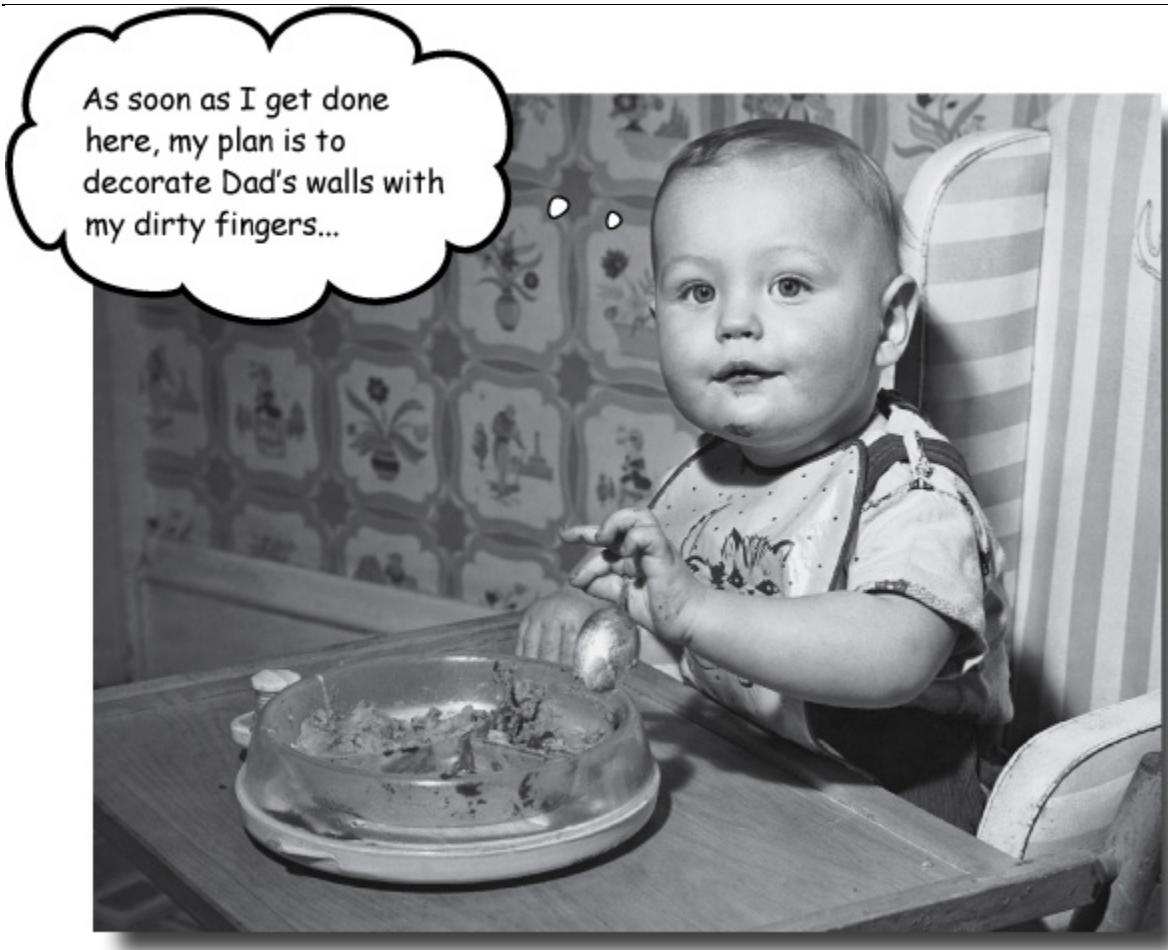


Chapter 10. Function Decorators: Wrapping Functions



When it comes to augmenting your code, [Chapter 9](#)'s context management protocol is not the only game in town.

Python also lets you use function **decorators**, a technique whereby you can add code to an existing function *without* having to change any of the existing function's code. If you think this sounds like some sort of black art, don't despair: it's nothing of the sort. However, as coding techniques go, creating a function decorator is often considered to be on the harder side by many Python programmers, and thus is not used as often as it should be. In this chapter, our plan is to show you that, despite being an advanced technique, creating and using your own decorators is not that hard.

Your Webapp Is Working Well, But...

You've shown the latest version of your webapp to a colleague, and they're impressed by what you've done. However, they pose an interesting question: *is it wise to let any web user view the log page?*

The point they're making is that anybody who is aware of the `/viewlog` URL can use it to view the logged data whether they have your permission or not. In fact, at the moment, every one of your webapp's URLs are public, so any web user can access any of them.

Depending on what you're trying to do with your webapp, this may or may not be an issue. However, it is common for websites to require users to authenticate before certain content is made available to them. It's probably a good idea to be prudent when it comes to providing access to the `/viewlog` URL. The question is: *how do you restrict access to certain pages in your webapp?*

ONLY AUTHENTICATED USERS GAIN ACCESS

You typically need to provide an **ID** and **password** when you access a website that serves restricted content. If your ID/password combination match, access is granted, as you've been authenticated. Once you're authenticated, the system knows to let you access the restricted content. Maintaining this state (whether authenticated or not) seems like it might be as simple as setting a switch to `True` (access allowed; you are logged in) or `False` (access forbidden; you are *not* logged in).



That sounds straightforward to me. A simple HTML form can ask for the user's credentials, and then a boolean on the server can be set to "True" or "False" as needed, right?

It's a bit more complicated than that.

There's a twist here (due to the way the Web works) which makes this idea a tad more complicated than it at first appears. Let's explore what this complication is first (and see how to deal with it) before solving our restricted access issue.

The Web Is Stateless

In its most basic form, a web server appears incredibly silly: each and every request that a web server processes is treated as an independent request, having nothing whatsoever to do with what came before, nor what comes after.

This means that sending three quick requests to a web server from your computer appears as three independent *individual* requests. This is in spite of the fact that the three requests originated from the same web browser running on the same computer, which is using the same unchanging IP address (which the web server sees as part of the request).

As stated at the top of the page: it's as if the web server is being silly. Even though we assume the three requests sent from our computer are related, the web server doesn't see things this way: *every web request is independent of what came before it, as well as what comes after.*



HTTP IS TO BLAME...

The reason web servers behave in this way is due to the protocol that underpins the Web, and which is used by both the web server and your web browser: HTTP (the HyperText Transfer Protocol).

HTTP dictates that web servers must work as described above, and the reason for this has to do with performance: if the amount of work a web server needs to do is minimized, it's possible to scale web servers to handle many, many requests. Higher performance is achieved at the expense of requiring the web server to maintain information on how a series of requests may be related. This information—known as **state** in HTTP (and not related to OOP in any way)—is of no interest to the web server, as every request is treated as an

independent entity. In a way, the web server is optimized to respond quickly, but forget fast, and is said to operate in a **stateless**manner.

Which is all well and good until such time as your webapp needs to remember something.



If only the Web were that simple.

When your code is running as part of a web server, its behavior can differ from when you run it on your computer. Let's explore this issue in more detail.

Your Web Server (Not Your Computer) Runs Your Code

When Flask runs your webapp on your computer, it keeps your code in memory at all times. With this in mind, recall these two lines from the bottom of your webapp's code, which we initially discussed at the end of [Chapter 5](#):

```
if __name__ == '__main__':
    app.run(debug=True)
```

This line of code does NOT execute when this code is imported.

This `if` statement checks to see whether the interpreter is executing the code directly or whether the code is being imported (by the interpreter or by something like *PythonAnywhere*). When Flask executes on your computer, your webapp's code runs directly, resulting in this `app.run` line executing. However, when a web server is configured to execute your code your webapp's code is *imported*, and the `app.run`line does **not** run.

Why? Because the web server runs your webapp code *as it sees fit*. This can involve the web server importing your webapp's code, then calling its functions as needed, keeping your

webapp's code in memory at all times. Or the web server may decide to load/unload your webapp code as needed, the assumption being that, during periods of inactivity, the web server will only load and run the code it needs. It's this second mode of operation—where the web server loads your code as and when it needs it—that can lead to problems with storing your webapp's state in variables. For instance, consider what would happen if you were to add this line of code to your webapp:

```
logged_in = False  
if __name__ == '__main__':  
    app.run(debug=True)
```

The "logged_in" variable could be used to indicate whether a user of your webapp is logged in or not.

The idea here is that other parts of your webapp can refer to the variable `logged_in` in order to determine whether a user is authenticated. Additionally, your code can change this variable's value as needed (based on, say, a successful login). As the `logged_in` variable is *global* in nature, all of your webapp's code can access and set its value. This seems like a reasonable approach, but has *two* problems.

Firstly, your web server can unload your webapp's running code at any time (and without warning), so any values associated with global variables are likely **lost**, and are going to be reset to their starting value when your code is next imported. If a previously loaded function sets `logged_in` to `True`, your reimported code helpfully resets `logged_in` to `False`, and confusion reigns...



Secondly, as it stands, there's only a *single copy* of the global `logged_in` variable in your running code, which is fine if all you ever plan to have is a single user of your webapp (good luck with that). If you have two or more users each accessing and/or changing the value of `logged_in`, not only will confusion reign, but frustration will make a guest appearance, too. As a general rule of thumb, storing your webapp's state in a global variable is a bad idea.

Don't store your webapp's state in global variables.

It's Time for a Bit of a Session

As a result of what we learned on the last page, we need two things:

- A way to store variables without resorting to using globals
- A way to keep one webapp user's data from interfering with another's

Most webapp development frameworks (including Flask) provide for both of these requirements using a single technology: the **session**.

Think of a session as a layer of state spread on top of the stateless Web.

By adding a small piece of identification data to your browser (a *cookie*), and linking this to a small piece of identification data on the web server (the *session ID*), Flask uses its session technology to keep everything straight. Not only can you store state in your webapp that persists over time, but each user of your webapp gets their own copy of the state. Confusion and frustration are no more.

