher to BPB in the request body.

PUT /book/{id} Add Book

Parameters

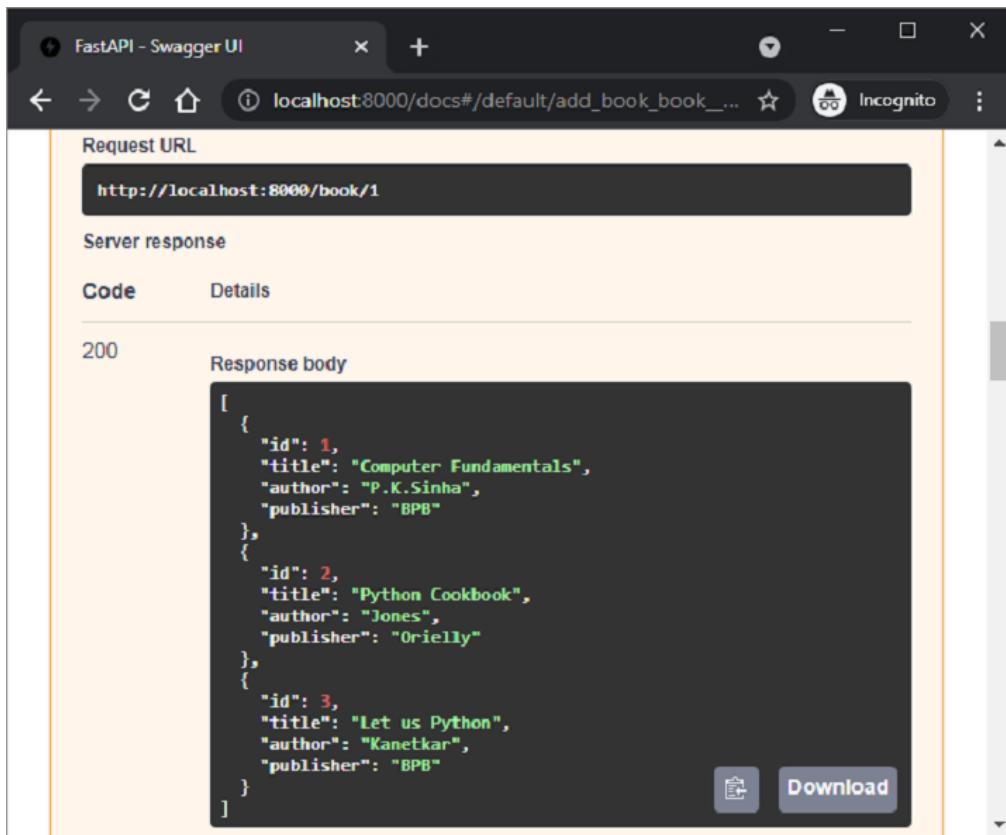
| Name | Description |
|---|-------------|
| id * required integer (path) | 1 |

Request body required

application/json

```
{  
    "id": 1,  
    "title": "Computer fundamentals",  
    "author": "P.K.Sinha",  
    "publisher": "BPB"  
}
```

When executed, the response shows the list with object with id=1 updated with the new values.



The screenshot shows a browser window titled "FastAPI - Swagger UI" with the URL "localhost:8000/docs#/default/add_book_book_...". The "Request URL" field contains "http://localhost:8000/book/1". Under "Server response", there are tabs for "Code" and "Details", with "Code" selected. The status code is 200, and the "Response body" is a JSON array with three elements:

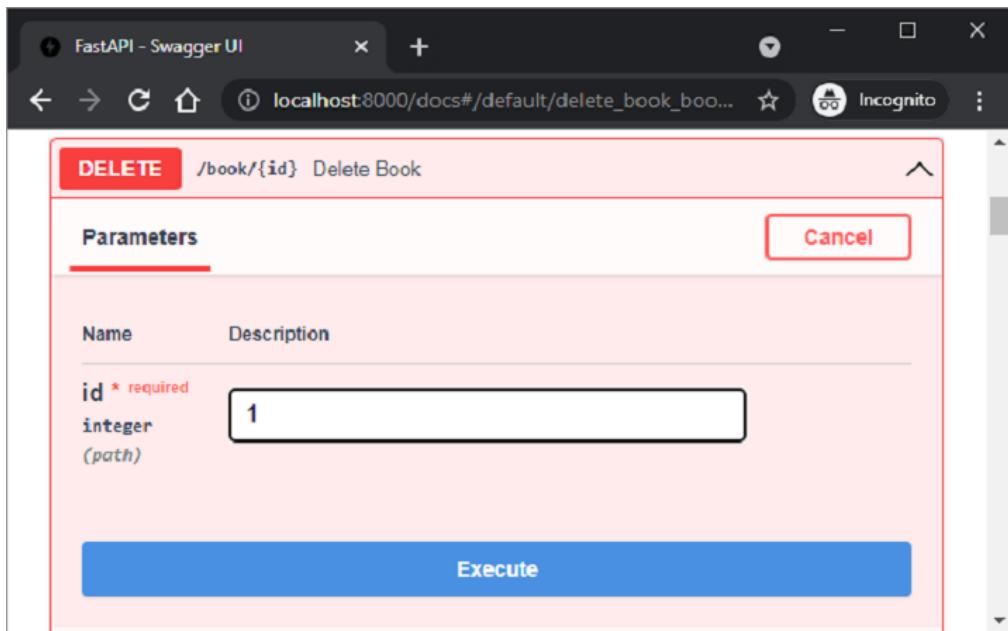
```
[{"id": 1, "title": "Computer Fundamentals", "author": "P.K.Sinha", "publisher": "BPB"}, {"id": 2, "title": "Python Cookbook", "author": "Jones", "publisher": "Orielly"}, {"id": 3, "title": "Let us Python", "author": "Kanetkar", "publisher": "BPB"}]
```

At the bottom right of the response body area are two buttons: "Copy" and "Download".