To demonstrate how Flask's session mechanism works, let's take a look at a very small webapp that is saved to a file called `quick_session.py`. Take a moment to read the code first, paying particular attention to the highlighted parts. We'll discuss what's going on after you've had a chance to read this code:

READY BAKE CODE



This is the
"quick_session.py"
code.

```
from flask import Flask, session
app = Flask(__name__)
app.secret_key = 'YouWillNeverGuess'

@app.route('/setuser/<user>')
def setuser(user: str) -> str:
    session['user'] = user
    return 'User value set to: ' + session['user']

@app.route('/getuser')
def getuser() -> str:
    return 'User value is currently set to: ' + session['user']

if __name__ == '__main__':
    app.run(debug=True)
```

Be sure to add "session" to your list of imports.

Your secret key should be hard to guess.

Manipulate the data in "session" as required.

Flask's Session Technology Adds State

In order to use Flask's session technology, you first have to import `session` from the `flask` module, which the `quick_session.py` webapp you just saw does on its very first line.

Think of `session` as a global Python dictionary within which you store your webapp's state (albeit a dictionary with some added superpowers):

```
from flask import Flask, session  
...
```

Start by importing "session".

Even though your webapp is still running on the stateless Web, this single import gives your webapp the ability to remember state.

Flask ensures that any data stored in `session` exists for the entire time your webapp runs (no matter how many times your web server loads and reloads your webapp code). Additionally, any data stored in `session` is keyed by a unique browser cookie, which ensures your session data is kept away from that of every other user of your webapp.

Find out more about Flask sessions here: <http://flask.pocoo.org/docs/0.11/api/#sessions>

Just how Flask does all of this is not important: the fact that it does *is*. To enable all this extra goodness, you need to seed Flask's cookie generation technology with a "secret key," which is used by Flask to encrypt your cookie, protecting it from any prying eyes. Here's how `quick_session.py` does this:

```
...  
app = Flask(__name__)  
app.secret_key = 'YouWillNeverGuess'  
...
```

Create a new Flask webapp in the usual way.

Seed Flask's cookie-generation technology with a secret key. (Note: any string will do here. Although, like any other password you use, it should be hard to guess.)

Flask's documentation suggests picking a secret key that is hard to guess, but any stringed value works here. Flask uses the string to encrypt your cookie prior to transmitting it to your browser.

Once `session` is imported and the secret key set, you can use `session` in your code as you would any other Python dictionary. Within `quick_session.py`, the `/setuser` URL (and its associated `setuser` function) assigns a user-supplied value to the `user` key in `session`, then returns the value to your browser:

```
...  
@app.route('/setuser/<user>')  
def setuser(user: str) -> str:  
    session['user'] = user  
    return 'User value set to: ' + session['user']  
...
```

The value of the "user" variable is assigned to the "user" key in the "session" dictionary.

The URL expects to be provided with a value to assign to the "user" variable (you'll see how this works in a little bit).

Now that we've set some session data, let's look at the code that accesses it.

Dictionary Lookup Retrieves State

Now that a value is associated with the `user` key in `session`, it's not hard to access the data associated with `user` when you need it.

The second URL in the `quick_session.py` webapp, `/getuser`, is associated with the `getuser` function. When invoked, this function accesses the value associated with the `user` key and returns it to the waiting web browser as part of the stringed message. The `getuser` function is shown below, together with this webapp's *dunder name equals dunder main* test (first discussed near the end of [Chapter 5](#)):

```
...
@app.route('/getuser')
def getuser() -> str:
    return 'User value is currently set to: ' + session['user']
```

```
{ if __name__ == '__main__':
    app.run(debug=True)
```

As is the custom with all Flask apps, we control when "app.run" executes using this well-established Python idiom.

Accessing the data in "session" is not hard. It's a dictionary lookup.

TIME FOR A TEST DRIVE?

It's nearly time to take the `quick_session.py` webapp for a spin. However, before we do, let's think a bit about what it is we want to test.

For starters, we want to check that the webapp is storing and retrieving the session data provided to it. On top of that, we want to ensure that more than one user can interact with the webapp without stepping on any other user's toes: the session data from one user shouldn't impact the data of any other.

To perform these tests, we're going to simulate multiple users by running multiple browsers. Although the browsers are all running on one computer, as far as the web server is concerned, they are all independent, individual connections: the Web is stateless, after all. If we were to repeat these tests on three physically different computers on three different networks, the results would be the same, as all web servers see each request in isolation, no matter where the request originates. Recall that the `session` technology in Flask layers a stateful technology on top of the stateless Web.

To start this webapp, use this command within a terminal on *Linux* or *Mac OS X*:

```
$ python3 quick_session.py
```

or use this command at a command prompt on *Windows*:

```
C:\> py -3 quick_session.py  
TEST DRIVE, 1 OF 2
```

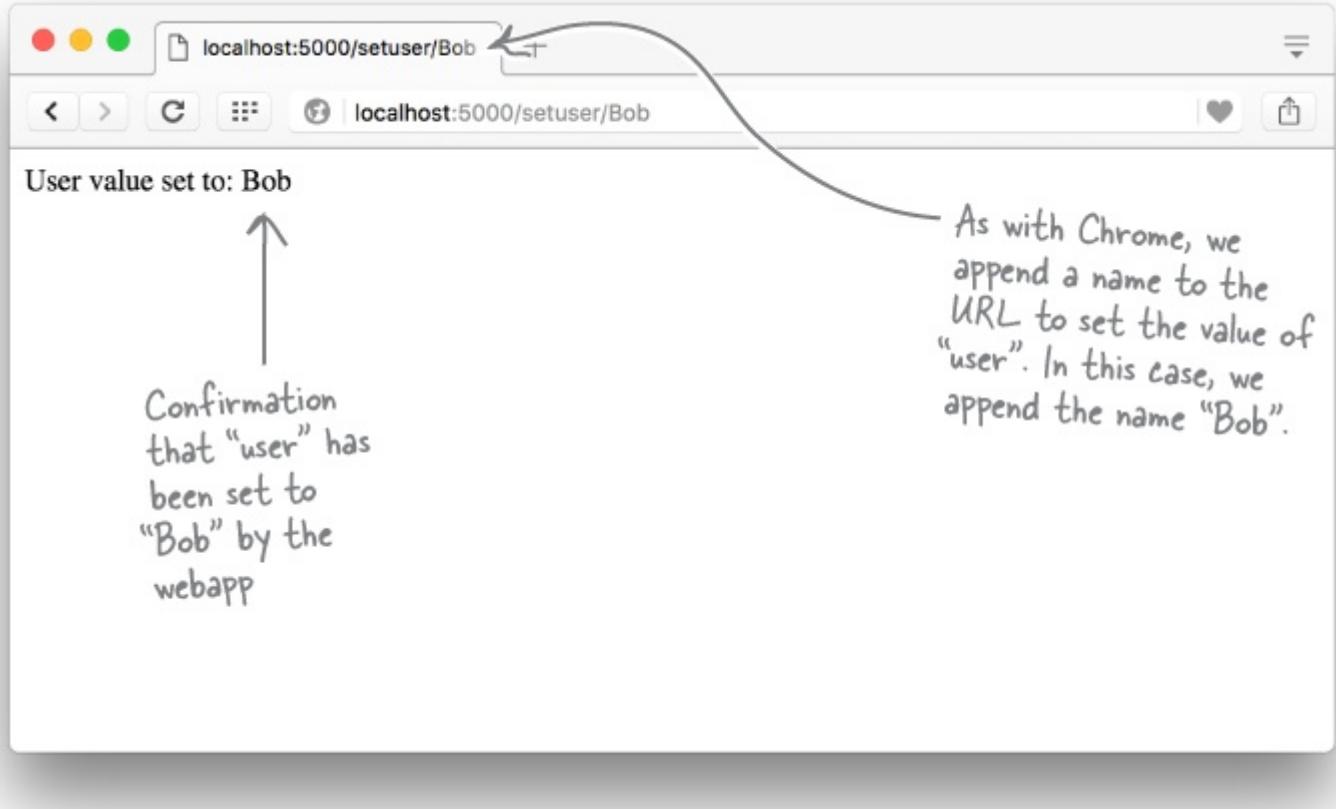


With the `quick_session.py` webapp up and running, let's open a Chrome browser and use it to set a value for the `user` key in `session`. We do this by typing `/setuser/Alice` into the location bar, which instructs the webapp to use the value `Alice` for `user`:

Appending a name to the end of the URL tells the webapp to use "Alice" as the value for "user".



Next, let's open up the Opera browser and use it to set the value of `user` to `Bob`(if you don't have access to Opera, use whichever browser is handy, as long as it's not Chrome):



When we opened up Safari (or you can use Edge if you are on Windows), we used the webapp's other URL, `/getuser`, to retrieve the current value of `user` from the webapp. However, when we did this, we're greeted with a rather intimidating error message:

The “/getuser” URL lets you check the current value of “user”.

127.0.0.1:5000/getuser

builtins.KeyError

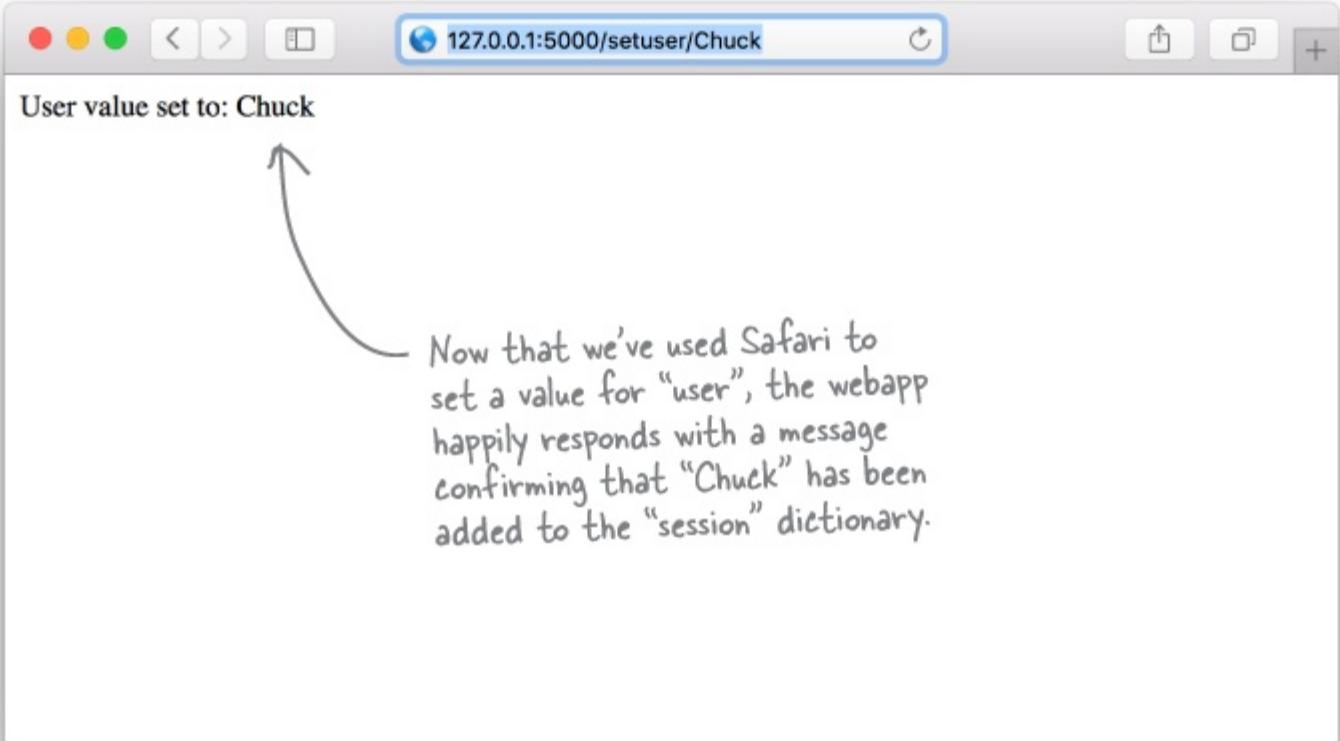
KeyError: 'user'

Traceback (most recent call last)

```
File "/Library/Frameworks/Python.framework/Versions/3.5/lib/python3.5/site-packages/flask/app.py", line 1836, in __call__
    return self.wsgi_app(environ, start_response)
File "/Library/Frameworks/Python.framework/Versions/3.5/lib/python3.5/site-packages/flask/app.py", line 1820, in wsgi_app
    response = self.make_response(self.handle_exception(e))
File "/Library/Frameworks/Python.framework/Versions/3.5/lib/python3.5/site-packages/flask/app.py", line 1403, in handle_exception
```

Yikes! That's quite the error message, isn't it? The important bit is at the top: we have a “KeyError”, as we haven't used Safari to set a value for “user” yet. (Remember: we set a “user” value using Chrome and Opera, not Safari.)

Let's use Safari to set the value of user to Chuck:



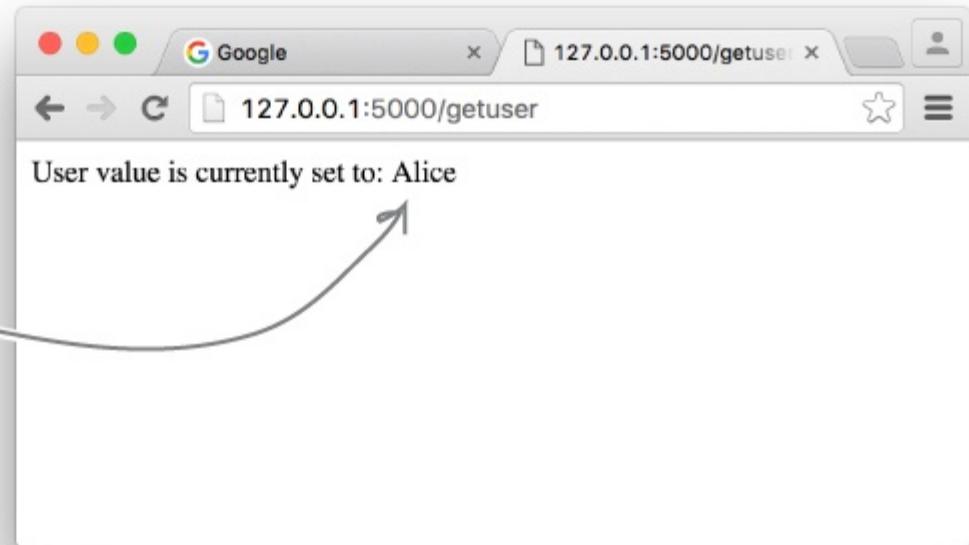
TEST DRIVE, 2 OF 2



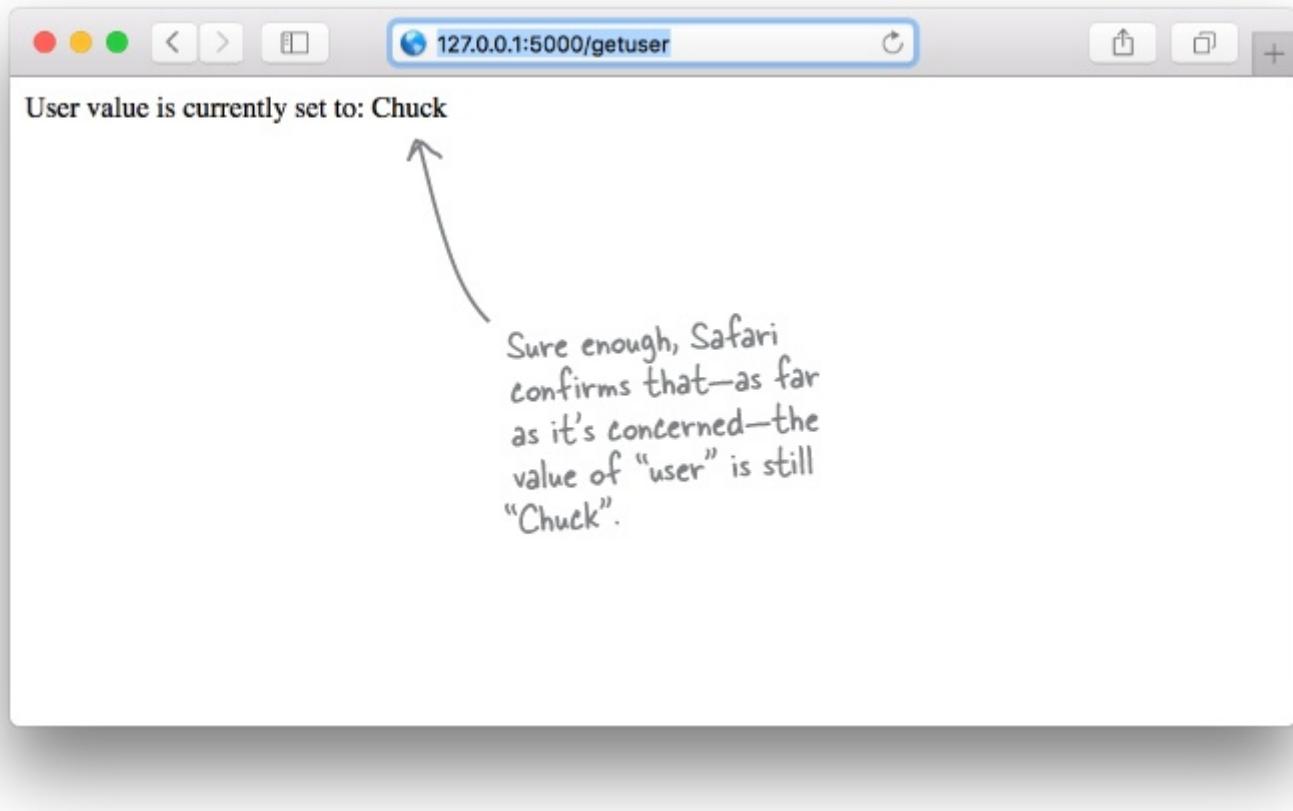
Now that we've used the three browsers to set values for `user`, let's confirm that the webapp (thanks to our use of `session`) is stopping each browser's value of `user` from interfering with any other browser's data. Even though we've just used Safari to set the value of `user` to `chuck`, let's see what its value is in Opera by using the `/getuser` URL:



Having confirmed that Opera is showing `user`'s value as `Bob`, let's return to the Chrome browser window and issue the `/getuser` URL there. As expected, Chrome confirms that, as far as it's concerned, the value of `user` is `Alice`:



We've just used Opera and Chrome to access the value of `user` using the `/getuser` URL, which just leaves Safari. Here's what we see when we issue `/getuser` in Safari, which doesn't produce an error message this time, as `user` has a value associated with it now (so, no more `KeyError`):





No, not quite—it all happens in the webapp.

The use of the `session` dictionary in the webapp enables the behavior you're seeing here. By automatically setting a unique cookie within each browser, the webapp (thanks to `session`) maintains a browser-identifiable value of `user` for *each* browser.

From the webapp's perspective, it's as if there are multiple values of `user` in the `session` dictionary (keyed by cookie). From each browser's perspective, it's as if there is only ever one value of `user` (the one associated with their individual, unique cookie).

Managing Logins with Sessions

Based on our work with `quick_session.py`, we know we can store browser-specific state in `session`. No matter how many browsers interact with our webapp, each browser's server-side data (a.k.a. `state`) is managed for us by Flask whenever `session` is used.

Let's use this new know-how to return to the problem of controlling web access to specific pages within the `vsearch4web.py` webapp. Recall that we want to get to the point where we can restrict who has access to the `/viewlog` URL.