Finally, we define the `@app.delete()` decorator to delete an object corresponding to the path parameter.

```
@app.delete("/book/{id}")
def delete_book(id: int):
    data.pop(id-1)
    return data
```

Give `id=1` as the path parameter and execute the function.



25. FastAPI – SQL Databases

In the previous chapter, a Python list has been used as an in-memory database to perform CRUD operations using FastAPI. Instead, we can use any relational database (such as MySQL, Oracle, etc.) to perform store, retrieve, update and delete operations.

Instead of using a **DB-API** compliant database driver, we shall use **SQLAlchemy** as an interface between Python code and a database (we are going to use SQLite database as Python has in-built support for it). SQLAlchemy is a popular SQL toolkit and **Object Relational Mapper**.

Object Relational Mapping is a programming technique for converting data between incompatible type systems in object-oriented programming languages. Usually, the type system used in an Object-Oriented language like Python contains non-scalar types. However, data types in most of the database products such as Oracle, MySQL, etc., are of primitive types such as integers and strings.

In an ORM system, each class maps to a table in the underlying database. Instead of writing tedious database interfacing code yourself, an ORM takes care of these issues for you while you can focus on programming the logics of the system.

In order to use SQLAlchemy, we need to first install the library using the PIP installer.

```
pip install sqlalchemy
```

SQLAlchemy is designed to operate with a DBAPI implementation built for a particular database. It uses dialect system to communicate with various types of DBAPI implementations and databases. All dialects require that an appropriate DBAPI driver is installed.

The following are the dialects included –

- Firebird
- Microsoft SQL Server
- MySQL
- Oracle
- PostgreSQL

- SQLite
- Sybase

Since we are going to use SQLite database, we need to create a database engine for our database called test.db. Import **create_engine()** function from sqlalchemy module.

```
from sqlalchemy import create_engine
from sqlalchemy.dialects.sqlite import *
SQLALCHEMY_DATABASE_URL = "sqlite:///./test.db"
engine = create_engine(SQLALCHEMY_DATABASE_URL, connect_args =
{"check_same_thread": False})
```

In order to interact with the database, we need to obtain its handle. A session object is the handle to database. Session class is defined using **sessionmaker()** – a configurable session factory method which is bound to the engine object.

```
from sqlalchemy.orm import sessionmaker, Session
session = sessionmaker(autocommit=False, autoflush=False,
bind=engine)
```

Next, we need a declarative base class that stores a catalog of classes and mapped tables in the Declarative system.

```
from sqlalchemy.ext.declarative import declarative_base
Base = declarative_base()
```

Books, a subclass of **Base**, is mapped to a **book** table in the database. Attributes in the **Books** class correspond to the data types of the columns in the target table. Note that the id attribute corresponds to the primary key in the book table.

```
from sqlalchemy import Column, Integer, String
class Books(Base):
    __tablename__ = 'book'
    id = Column(Integer, primary_key=True, nullable=False)
    title = Column(String(50), unique=True)
```

```

author = Column(String(50))
publisher = Column(String(50))
Base.metadata.create_all(bind=engine)

```

The **create_all()** method creates the corresponding tables in the database.

We now have to declare a Pydantic model that corresponds to the declarative base subclass (Books class defined above).

```

from typing import List
from pydantic import BaseModel, constr

class Book(BaseModel):
    id: int
    title: str
    author: str
    publisher: str

    class Config:
        orm_mode = True

```

Note the use of **orm_mode=True** in the config class indicating that it is mapped with the ORM class of SQLAlchemy.

Rest of the code is just similar to in-memory CRUD operations, with the difference being the operation functions interact with the database through SQLAlchemy interface. The POST operation on the FastAPI application object is defined below:

```

from fastapi import FastAPI, Depends
app=FastAPI()

def get_db():
    db = session()
    try:
        yield db
    finally:

```

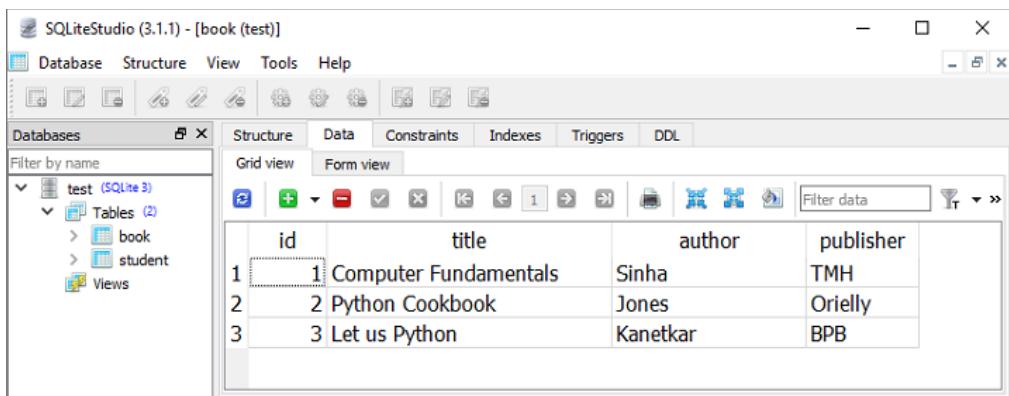
```

db.close()

@app.post('/add_new', response_model=Book)
def add_book(b1: Book, db: Session = Depends(get_db)):
    bk=Books(id=b1.id, title=b1.title, author=b1.author,
publisher=b1.publisher)
    db.add(bk)
    db.commit()
    db.refresh(bk)
    return Books(**b1.dict())

```

A database session is first established. Data from the POST request body is added to the book table as a new row. Execute the **add_book()** operation function to add sample data to the books table. To verify, you can use SQLiteStudio, a GUI tool for SQLite databases.



Two operation functions for GET operation are defined, one for fetching all the records, and one for the record matching a path parameter.