Rather than experimenting on our working `vsearch4web.py` code, let's put that code to one side for now and work with some other code, which we'll experiment with in order to work out what we need to do. We'll return to the `vsearch4web.py` code once we've worked out the best way to approach this. We can then confidently amend the `vsearch4web.py` code to restrict access to `/viewlog`.

Here's the code to yet another Flask-based webapp. As before, take some time to read this code prior to our discussion of it. This is `simple_webapp.py`:

READY BAKE CODE



```
from flask import Flask

app = Flask(__name__)

@app.route('/')
def hello() -> str:
    return 'Hello from the simple webapp.'

@app.route('/page1')
def page1() -> str:
    return 'This is page 1.'

@app.route('/page2')
def page2() -> str:
    return 'This is page 2.'

@app.route('/page3')
def page3() -> str:
    return 'This is page 3.'

if __name__ == '__main__':
    app.run(debug=True)
```

This is "simple_webapp.py".
At this stage in this
book, you should have no
difficulty reading this
code and understanding
what this webapp does.

Let's Do Login

The `simple_webapp.py` code is straightforward: all of the URLs are public in that they can be accessed by anyone using a browser.

In addition to the default / URL (which results in the `hello` function executing), there are three other URLs, `/page1`, `/page2`, and `/page3` (which invoke similarly named functions when accessed). All of the webapp's URLs return a specific message to the browser.

As webapps go, this one is really just a shell, but will do for our purposes. We'd like to get to the point where `/page1`, `/page2`, and `/page3` are only visible to logged-in users, but restricted to everyone else. We're going to use Flask's `session` technology to enable this functionality.

Let's begin by providing a really simple `/login` URL. For now, we're not going to worry about providing an HTML form that asks for a login ID and password. All we're going to do here is create some code that adjusts `session` to indicate that a successful login has occurred.

SHARPEN YOUR PENCIL



Let's write the code for the `/login` URL below. In the space shown, provide code that adjusts `session` by setting a value for the `logged_in` key to `True`. Additionally, have the URL's function return the "You are now logged in" message to the waiting browser:

Add the
new code
here.

```
@app.route('/login')
def do_login() -> str:
    .....
    return
```

In addition to creating the code for the `/login` URL, you'll need to make two other changes to the code to enable sessions. Detail what you think these changes are here:

1.
2.

SHARPEN YOUR PENCIL SOLUTION



You were to write the code for the `/login` URL below. You were to provide code that adjusts `session` by setting a value for the `logged_in` key to `True`. Additionally, you were to have the URL's function return the "You are now logged in" message to the waiting browser:

```
@app.route('/login')
def do_login() -> str:
```

session['logged_in'] = True

return 'You are now logged in.'

Set the "logged_in" key in
the "session" dictionary to
"True".

Return this message
to the waiting
browser.

In addition to creating the code for the */login* URL, you needed to make two other changes to the code to enable sessions. You were to detail what you think these changes were:

- 1 We need to add 'session' to the import line at the top of the code.
- 2 We need to set a value for this webapp's secret key.

Let's not
forget to
do these.

AMEND THE WEBAPP'S CODE TO HANDLE LOGINS

We're going to hold off on testing this new code until we've added another two URLs: */logout* and */status*. Before you move on, make sure your copy of `simple_webapp.py` has been amended to include the changes shown below. Note: we're not showing all of the webapp's code here, just the new bits (which are highlighted):

Add the
code for the
"/login" URL.

```
from flask import Flask, session
app = Flask(__name__)
```

Remember
to import
"session".

```
...
@app.route('/login')
def do_login() -> str:
    session['logged_in'] = True
    return 'You are now logged in.'
```

Set a value for this
webapp's secret key
(which enables the
use of sessions).

```
app.secret_key = 'YouWillNeverGuessMySecretKey'

if __name__ == '__main__':
    app.run(debug=True)
```

Let's Do Logout and Status Checking

Adding the code for the */logout* and */status* URLs is our next task.

When it comes to logging out, one strategy is to set the `session` dictionary's `logged_in` key to `False`. Another strategy is to *remove* the `logged_in` key from `session` altogether. We're

going to go with the second option; the reason why will become clear after we code the `/status` URL.

SHARPEN YOUR PENCIL



Let's write the code for the `/logout` URL, which needs to remove the `logged_in` key from the session dictionary, then return the "You are now logged out" message to the waiting browser. Add your code into the spaces below:

Add the
logout
code here.

```
@app.route('/logout')
def do_logout() -> str:
    .....
    return .....
```

Hint: if you've forgotten how to
remove a key from a dictionary,
type "dir(dict)" at the >>>
prompt for a list of available
dictionary methods.

With `/logout` written, we now turn our attention to `/status`, which returns one of two messages to the waiting web browser.

The message "You are currently logged in" is returned when `logged_in` exists as a value in the session dictionary (and, by definition, is set to `True`).

The message "You are NOT logged in" is returned when the session dictionary doesn't have a `logged_in` key. Note that we can't check `logged_in` for `False`, as the `/logout` URL removes the key from the session dictionary as opposed to changing its value. (We haven't forgotten that we still need to explain why we're doing things this way, and we'll get to the explanation in a while. For now, trust that this is the way you have to code this functionality.)

Let's write the code for the `/status` URL in the space below:

Put your status-
checking code here.

```
@app.route('/status')
def check_status() -> str:
    if .....
        return .....
    return .....
```

Check if the "logged_in" key exists
in the "session" dictionary, then
return the appropriate message.

SHARPEN YOUR PENCIL SOLUTION



You were to write the code for the `/logout` URL, which needed to remove the `logged_in` key from the `session` dictionary, then return the “You are now logged out” message to the waiting browser:

```
@app.route('/logout')  
def do_logout() -> str:
```

`session.pop('logged_in')`

Use the “pop” method to remove the “logged_in” key from the “session” dictionary.

```
return 'You are now logged out.'
```

With `/logout` written, you were to turn your attention to the `/status` URL, which returns one of two messages to the waiting web browser.

The message “You are currently logged in” is returned when `logged_in` exists as a value in the `session` dictionary (and, by definition, is set to `True`).

The message “You are NOT logged in” is returned when the `session` dictionary doesn’t have a `logged_in` key.

You were to write the code for `/status` in the space below:

```
@app.route('/status')  
def check_status() -> str:
```

`if 'logged_in' in session:`

Does the “logged_in” key exist in the “session” dictionary?

```
return 'You are currently logged in.'
```

If yes, return this message.

`return 'You are NOT logged in.'`

If no, return this message.

AMEND THE WEBAPP’S CODE ONCE MORE

We’re still holding off on testing this new version of the webapp, but here (on the right) is a highlighted version of the code you need to add to your copy of `simple_webapp.py`.

```

...
@app.route('/logout')
def do_logout() -> str:
    session.pop('logged_in')
    return 'You are now logged out.'

@app.route('/status')
def check_status() -> str:
    if 'logged_in' in session:
        return 'You are currently logged in.'
    return 'You are NOT logged in.'

app.secret_key = 'YouWillNeverGuessMySecretKey'

if __name__ == '__main__':
    app.run(debug=True)

```

Make sure you've amended your code to match ours before getting to the next *Test Drive*, which is coming up right after we make good on an earlier promise.

Why Not Check for False?

When you coded the `/login` URL, you set the `logged_in` key to `True` in the `session` dictionary (which indicated that the browser was logged into the webapp). However, when you coded the `/logout` URL, the code didn't set the value associated with the `logged_in` key to `False`, as we preferred instead to remove all trace of the `logged_in` key from the `session` dictionary. In the code that handled the `/status` URL, we checked the "login status" by determining whether or not the `logged_in` key existed in the `session` dictionary; we didn't check whether `logged_in` is `False` (or `True`, for that matter). Which begs the question: *why does the webapp not use False to indicate "not logged in"?*

The answer is subtle, but important, and it has to do with the way dictionaries work in Python. To illustrate the issue, let's experiment at the `>>>` prompt and simulate what can happen to the `session` dictionary when used by the webapp. Be sure to follow along with this session, and carefully read each of the annotations:

Two new
URL
routes

```

Python 3.5.1 Shell
>>>
>>> session = dict()
>>>
>>> if session['logged_in']:
    print('Found it.')
Traceback (most recent call last):
  File "<pyshell#47>", line 1, in <module>
    if session['logged_in']:
KeyError: 'logged_in'
>>>
>>> if 'logged_in' in session:
    print('Found it.')
>>>
>>> session['logged_in'] = True
>>>
>>> if 'logged_in' in session:
    print('Found it.')
Found it.
>>>
>>> if session['logged_in']:
    print('Found it.')
Found it.
>>> |

```

Ln: 115 Col: 4

Create a new, empty dictionary called "session".

Try to check for the existence of a "logged_in" value using an "if" statement.

Whoops! The "logged_in" key doesn't exist yet, so we get a "KeyError", and our code has crashed as a result.

However, if we check for existence using "in", our code doesn't crash (there's no "KeyError") even though the key has no value.

Let's assign a value to the "logged_in" key.

Checking for existence with "in" still works, although this time around we get a positive result (as the key exists and has a value).

Checking with an "if" statement works too (now that the key has a value associated with it). However, if the key is removed from the dictionary (using the "pop" method) this code is once again vulnerable to "KeyError".