Following is the **get_books()** function bound to the /list route. When executed, its server response is the list of all records.

```

@app.get('/list', response_model=List[Book])
def get_books(db: Session = Depends(get_db)):
    recs = db.query(Books).all()
    return recs

```

The `/book/{id}` route calls the `get_book()` function with `id` as path parameter. The SQLAlchemy's query returns an object corresponding to the given `id`.

```
@app.get('/book/{id}', response_model=Book)
def get_book(id:int, db: Session = Depends(get_db)):
    return db.query(Books).filter(Books.id == id).first()
```

The following image shows the result of `get_books()` function executed from the Swagger UI.

The screenshot shows the FastAPI - Swagger UI interface. At the top, it displays the URL `localhost:8000/docs#/default/get_books_list_get`. The main area is titled "Responses". It contains sections for "Curl" and "Request URL". The "Curl" section shows the command:

```
curl -X 'GET' \
'http://localhost:8000/list' \
-H 'accept: application/json'
```

The "Request URL" section shows the URL `http://localhost:8000/list`. Below these, under "Server response", there are tabs for "Code" and "Details". The "Code" tab is selected, showing the status code 200. Under "Response body", there is a JSON array representing three books:

```
[{"id": 1, "title": "Computer Fundamentals", "author": "Sinha", "publisher": "TMH"}, {"id": 2, "title": "Python Cookbook", "author": "Jones", "publisher": "Orielly"}, {"id": 3, "title": "Let us Python", "author": "Kanetkar", "publisher": "BPB"}]
```

At the bottom right of the "Response body" panel, there are "Copy" and "Download" buttons.

The update and delete operations are performed by **update_book()** function (executed when **/update/{id}** route is visited) and **del_book()** function called when the route **/delete/{id}** is given in as the URL.

```
@app.put('/update/{id}', response_model=Book)
def update_book(id:int, book:Book, db: Session = Depends(get_db)):
    b1 = db.query(Books).filter(Books.id == id).first()
    b1.id=book.id
    b1.title=book.title
    b1.author=book.author
    b1.publisher=book.publisher
    db.commit()
    return db.query(Books).filter(Books.id == id).first()

@app.delete('/delete/{id}')
def del_book(id:int, db: Session = Depends(get_db)):
    try:
        db.query(Books).filter(Books.id == id).delete()
        db.commit()
    except Exception as e:
        raise Exception(e)
    return {"delete status": "success"}
```

If you intend to use any other database in place of SQLite, you need to only the change the dialect definition accordingly. For example, to use MySQL database and **pymysql** driver, change the statement of engine object to the following:

```
engine =
create_engine('mysql+pymysql://user:password@localhost/test')
```

26. FastAPI – Using MongoDB

FastAPI can also use NoSQL databases such as MongoDB, Cassandra, CouchDB, etc. as the backend for the CRUD operations of a REST app. In this topic, we shall see how to use MongoDB in a FastAPI application.

MongoDB is a document oriented database, in which the semi-structured documents are stored in formats like JSON. Documents can contain many different key-value pairs, or key-array pairs, or even nested documents. It is a collection of key-value pairs, similar to Python dictionary object. One or more such documents are stored in a Collection.

A Collection in MongoDB is equivalent to a table in relational database. However, MongoDB (as do all the NoSQL databases) doesn't have a predefined schema. A Document is similar to single row in a table of SQL based relational database. Each document may be of variable number of key-value pairs. Thus MongoDB is a schema-less database.

To use MongoDB with FastAPI, MongoDB server must be installed on the machine. We also need to install **PyMongo**, an official Python driver for MongoDB.

```
pip3 install pymongo
```

Before interacting with MongoDB database through Python and FastAPI code, ensure that MongoDB is running by issuing following command (assuming that MongoDB server is installed in e:\mongodb folder).

```
E:\mongodb\bin>mongod
..
waiting for connections on port 27017
```

An object of **MongoClient** class in the PyMongo module is the handle using which Python interacts with MongoDB server.

```
from pymongo import MongoClient
client=MongoClient()
```

We define Book as the BaseModel class to populate the request body (same as the one used in the SQLite example)

```
from pydantic import BaseModel
from typing import List
class Book(BaseModel):
    bookID: int
    title: str
    author: str
    publisher: str
```

Set up the FastAPI application object:

```
from fastapi import FastAPI, status
app = FastAPI()
```

The POST operation decorator has "**/add_new**" as URL route and executes **add_book()** function. It parses the Book BaseModel object into a dictionary and adds a document in the BOOK_COLLECTION of test database.

```
@app.post("/add_new", status_code=status.HTTP_201_CREATED)
def add_book(b1: Book):
    """Post a new message to the specified channel."""
    with MongoClient() as client:
        book_collection = client[DB][BOOK_COLLECTION]
        result = book_collection.insert_one(b1.dict())
        ack = result.acknowledged
    return {"insertion": ack}
```

Add a few documents using the web interface of Swagger UI by visiting <http://localhost:8000/docs>. You can verify the collection in the Compass GUI front end for MongoDB.

The screenshot shows the MongoDB Compass interface. On the left, the sidebar displays the 'Local' database with 9 DBs and 18 collections. The 'test' database is selected, and its 'book' collection is currently viewed. The main pane shows the 'test.book' collection with 3 documents. The table has columns: d, bookID Int32, title String, author String, and publisher String. The data is as follows:

| d | bookID | title | author | publisher |
|---|---------------|-------------------------|------------|-----------|
| 1 | 12863529cc5d | "Computer Fundamentals" | "Sinha" | "BPB" |
| 2 | 86d7dd7cd900b | "Python Cookbook" | "Jones" | "Oreilly" |
| 3 | 86d7dd7cd900d | "Let Us Python" | "Kanetkar" | "BPB" |

To retrieve the list of all books, let us include the following get operation function – **get_books()**. It will be executed when "**/books**" URL route is visited.

```
@app.get("/books", response_model=List[str])
def get_books():
    """Get all books in list form."""
    with MongoClient() as client:
        book_collection = client[DB][BOOK_COLLECTION]
        booklist = book_collection.distinct("title")
    return booklist
```

In this case, the server response will be the list of all titles in the books collection.

```
[  
    "Computer Fundamentals",  
    "Python Cookbook",  
    "Let Us Python"  
]
```

This following GET decorator retrieves a book document corresponding to given ID as path parameter:

```
@app.get("/books/{id}", response_model=Book)

def get_book(id: int):
    """Get all messages for the specified channel."""
    with MongoClient() as client:
        book_collection = client[DB][BOOK_COLLECTION]
        b1 = book_collection.find_one({"bookID": id})
        return b1
```

Swagger UI documentation page shows the following interface:

The screenshot shows the Swagger UI interface for a FastAPI application. The URL in the browser is `localhost:8000/docs#default/get_book_books_...`. The main panel displays the `GET /books/{id} Get Book` endpoint. Below it, a description states: "Get all messages for the specified channel." A "Parameters" section lists the `id` parameter, which is marked as required and of type integer (path). A value "1" is entered into the input field for this parameter. At the bottom of the panel is a large blue "Execute" button.

The server's JSON response, when the above function is executed, is as follows:

Request URL
http://localhost:8000/books/1

Server response

| Code | Details |
|------|---------------|
| 200 | Response body |

```
{  
    "bookID": 1,  
    "title": "Computer Fundamentals",  
    "author": "Sinha",  
    "publisher": "BPB"  
}
```

Download

Response headers

```
content-length: 79  
content-type: application/json  
date: Sun, 21 Nov 2021 08:29:46 GMT  
server: uvicorn
```

27. FastAPI – Using GraphQL

Facebook developed **GraphQL** in 2012, a new API standard with the intention of optimizing RESTful API Calls. GraphQL is the data query and manipulation language for the API. GraphQL is more flexible, efficient, and accurate as compared to REST. A GraphQL server provides only a single endpoint and responds with the precise data required by the client.

As GraphQL is compatible with ASGI, it can be easily integrated with a FastAPI application. There are many Python libraries for GraphQL. Some of them are listed below:

- Strawberry
- Ariadne
- Tartiflette
- Graphene

FastAPI's official documentation recommends using Strawberry library as its design is also based on type annotations (as in the case of FastAPI itself).

In order to integrate GraphQL with a FastAPI app, first decorate a Python class as Strawberry type.

```
@strawberry.type
class Book:
    title: str
    author: str
    price: int
```

Next, declare a **Query** class containing a function that returns a Book object.

```
@strawberry.type
class Query:
    @strawberry.field
    def book(self) -> Book:
        return Book(title="Computer Fundamentals",
author="Sinha", price=300)
```

Use this Query class as the parameter to obtain **Strawberry.Schema** object.

```
schema = strawberry.Schema(query=Query)
```

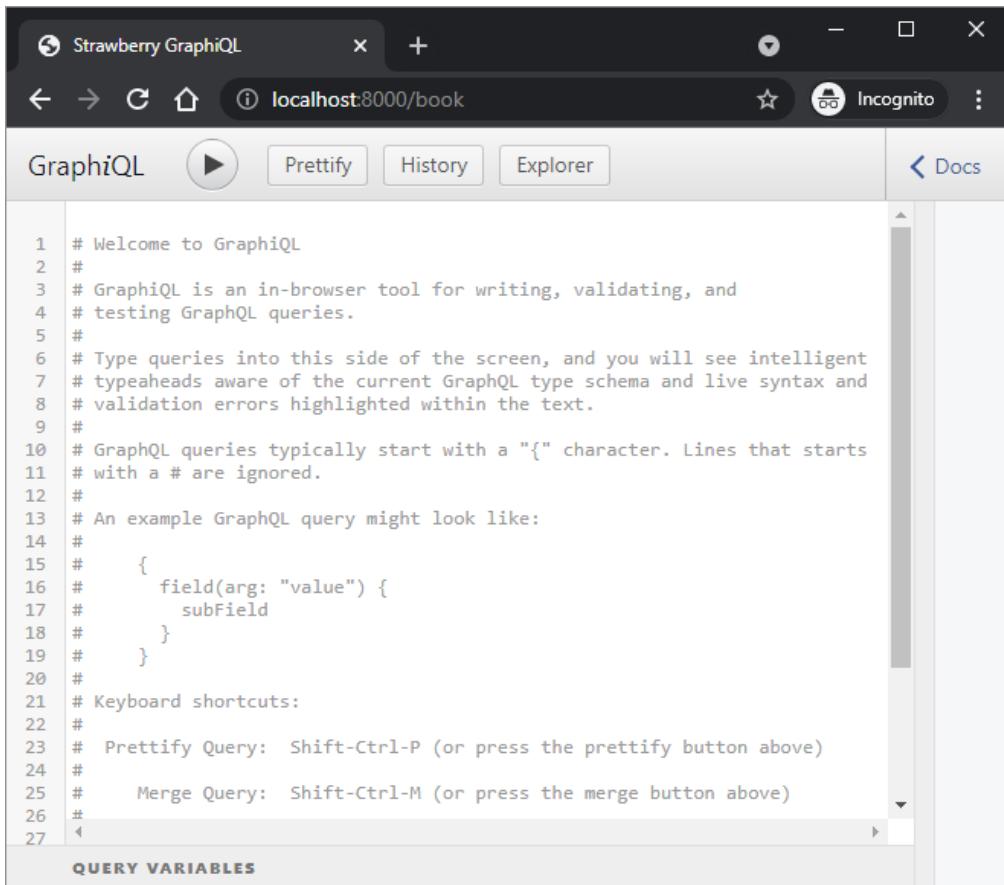
Then declare the objects of both GraphQL class and FastAPI application class.

```
graphql_app = GraphQL(schema)
app = FastAPI()
```

Finally, add routes to the FastAPI object and run the server.

```
app.add_route("/book", graphql_app)
app.add_websocket_route("/book", graphql_app)
```

Visit <http://localhost:8000/book> in the browser. An in-browser GraphQL IDE opens up.