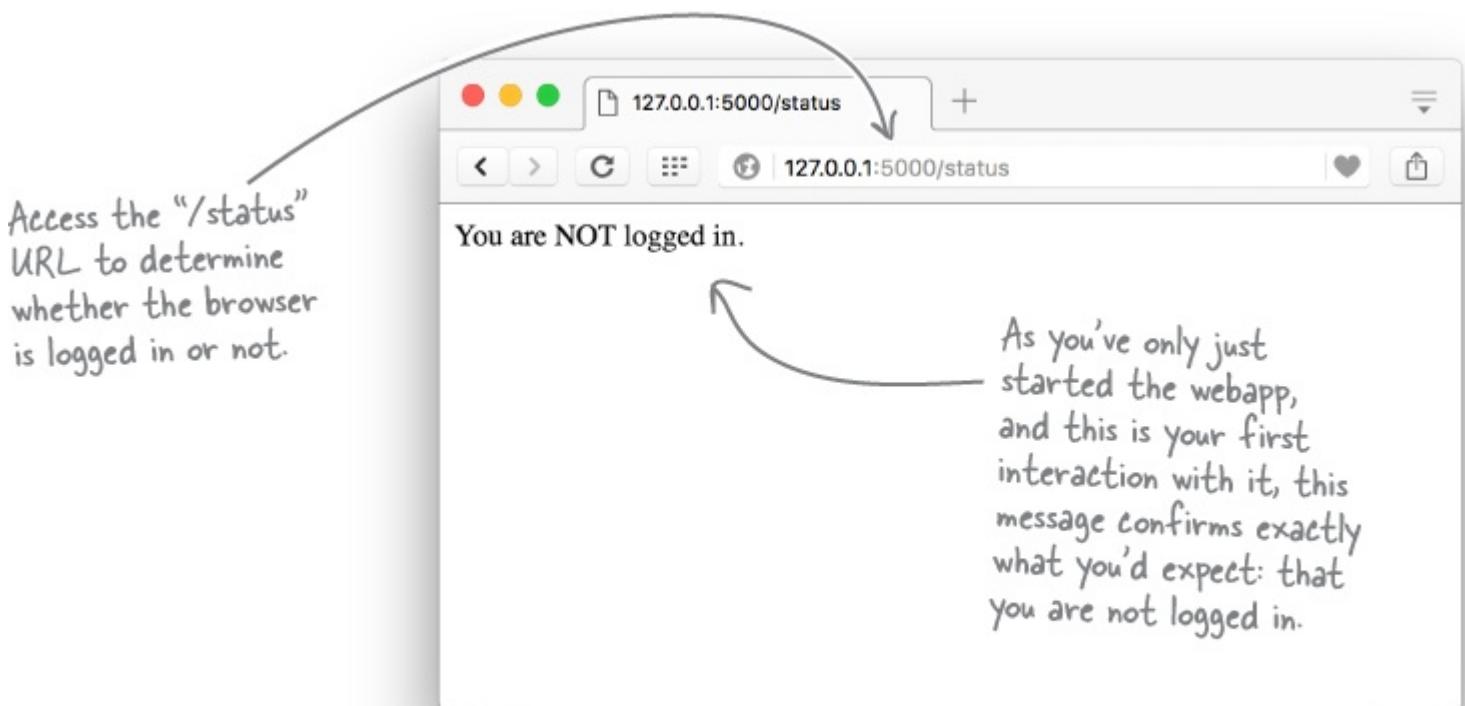
The above experimentation shows that it is **not** possible to check a dictionary for a key's value until a key/value pairing exists. Trying to do so results in an `KeyError`. As it's a good idea to avoid errors like this, the `simple_webapp.py` code checks for the existence of the `logged_in` key as proof that the browser's logged in, as opposed to checking the key's actual value, thus avoiding the possibility of a `KeyError`.



Let's take the `simple_webapp.py` webapp for a spin to see how well the `/login`, `/logout`, and `/status` URLs perform. As with the last *Test Drive*, we're going to test this webapp using more than one browser in order to confirm that each browser maintains its own "login state" on the server. Let's start the webapp from our operating system's terminal:

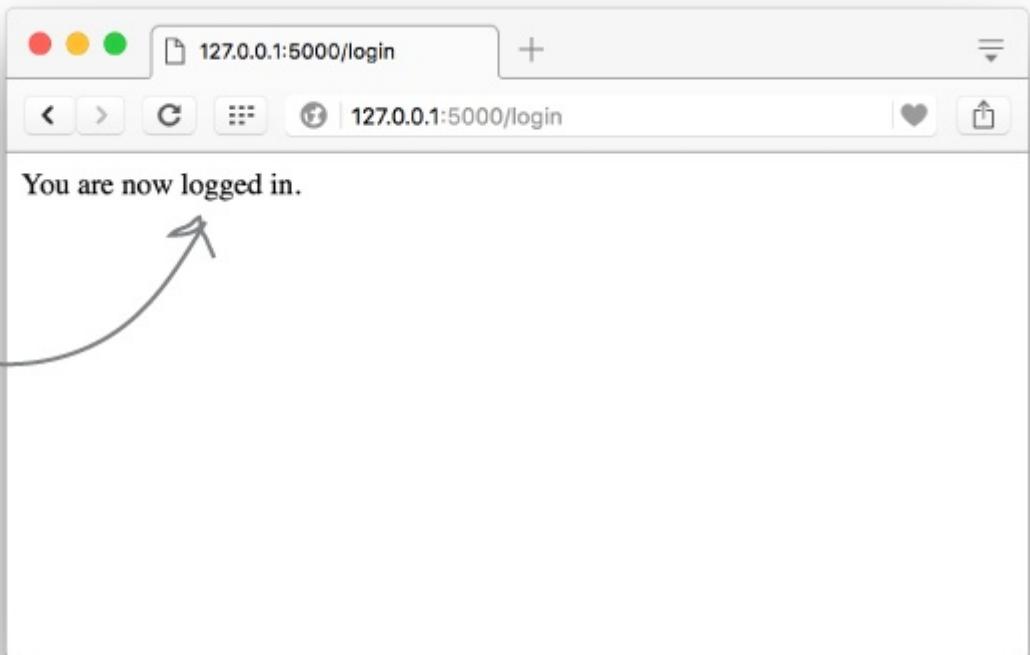
On Linux and Mac OS X:	<code>python3 simple_webapp.py</code>
On Windows:	<code>py -3 simple_webapp.py</code>

Let's fire up Opera and check its initial login status by accessing the `/status` URL. As expected, the browser is not logged in:

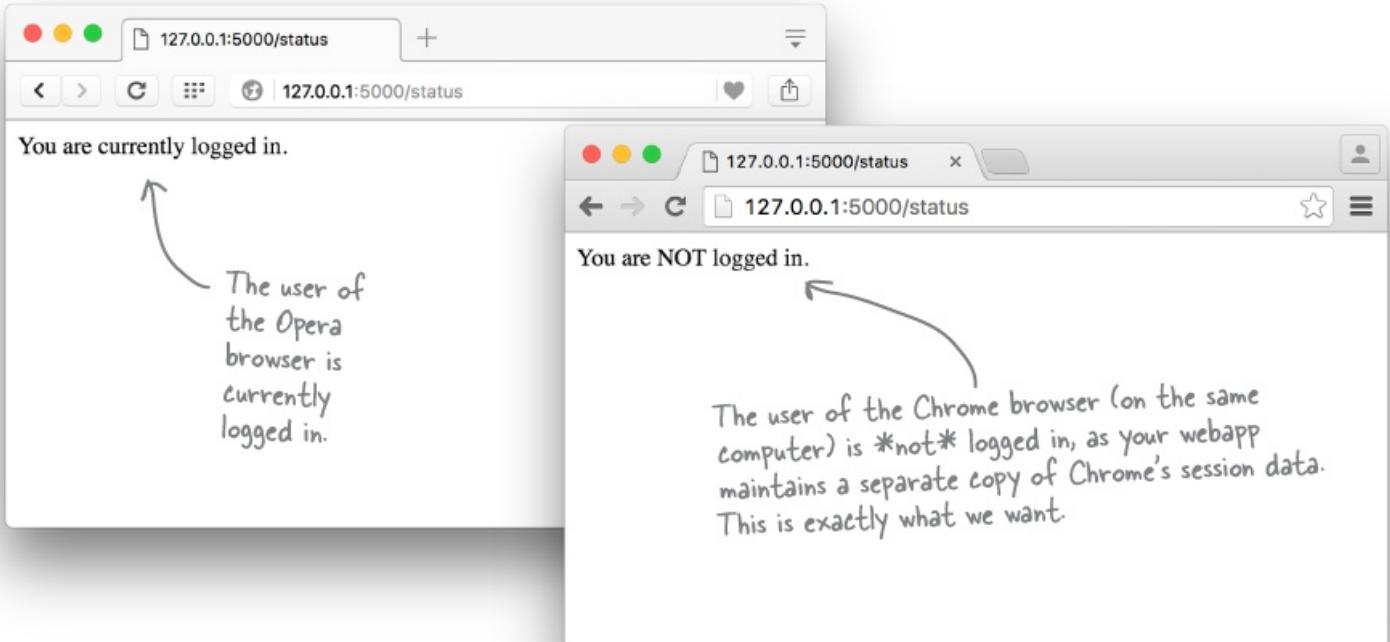


Let's simulate logging in, by accessing the `/login` URL. The message changes to confirm that the login was successful:

Accessing "/login" does exactly what is expected of it. The browser is now logged into the webapp.



Now that you are logged in, let's confirm the status change by accessing the /status URL within Opera. Doing so confirms that the user of the Opera browser is logged in. If you use Chrome to check the status, too, you'll see that the user of Chrome isn't logged in, which is exactly what we want (as each user of the webapp—each browser—has its own state maintained by the webapp):



To conclude, let's access the `/logout` URL within Opera to tell the webapp that we are logging out of the session:



Although we haven't asked any of our browser's users for a login ID or password, the `/login`, `/logout`, and `/status` URLs allow us to simulate what would happen to the webapp's session dictionary if we were to create the required HTML form, then hook up the form's data to a backend "credentials" database. The details of how this might happen are very much application-specific, but the basic mechanism (i.e., manipulating `session`) is the same no matter what a specific webapp might want to do.

Are we now ready to restrict access to the `/page1`, `/page2`, and `/page3` URLs?

Can We Now Restrict Access to URLs?

Jim: Hey, Frank...what are you stuck on?