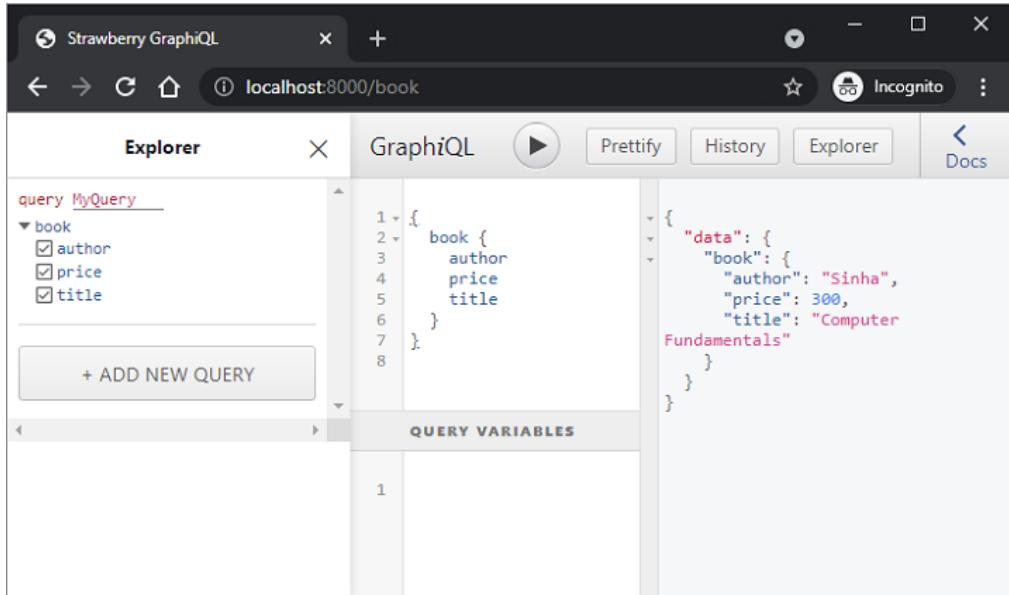
The screenshot shows a browser window titled "Strawberry GraphQL". The address bar says "localhost:8000/book". The main content area is a "GraphiQL" interface. At the top, there are buttons for "Prettify", "History", and "Explorer". To the right, there is a "Docs" link. Below these are two tabs: one with line numbers (1-27) and another with "QUERY VARIABLES". The code in the editor is:

```

1 # Welcome to GraphiQL
2 #
3 # GraphQL is an in-browser tool for writing, validating, and
4 # testing GraphQL queries.
5 #
6 # Type queries into this side of the screen, and you will see intelligent
7 # typeahead aware of the current GraphQL type schema and live syntax and
8 # validation errors highlighted within the text.
9 #
10 # GraphQL queries typically start with a "{" character. Lines that starts
11 # with a # are ignored.
12 #
13 # An example GraphQL query might look like:
14 #
15 #   {
16 #     field(arg: "value") {
17 #       subField
18 #     }
19 #   }
20 #
21 # Keyboard shortcuts:
22 #
23 # Prettify Query: Shift-Ctrl-P (or press the prettify button above)
24 #
25 # Merge Query: Shift-Ctrl-M (or press the merge button above)
26 #
27

```

Below the commented section, enter the following query using the Explorer bar of the Graphiql IDE. Run the query to display the result in the output pane.



The screenshot shows the Strawberry GraphiQL interface running in a browser window. The URL is `localhost:8000/book`. The interface has several tabs: 'Explorer' (selected), 'GraphiQL' (active), 'Prettify', 'History', 'Explorer', and 'Docs'. In the 'Explorer' tab, there is a sidebar with a tree view under 'MyQuery'. The 'book' node has three checked fields: 'author', 'price', and 'title'. Below the tree is a button '+ ADD NEW QUERY'. The main area contains a GraphQL query and its results. The query is:

```
query MyQuery {
  book {
    author
    price
    title
  }
}
```

The results are:

```
{
  "data": {
    "book": {
      "author": "Sinha",
      "price": 300,
      "title": "Computer Fundamentals"
    }
  }
}
```

28. FastAPI – WebSockets

A **WebSocket** is a persistent connection between a client and server to provide bidirectional, **full-duplex** communication between the two. The communication takes place over HTTP through a single TCP/IP socket connection. It can be seen as an upgrade of HTTP instead of a protocol itself.

One of the limitations of HTTP is that it is a strictly half-duplex or unidirectional protocol. With WebSockets, on the other hand, we can send message-based data, similar to UDP, but with the reliability of TCP. WebSocket uses HTTP as the initial transport mechanism, but keeps the TCP connection alive the connection after the HTTP response is received. Same connection object it can be used two-way communication between client and server. Thus, real-time applications can be built using WebSocket APIs.

FastAPI supports WebSockets through `WebSocket` class in `FastAPI` module. Following example demonstrates functioning of `WebSocket` in `FastAPI` application.