Frank: I need to come up with a way to restrict access to the `/page1`, `/page2`, and `/page3` URLs...

Joe: It can't be that hard, can it? You've already got the code you need in the function that handles `/status`...

Frank: ...and it knows if a user's browser is logged in or not, right?

Joe: Yeah, it does. So, all you have to do is copy and paste that checking code from the function that handles `/status` into each of the URLs you want to restrict, and then you're home and dry!



Jim: Oh, man! Copy and paste...the web developer's *Achilles' heel*. You really don't want to copy and paste code like that... it can only lead to problems down the road.

Frank: Of course! CS 101... I'll create a function with the code from `/status`, then call *that* function as needed within the functions that handle the `/page1`, `/page2`, and `/page3` URLs. Problem solved.

Joe: I like that idea...and I think it'll work. (I knew there was a reason we sat through all those *boring* CS lectures.)

Jim: Hang on...not so fast. What you're suggesting with a function is much better than your copy-and-paste idea, but I'm still not convinced it's the best way to go here.

Frank and Joe (together, and incredulously): *What's not to like?!?!*

Jim: It bugs me that you're planning to add code to the functions that handle the `/page1`, `/page2`, and `/page3` URLs that has nothing to do with what those functions actually *do*. Granted, you need to check whether a user is logged in before granting access, but adding a function call to do this to every URL doesn't sit quite right with me...

Frank: So what's your big idea, then?

Jim: If it were me, I'd create, then use, a decorator.

Joe: Of course! That's an even better idea. Let's do that.

Copy-and-Paste Is Rarely a Good Idea

Let's convince ourselves that the ideas suggested on the last page are *not* the best way to approach the problem at hand—namely, how best to restrict access to specific web pages.

The first suggestion was to copy and paste some of the code from the function that handles the `/status` URL (namely, the `check_status` function). Here's the code in question:

This is the code to copy and paste.

```
@app.route('/status')
def check_status() -> str:
    if 'logged_in' in session:
        return 'You are currently logged in.'
    return 'You are NOT logged in.'
```

This code returns a different message based on whether or not the user's browser is logged in.

Here's what the `page1` function currently looks like:

```
@app.route('/page1')
def page1() -> str:
    return 'This is page 1.'
```

This is the page-specific functionality.

If we copy and paste the highlighted code from `check_status` into `page1`, the latter's code would end up looking like this:

```

@app.route('/page1')
def page1() -> str:
    if 'logged_in' in session:
        return 'This is page 1.'
    return 'You are NOT logged in.'

```

Check if the user's browser is logged in...

...then do the page-specific functionality.

Otherwise, inform the user that they are not logged in.

The above code works, but if you were to repeat this copy-and-paste activity for the `/page2` and `/page3` URLs (as well as any other URLs you were to add to your webapp), you'd quickly create a *maintenance nightmare*, especially when you consider all the edits you'd have to make should you decide to change how your login-checking code works (by, maybe, checking a submitted user ID and password against data stored in a database).

PUT SHARED CODE INTO ITS OWN FUNCTION

When you have code that you need to use in many different places, the classic solution to the maintenance problem inherent in any copy-and-paste “quick fix” is to put the shared code into a function, which is then invoked as needed.

As such a strategy solves the maintenance problem (as the shared code exists in only one place as opposed to being copied and pasted willy-nilly), let’s see what creating a login-checking function does for our webapp.

Creating a Function Helps, But...

Let’s create a new function called `check_logged_in`, which, when invoked, returns `True` if the user’s browser is currently logged in, and `False` otherwise.

It’s not a big job (most of the code is already in `check_status`); here’s how we’d write this new function:

```

def check_logged_in() -> bool:
    if 'logged_in' in session:
        return True
    return False

```

Rather than returning a message, this code returns a boolean based on whether or not the user's browser is logged in.

With this function written, let’s use it in the `page1` function instead of that copied and pasted code:

```

@app.route('/page1')
def page1() -> str:
    if not check_logged_in():
        return 'You are NOT logged in.'
    return 'This is page 1.'

```

This strategy is a bit better than copy-and-paste, as you can now change how the login process works by making changes to the `check_logged_in` function. However, to use the `check_logged_in` function you still have to make similar changes to the `page2` and `page3` functions (as well as to any new URLs you create), and you do that by copying and pasting this new code from `page1` into the other functions... In fact, if you compare what you did to the `page1` function on this page with what you did to `page1` on the last page, it's roughly the same amount of work, and it's *still* copy-and-paste! Additionally, with *both* of these “solutions,” the added code is **obscuring** what `page1` actually does.

It would be nice if you could somehow check if the user’s browser is logged in *without* having to amend *any* of your existing function’s code (so as not to obscure anything). That way, the code in each of your webapp’s functions can remain *directly* related to what each function does, and the login status-checking code won’t get in the way. If only there was a way to do this?

As we learned from our three friendly developers—Frank, Joe, and Jim—a few pages back, Python includes a language feature that can help here, and it goes by the name **decorator**. A decorator allows you to augment an existing function with extra code, and it does this by letting you change the behavior of the existing function *without* having to change its code.

If you’re reading that last sentence and saying: “*What?!?!*”, don’t worry: it does sound strange the first time you hear it. After all, how can you possibly change how a function works without changing the function’s code? Does it even make sense to try?

Let’s find out by learning about decorators.

You’ve Been Using Decorators All Along

You’ve been *using* decorators for as long as you’ve written webapps with Flask, which you started back in [Chapter 5](#).

Here’s the earliest version of the `hello_flask.py` webapp from that chapter, which highlights the use of a decorator called `@app.route`, which comes with Flask. The `@app.route` decorator is applied to an existing function (`hello` in this code), and the decorator augments the function it precedes by arranging to call `hello` whenever the webapp processes the / URL. Decorators are easy to spot; they’re prefixed with the @ symbol:

Here's the decorator,
which—like all decorators—
is prefixed with the @
symbol.

```
from flask import Flask  
  
app = Flask(__name__)  
  
@app.route('/')  
def hello() -> str:  
    return 'Hello world from Flask!'  
  
app.run()
```

Note how, as a user of the `@app.route` decorator, you have no idea how the decorator works its magic. All you're concerned with is that the decorator does what it promises: links a given URL with a function. All of the nitty-gritty, behind-the-scenes details of how the decorator works are hidden from you.

When you decide to create a decorator, you need to peek under the covers and (much like when you created a context manager in the last chapter) hook into Python's decorator machinery. There are four things that you need to know and understand to write a decorator:

1. **How to create a function**
2. **How to pass a function as an argument to a function**
3. **How to return a function from a function**
4. **How to process any number and type of function arguments**

You've been successfully creating and using your own functions since [Chapter 4](#), which means this list of “four things to know” is really only three. Let's take some time to work through items 2 through 4 from this list as we progress toward writing a decorator of our own.

Pass a Function to a Function

It's been a while, but way back in [Chapter 2](#) we introduced the notion that *everything is an object* in Python. Although it may sound counterintuitive, the “everything” includes functions, which means functions are objects, too.

<input type="checkbox"/>	Pass a function to a function.
<input type="checkbox"/>	Return a function from a function.
<input type="checkbox"/>	Process any number/type of arguments.

NOTE

We'll check off each completed topic as we work through this material.

Clearly, when you invoke a function, it runs. However, like everything else in Python, functions are objects, and have an object ID: think of functions as “function objects.”

Take a quick look at the short IDLE session below. A string is assigned to a variable called `msg`, and then its object ID is reported through a call to the `id` built-in function (BIF). A small function, called `hello`, is then defined. The `hello` function is then passed to the `id` BIF that reports the function’s object ID. The `type` BIF then confirms that `msg` is a string and `hello` is a function, and finally `hello` is invoked and prints the current value of `msg` on screen:

```
Python 3.5.1 Shell
>>>
>>> msg = "Hello from Head First Python 2e"
>>> id(msg)
4385961264
>>> def hello():
    print(msg)

>>> id(hello)
4389417984
>>> type(msg)
<class 'str'>
>>> type(hello)
<class 'function'>
>>> hello()
Hello from Head First Python 2e
>>>
```

The “`id`” BIF reports the unique object identifier for any object provided to it.

The “`type`” BIF reports on an object’s type.

Ln: 20 Col: 4

We were a little devious in not drawing your attention to this before we had you look at the above IDLE session, but...did you notice *how* we passed `hello` to the `id` and `type` BIFs? We didn’t invoke `hello`; we passed its *name* to each of the functions as an argument. In doing so, we passed a function to a function.

FUNCTIONS CAN TAKE A FUNCTION AS AN ARGUMENT

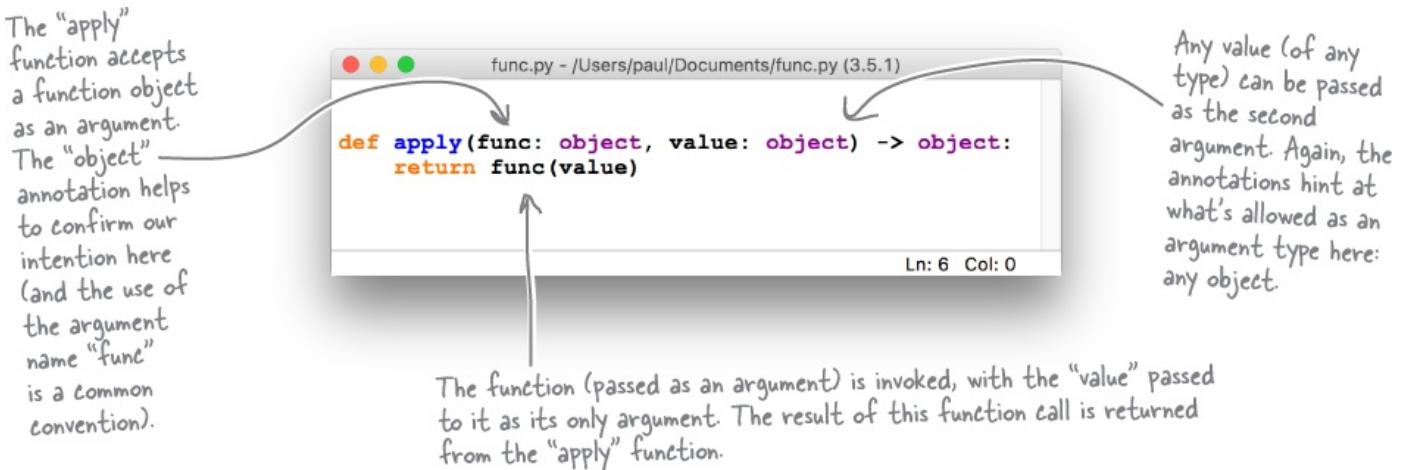
The calls to `id` and `type` above demonstrate that some of Python’s built-in functions accept a function as an argument (or to be more precise: *a function object*). What a function does with the argument is up to the function. Neither `id` nor `type` invokes the function, although it could have. Let’s see how that works.