First we have an `index()` function that renders a template (`socket.html`). It is bound to "/" route. The HTML file `socket.html` is placed in the "templates" folder.

main.py

```
from fastapi import FastAPI, Request
from fastapi.responses import HTMLResponse
from fastapi.templating import Jinja2Templates
templates = Jinja2Templates(directory="templates")

from fastapi.staticfiles import StaticFiles

app = FastAPI()

app.mount("/static", StaticFiles(directory="static"), name="static")
```

```
@app.get("/", response_class=HTMLResponse)
async def index(request: Request):
    return templates.TemplateResponse("socket.html", {"request": request})
```

The template file renders a text box and a button.

socket.html

```
<!DOCTYPE html>
<html>
    <head>
        <title>Chat</title>
        <script src="{{ url_for('static',
path='ws.js') }}"></script>
    </head>
    <body>
        <h1>WebSocket Chat</h1>
        <form action="" onsubmit="sendMessage(event)">
            <input type="text" id="messageText"
autocomplete="off"/>
            <button>Send</button>
        </form>
        <ul id='messages'>
        </ul>
    </body>
</html>
```

Inside the socket.html, there is a call to the JavaScript function to be executed on the form's submit. Hence, to serve JavaScript, the "static" folder is first mounted. The JavaScript file ws.js is placed in the "static" folder.

ws.js

```

var ws = new WebSocket("ws://localhost:8000/ws");
ws.onmessage = function(event) {
    var messages = document.getElementById('messages')
    var message = document.createElement('li')
    var content = document.createTextNode(event.data)
    message.appendChild(content)
    messages.appendChild(message)
};

function sendMessage(event) {
    var input = document.getElementById("messageText")
    ws.send(input.value)
    input.value = ''
    event.preventDefault()
}

```

As the JavaScript code is loaded, it creates a websocket listening at "ws://localhost:8000/ws". The **sendMessage()** function directs the input message to the WebSocket URL.

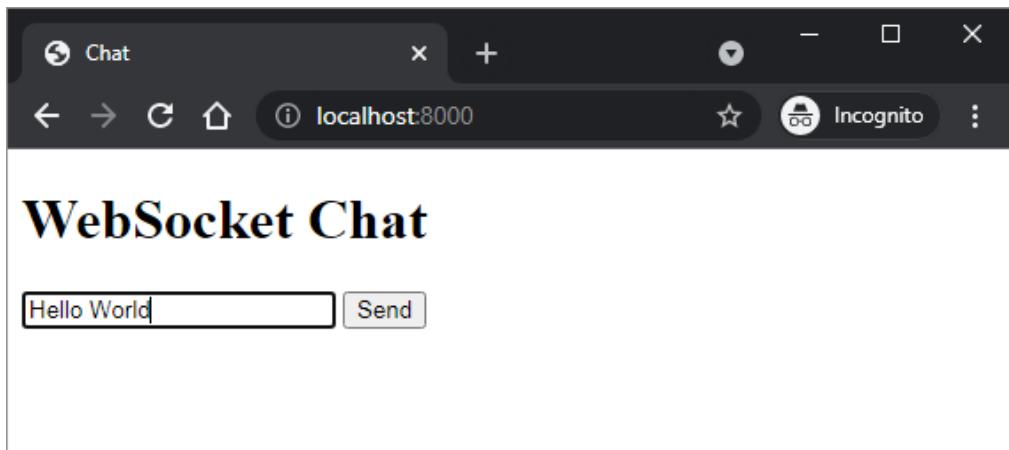
This route invokes the **websocket_endpoint()** function in the application code. The incoming connection request is accepted and the incoming message is echoed on the client browser. Add the below code to main.py.

```

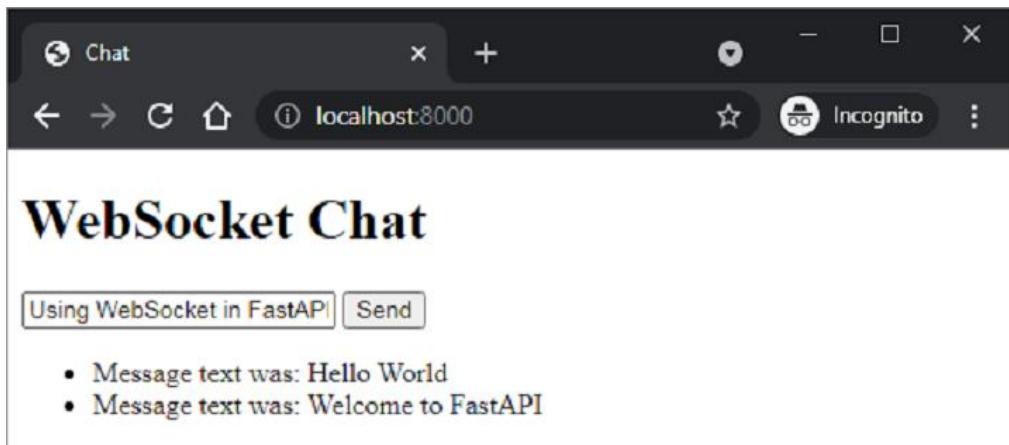
from fastapi import WebSocket
@app.websocket("/ws")
async def websocket_endpoint(websocket: WebSocket):
    await websocket.accept()
    while True:
        data = await websocket.receive_text()
        await websocket.send_text(f"Message text was: {data}")

```

Save the FastAPI code file (main.py), template (socket.html) and JavaScript file (ws.js). Run the Uvicorn server and visit <http://localhost:8000/> to render the chat window as below:



Type a certain text and press Send button. The input message will be redirected on the browser through the websocket.



29. FastAPI – FastAPI Event Handlers

Event handlers are the functions to be executed when a certain identified event occurs. In FastAPI, two such events are identified – **startup** and **shutdown**. FastAPI’s application object has **on_event()** decorator that uses one of these events as an argument. The function registered with this decorator is fired when the corresponding event occurs.

The startup event occurs before the development server starts and the registered function is typically used to perform certain initialization tasks, establishing connection with the database etc. The event handler of shutdown event is called just before the application shutdown.