Invoking a Passed Function

When a function object is passed as an argument to a function, the receiving function can *invoke* the passed-in function object.

<input type="checkbox"/>	Pass a function to a function.
<input type="checkbox"/>	Return a function from a function.
<input type="checkbox"/>	Process any number/type of arguments.

Here's a small function (called `apply`) that takes two arguments: a function object and a value. The `apply` function invokes the function object and passes the value to the invoked function as an argument, returning the results of invoking the function on the value to the calling code:



Note how `apply`'s annotations hint that it accepts any function object together with any value, then returns anything (which is all very *generic*). A quick test of `apply` at the `>>>` prompt confirms that `apply` works as expected:

The screenshot shows the Python 3.5.1 Shell with the following interactions:

```
>>>
>>> apply(print, 42)
42
>>> apply(id, 42)
4297539264
>>> apply(type, 42)
<class 'int'>
>>> apply(len, 'Marvin')
6
>>> apply(type, apply)
<class 'function'>
>>> |
```

Annotations and comments explain the interactions:

- The "apply" function runs a bunch of BIFs against some values (and works as expected).
- The "apply" function takes any object for "value". In this example, it takes itself as "value" and confirms that it's a function.
- In each of these examples, the first argument to "apply" is assigned to the "func" argument (above).

If you're reading this page and wondering when you'd ever need to do something like this, don't fret: we'll get to that when we write our decorator. For now, concentrate on understanding that it's possible to pass a function object to a function, which the latter can then invoke.

Functions Can Be Nested Inside Functions

Usually, when you create a function, you take some existing code and make it reusable by giving it a name, and using the existing code as the function's suite. This is the most common function use case. However, what sometimes comes as a surprise is that, in Python, the code in a function's suite can be *any* code, including code that defines another function (often referred to as a *nested* or *inner* function). Even more surprising is that the nested function can be *returned* from the outer, enclosing function; in effect, what gets returned is a *function object*. Let's look at a few examples that demonstrate these other, less common function use cases.

<input checked="" type="checkbox"/>	Pass a function to a function.
<input type="checkbox"/>	Return a function from a function.
<input type="checkbox"/>	Process any number/type of arguments.

First up is an example that shows a function (called `inner`) nested inside another function (called `outer`). It is not possible to invoke `inner` from anywhere other than within `outer`'s suite, as `inner` is local in scope to `outer`:

The diagram illustrates a nested function call. On the left, handwritten text states: "The 'inner' function is defined within the enclosing function's suite." An arrow points from this text to the opening brace of the inner function definition. On the right, handwritten text states: "The 'inner' function is invoked from 'outer'." An arrow points from this text to the call to `inner()` within the `outer()` function. The code itself is as follows:

```
def outer():
    def inner():
        print('This is inner.')
    print('This is outer, invoking inner.')
    inner()
```

When `outer` is invoked, it runs all the code in its suite: `inner` is defined, the call to the `print` BIF in `outer` is executed, and then the `inner` function is invoked (which calls the `print` BIF within `inner`). Here's what appears on screen:

This is outer, invoking inner.
This is inner.



The printed
messages appear in
the order: "outer"
first, then "inner".

WHEN WOULD YOU EVER USE THIS?

Looking at this simple example, you might find it hard to think of a situation where creating a function inside another function would be useful. However, when a function is complex and contains many lines of code, abstracting some of the function's code into a nested function often makes sense (and can make the enclosing function's code easier to read).

A more common usage of this technique arranges for the enclosing function to return the nested function as its value, using the `return` statement. This is what allows you to create a decorator.

So, let's see what happens when we return a function from a function.

Return a Function from a Function

Our second example is very similar to the first, but for the fact that the `outer` function no longer invokes `inner`, but instead returns it. Take a look at the code:

<input checked="" type="checkbox"/>	Pass a function to a function.
<input type="checkbox"/>	Return a function from a function.
<input type="checkbox"/>	Process any number/type of arguments.

The "inner"
function is still
defined within
"outer".

```
def outer():
    def inner():
        print('This is inner.')
    print('This is outer, returning inner.')
    return inner
```

The "return" statement does not
invoke "inner"; instead, it returns
the "inner" function object to the
calling code.

Let's see what this new version of the `outer` function does, by returning to the IDLE shell and taking `outer` for a spin.

Note how we assign the result of invoking `outer` to a variable, called `i` in this example. We then use `i` as if it were a function object—first checking its type by invoking the `type` BIF, then invoking `i` as we would any other function (by appending parentheses). When we invoke `i`, the `inner` function executes. In effect, `i` is now an *alias* for the `inner` function as created inside `outer`:

The screenshot shows a Python 3.5.1 Shell window. The code entered is:

```
>>> i = outer()
This is outer, returning inner.
>>> type(i)
<class 'function'>
>>> i()
This is inner.
>>>
>>> |
```

Annotations with arrows explain the steps:

- An arrow points from the text "The result of calling 'outer'" to the line `i = outer()`.
- An arrow points from the text "The 'outer' function is invoked." to the line `i()`.
- An arrow points from the text "We check that 'i' is, in fact, a function." to the line `type(i)`.
- An arrow points from the text "We invoke 'i' and—voila!—the 'inner' function's code executes." to the line `i()`.

Bottom right of the shell window: Ln: 115 Col: 4

So far, so good. You can now *return* a function from a function, as well as *send* a function to a function. You're nearly ready to put all this together in your quest to create a decorator. There's just one more thing you need to understand: creating a function that can handle any number and type of arguments. Let's look at how to do this now.

Accepting a List of Arguments

Imagine you have a requirement to create a function (which we'll call `myfunc` in this example) that can be called with any number of arguments. For example, you might call `myfunc` like this:

<input checked="" type="checkbox"/>	Pass a function to a function.
<input checked="" type="checkbox"/>	Return a function from a function.
<input type="checkbox"/>	Process any number/type of arguments.

NOTE

You're nearly there. One more topic to cover, and then you'll be ready to create a decorator.

myfunc(10) 
One argument

or you might call `myfunc` like this:

myfunc() 
No arguments

or you might call `myfunc` like this:

myfunc(10, 20, 30, 40, 50, 60, 70) 
Many arguments (which, in this example, are all numbers, but could be anything: numbers, strings, booleans, list.)

In fact, you might call `myfunc` with *any* number of arguments, with the proviso that you don't know ahead of time how many arguments are going to be provided.

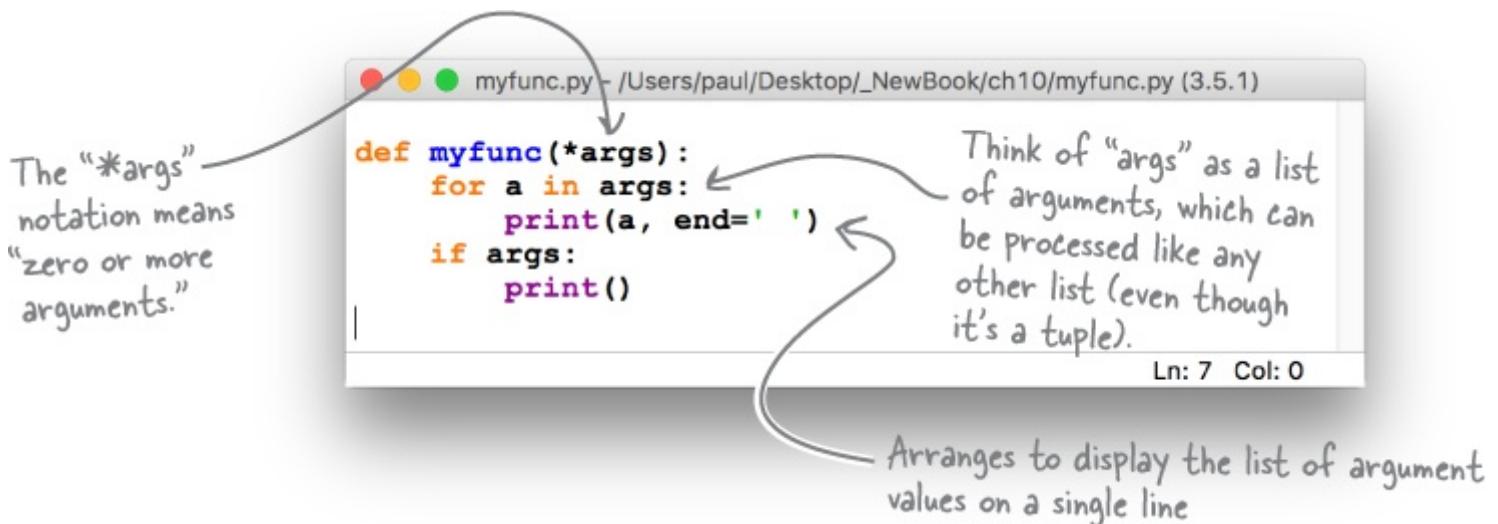
As it isn't possible to define three distinct versions of `myfunc` to handle each of the three above invocations, the question becomes: *is it possible to accept any number of arguments in a function?*

USE * TO ACCEPT AN ARBITRARY LIST OF ARGUMENTS

Python provides a special notation that allows you to specify that a function can take any number of arguments (where "any number" means "zero or more"). This notation uses the `*` character to represent *any number*, and is combined with an argument name (by convention, `args` is used) to specify that a function can accept an arbitrary list of arguments (even though `*args` is technically a tuple).