Example

Here is a simple example of startup and shutdown event handlers. As the app starts, the starting time is echoed in the console log. Similarly, when the server is stopped by pressing **ctrl+c**, the shutdown time is also displayed.

main.py

```
from fastapi import FastAPI
import datetime

app = FastAPI()

@app.on_event("startup")
async def startup_event():
    print('Server started :', datetime.datetime.now())

@app.on_event("shutdown")
async def shutdown_event():
    print('server Shutdown :', datetime.datetime.now())
```

Output

It will produce the following output:

```
uvicorn main:app --reload

INFO: Uvicorn running on http://127.0.0.1:8000 (Press CTRL+C
to quit)

INFO: Started reloader process [28720]
INFO: Started server process [28722]
INFO: Waiting for application startup.

Server started: 2021-11-23 23:51:45.907691

INFO: Application startup complete.

INFO: Shutting down

INFO: Waiting for application

server Shutdown: 2021-11-23 23:51:50.82955

INFO: Application shutdown com

INFO: Finished server process
```

30. FastAPI – Mounting a Sub-App

If you have two independent FastAPI apps, one of them can be mounted on top of the other. The one that is mounted is called a sub-application. The **app.mount()** method adds another completely "independent" application in a specific path of the main app. It then takes care of handling everything under that path, with the path operations declared in that sub-application.

Let us first declare a simple FastAPI application object to be used as a top level application.

```
from fastapi import FastAPI

app = FastAPI()

@app.get("/app")
def mainindex():
    return {"message": "Hello World from Top level app"}
```

Then create another application object subapp and add its own path operations.

```
subapp = FastAPI()

@subapp.get("/sub")
def subindex():
    return {"message": "Hello World from sub app"}
```

Mount this subapp object on the main app by using mount() method. Two parameters needed are the URL route and name of the sub application.

```
app.mount("/subapp", subapp)
```

Both the main and sub application will have its own docs as can be inspected using Swagger UI.

The screenshot shows the FastAPI Swagger UI interface. At the top, it displays the URL `localhost:8000/docs#/default/mainindex_app_get`. Below this, the main content area is for the `GET /app Mainindex` endpoint. The "Parameters" section indicates "No parameters". It features two buttons: "Execute" (in blue) and "Clear" (in grey). The "Responses" section includes a "Curl" code block:

```
curl -X 'GET' \
  'http://localhost:8000/app' \
  -H 'accept: application/json'
```

Below the curl block is a "Request URL" input field containing `http://localhost:8000/app`. The "Server response" section shows a status of 200. Under "Response body", the JSON output is displayed:

```
{  
  "message": "Hello World from Top level app"  
}
```

At the bottom of the response body panel are "Copy" and "Download" buttons.

The sub application's docs are available at <http://localhost:8000/subapp/docs>

The screenshot shows a browser window titled "FastAPI - Swagger UI" displaying the API documentation for a subapplication. The URL in the address bar is `localhost:8000/subapp/docs#/default/subindex...`. The main interface has a sidebar on the left labeled "Servers" with a dropdown menu set to `/subapp`. The main content area is titled "default". It shows a "GET" request for the endpoint `/sub` with the description "Subindex". Below this, under "Parameters", it says "No parameters". There are "Execute" and "Clear" buttons. Under "Responses", there is a "Curl" section with the command:

```
curl -X 'GET' \
  'http://localhost:8000/subapp/sub' \
  -H 'accept: application/json'
```

Below that is a "Request URL" field containing the value `http://localhost:8000/subapp/sub`.

31. FastAPI – Middleware

A **middleware** is a function that is processed with every request (before being processed by any specific path operation) as well as with every response before returning it. This function takes each request that comes to your application. It may perform some process with the request by running a code defined in it and then passes the request to be processed by the corresponding operation function. It can also process the response generated by the operation function before returning it.

Following are some of the middleware available in FastAPI library:

- CORSMiddleware
- HTTPSRedirectMiddleware
- TrustedHostMiddleware
- GZipMiddleware

FastAPI provides **app.add_middleware()** function to handle server errors and custom exception handlers. In addition to the above integrated middleware, it is possible to define a custom middleware. The following example defines the **addmiddleware()** function and decorates it into a middleware by decorating it with **@app.middleware()** decorator.

The function has two parameters, the HTTP request object, and the **call_next()** function that will send the API request to its corresponding path and return a response.

In addition to the middleware function, the application also has two operation functions.

```
import time
from fastapi import FastAPI, Request

app = FastAPI()

@app.middleware("http")
async def addmiddleware(request: Request, call_next):
    print("Middleware works!")
```

```
response = await call_next(request)
return response

@app.get("/")
async def index():
    return {"message": "Hello World"}

@app.get("/{name}")
async def hello(name:str):
    return {"message": "Hello "+name}
```

As the application runs, for each request made by the browser, the middleware output (Middleware works!) will appear in the console log before the response output.

32. FastAPI – Mounting Flask App

A WSGI application written in Flask or Django framework can be wrapped in **WSGIMiddleware** and mounted it on a FastAPI app to make it ASGI compliant.

First install the Flask package in the current FastAPI environment.

```
pip3 install flask
```

The following code is a minimal Flask application:

```
from flask import Flask  
flask_app = Flask(__name__)  
  
@flask_app.route("/")  
def index_flask():  
    return "Hello World from Flask!"
```

Then declare app as a FastAPI application object and define an operation function for rendering Hello World message.

```
from fastapi import FastAPI  
app = FastAPI()  
  
@app.get("/")  
def index():  
    return {"message": "Hello World from FastAPI!"}
```

Next, mount the flask application as a sub application of FastAPI main app using `mount()` method.

```
from fastapi.middleware.wsgi import WSGIMiddleware  
app.mount("/flask", WSGIMiddleware(flask_app))
```

Run the Uvicorn development server.

```
uvicorn flaskapp:app --reload
```

The main FastAPI application is available at the URL <http://localhost:8000/> route.

```
{"message": "Hello World from FastAPI!"}
```

The Flask sub application is mounted at the URL <http://localhost:8000/flask>.

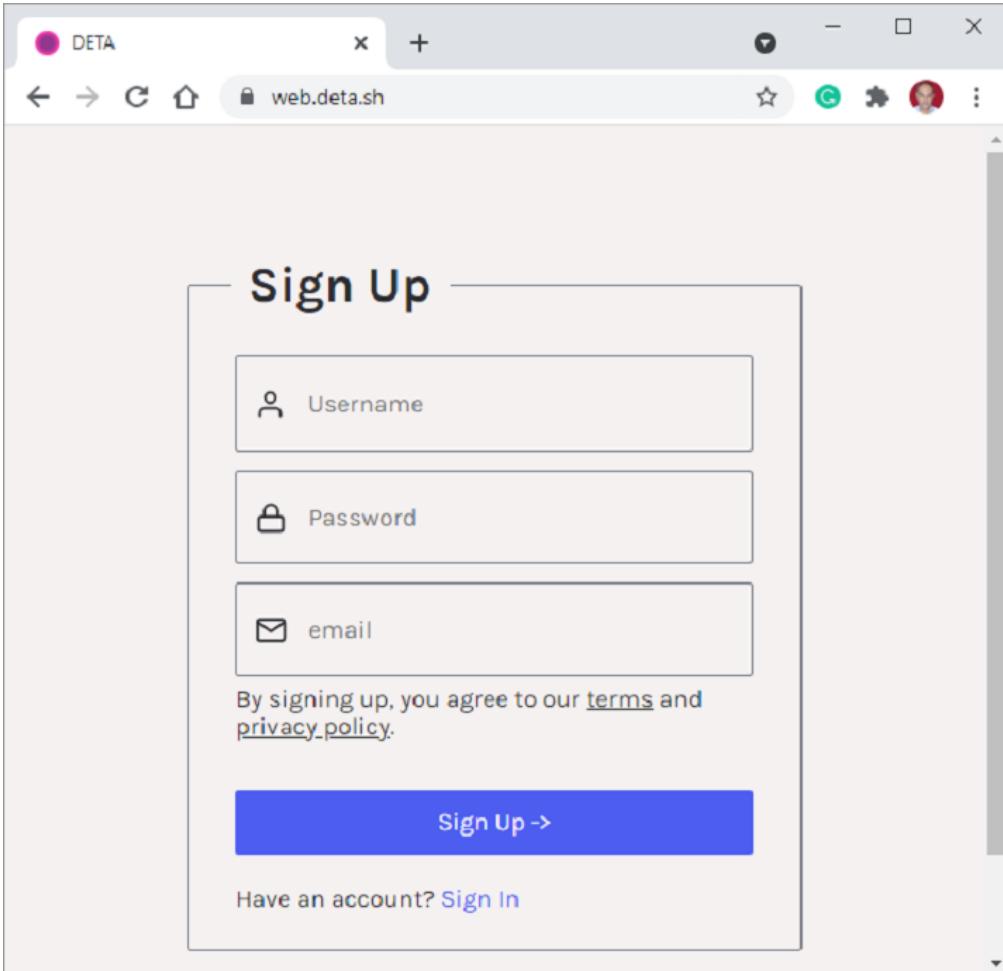
```
Hello World from Flask!
```

33. FastAPI – Deployment

So far, we have been using a local development server "Uvicorn" to run our FastAPI application. In order to make the application publicly available, it must be deployed on a remote server with a static IP address. It can be deployed to different platforms such as Heroku, Google Cloud, nginx, etc. using either free plans or subscription based services.

In this chapter, we are going to use **Deta** cloud platform. Its free to use deployment service is very easy to use.

First of all, to use Deta, we need to create an account on its website with a suitable username and password of choice.



Once the account is created, install **Deta CLI** (command line interface) on the local machine. Create a folder for your application (c:\fastapi_deta_app). If you are using Linux, use the following command in the terminal:

```
iwr https://get.deta.dev/cli.ps1 -useb | iex
```

If you are using Windows, run the following command from Windows PowerShell terminal:

```
PS C:\fastapi_deta_app> iwr https://get.deta.dev/cli.ps1 -useb
| iex

Deta was installed successfully to
C:\Users\User\.deta\bin\deta.exe

Run 'deta --help' to get started
```

Use the login command and authenticate your username and password.

```
PS C:\fastapi_deta_app> deta login
Please, log in from the web page. Waiting...
https://web.deta.sh/cli/60836
Logged in successfully.
```

In the same application folder, create a minimal FastAPI application in **main.py** file

```
# main.py
from fastapi import FastAPI

app = FastAPI()

@app.get("/")
def read_root():
    return {"Hello": "World"}

@app.get("/items/{item_id}")
def read_item(item_id: int):
    return {"item_id": item_id}
```

Now we are ready to deploy our application. Use **deta new** command from the power shell terminal.

```
PS C:\fastapi_deta_app> deta new
Successfully created a new micro
{
    "name": "fastapi_deta_app",
    "id": "2b236e8f-da6a-409b-8d51-7c3952157d3c",
    "project": "c03xfkte",
    "runtime": "python3.9",
    "endpoint": "https://vfrjgd.deta.dev",
    "region": "ap-southeast-1",
    "visor": "enabled",
    "http_auth": "disabled"
}
Adding dependencies...
.....
Installing collected packages: typing-extensions, pydantic,
idna, sniffio, anyio, starlette, fastapi
Successfully installed anyio-3.4.0 fastapi-0.70.0 idna-3.3
pydantic-1.8.2 sniffio-1.2.0 starlette-0.16.0 typing-
extensions-4.0.0
```

Deta deploys the application at the given endpoint (which may be randomly created for each application). It first installs the required dependencies as if it is installed on the local machine. After successful deployment, open the browser and visit the URL as shown in front of endpoint key. The Swagger UI documentation can also be found at <https://vfrjgd.deta.dev/docs>.

The screenshot shows a browser window titled "FastAPI - Swagger UI". The address bar displays the URL "vfrjgd.deta.dev/docs". The main content area is titled "FastAPI 0.1.0 OAS3". Below this, there is a link to "/openapi.json". The "default" section is expanded, showing two API endpoints:

- A "GET" method for the root endpoint: "/ Read Root".
- A "GET" method for reading an item: "/items/{item_id} Read Item".