Think of `*` as meaning "expand to a list of values."

Here's a version of `myfunc` that uses this notation to accept any number of arguments when invoked. If any arguments are provided, `myfunc` prints their values to the screen:



Processing a List of Arguments

Now that `myfunc` exists, let's see if it can handle the example invocations from the last page, namely:

<input checked="" type="checkbox"/>	Pass a function to a function.
<input checked="" type="checkbox"/>	Return a function from a function.
<input type="checkbox"/>	Process any number/type of arguments.

`myfunc(10)`

`myfunc()`

`myfunc(10, 20, 30, 40, 50, 60, 70)`

Here's another IDLE session that confirms that `myfunc` is up to the task. No matter how many arguments we supply (including *none*), `myfunc` processes them accordingly:

No matter
the number of
arguments provided, →
“myfunc” does
the right thing
(i.e., processes
its arguments, no
matter how many).

The screenshot shows a Python 3.5.1 Shell window. The code entered is:

```
>>>
>>> myfunc(10)
10
>>> myfunc()
>>> myfunc(10, 20, 30, 40, 50, 60, 70)
10 20 30 40 50 60 70
>>>
>>> myfunc(1, 'two', 3, 'four', 5, 'six', 7)
1 two 3 four 5 six 7
>>> |
```

Annotations in the image:

- A bracket on the left groups the first three examples, with an arrow pointing to the handwritten note: "No matter the number of arguments provided, → ‘myfunc’ does the right thing (i.e., processes its arguments, no matter how many)."
- An annotation above the fourth example says: "When provided with no arguments, ‘myfunc’ does nothing."
- An annotation below the fifth example says: "You can even mix and match the types of the values provided, and ‘myfunc’ still does the right thing."

* WORKS ON THE WAY IN, TOO

If you provide a list to `myfunc` as an argument, the list (despite potentially containing many values) is treated as one item (i.e., it's *one* list). To instruct the interpreter to **expand** the list to behave as if each of the list's items were an *individual* argument, prefix the list's name with the * character when invoking the function.

Another short IDLE session demonstrates the difference using * can have:

The list is
processed as a
single argument
to the function.

The screenshot shows a Python 3.5.1 Shell window. The code entered is:

```
>>>
>>> values = [1, 2, 3, 5, 7, 11]
>>>
>>> myfunc(values)
[1, 2, 3, 5, 7, 11]
>>>
>>> myfunc(*values)
1 2 3 5 7 11
>>>
>>> |
```

Annotations in the image:

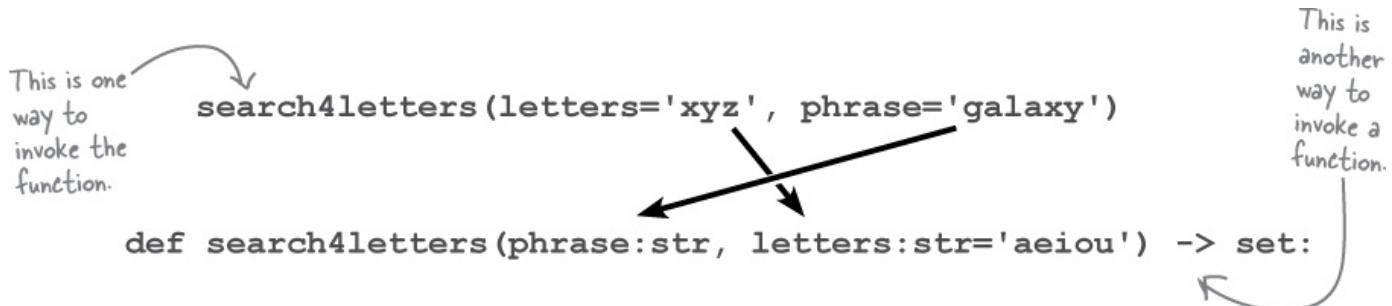
- An annotation points to the line `values = [1, 2, 3, 5, 7, 11]` with the text: "The list is processed as a single argument to the function."
- An annotation points to the line `values` with the text: "A list of six integers".
- An annotation points to the line `myfunc(*values)` with the text: "When a list is prefixed with ‘*’, it expands to a list of individual arguments."

Accepting a Dictionary of Arguments

When it comes to sending values into functions, it's also possible to provide the names of the arguments together with their associated values, then rely on the interpreter to match things up accordingly.

<input checked="" type="checkbox"/>	Pass a function to a function.
<input checked="" type="checkbox"/>	Return a function from a function.
<input type="checkbox"/>	Process any number/type of arguments.

You first saw this technique in [Chapter 4](#) with the `search4letters` function, which—you may recall—expects two argument values, one for `phrase` and another for `letters`. When keyword arguments are used, the order in which the arguments are provided to the `search4letters` function doesn't matter:



Like with lists, it's also possible to arrange for a function to accept an arbitrary number of keyword arguments—that is, keys with values assigned to them (as with `phrase` and `letters` in the above example).

USE ** TO ACCEPT ARBITRARY KEYWORD ARGUMENTS

In addition to the `*` notation, Python also provides `**`, which expands to a collection of keyword arguments. Where `*` uses `args` as its variable name (by convention), `**` uses `kwargs`, which is short for “keyword arguments.” (Note: you can use names other than `args` and `kwargs` within this context, but very few Python programmers do.)

Think of `` as meaning “expand to a dictionary of keys and values.”**

Let's look at another function, called `myfunc2`, which accepts any number of keyword arguments:

```

def myfunc(*args):
    for a in args:
        print(a, end=' ')
    if args:
        print()

def myfunc2(**kwargs):
    for k, v in kwargs.items():
        print(k, v, sep='->', end=' ')
    if kwargs:
        print()

```

Within the function, "kwargs" behaves just like any other dictionary.

The "<<" tells the function to expect keyword arguments.

Take each key and value pairing in the dictionary, and display it on screen.

Ln: 13 Col: 0

Processing a Dictionary of Arguments

The code within `myfunc2`'s suite takes the dictionary of arguments and processes them, displaying all the key/value pairings on a single line.

<input checked="" type="checkbox"/>	Pass a function to a function.
<input checked="" type="checkbox"/>	Return a function from a function.
<input type="checkbox"/>	Process any number/type of arguments.

Here's another IDLE session that demonstrates `myfunc2` in action. No matter how many key/value pairings are provided (including none), `myfunc2` does the right thing:

```

Python 3.5.1 Shell
>>> myfunc2(a=10, b=20)
b->20 a->10
>>> myfunc2()
>>> myfunc2(a=10, b=20, c=30, d=40, e=50, f=60)
b->20 f->60 d->40 c->30 e->50 a->10
>>>
>>>

```

Two keyword arguments provided

Providing no arguments isn't an issue.

You can provide any number of keyword arguments, and "myfunc2" does the right thing.

Ln: 24 Col: 4

** WORKS ON THE WAY IN, TOO

You probably guessed this was coming, didn't you? As with `*args`, when you use `**kwargs` it's also possible to use `**` when invoking the `myfunc2` function. Rather than demonstrate how this works with `myfunc2`, we're going to remind you of a prior usage of this technique from earlier in this book. Back in [Chapter 7](#), when you learned how to use Python's DB-API, you defined a dictionary of connection characteristics as follows:



```
dbconfig = { 'host': '127.0.0.1',
              'user': 'vsearch',
              'password': 'vsearchpasswd',
              'database': 'vsearchlogDB', }
```

When it came time to establish a connection to your waiting MySQL (or MariaDB) database server, you used the `dbconfig` dictionary as follows. Notice anything about the way the `dbconfig` argument is specified?



```
conn = mysql.connector.connect(**dbconfig)
```

By prefixing the `dbconfig` argument with `**`, we tell the interpreter to treat the single dictionary as a collection of keys and their associated values. In effect, it's as if you invoked `connect` with four individual keyword arguments, like this:

```
conn = mysql.connector.connect('host'= '127.0.0.1', 'user'= 'vsearch',
                               'password'= 'vsearchpasswd',
                               'database'= 'vsearchlogDB')
```

Accepting Any Number and Type of Function Arguments

When creating your own functions, it's neat that Python lets you accept a list of arguments (using `*`), in addition to any number of keyword arguments (using `**`). What's even neater is that you can combine the two techniques, which lets you create a function that can accept any number and type of arguments.

<input checked="" type="checkbox"/>	Pass a function to a function.
<input checked="" type="checkbox"/>	Return a function from a function.



Process any number/type of arguments.

Here's a third version of `myfunc` (which goes by the shockingly imaginative name of `myfunc3`). This function accepts any list of arguments, any number of keyword arguments, or a combination of both:

The original "myfunc" works with any list of arguments. →

The "myfunc2" function works with any amount of key/value pairs. →

The "myfunc3" function works with any input, whether a list of arguments, a bunch of key/value pairs, or both. →

```
myfunc.py - /Users/paul/Desktop/_NewBook/ch10/myfunc.py (3.5.1)

def myfunc(*args):
    for a in args:
        print(a, end=' ')
    if args:
        print()

def myfunc2(**kwargs):
    for k, v in kwargs.items():
        print(k, v, sep='->', end=' ')
    if kwargs:
        print()

def myfunc3(*args, **kwargs):
    if args:
        for a in args:
            print(a, end=' ')
        print()
    if kwargs:
        for k, v in kwargs.items():
            print(k, v, sep='->', end=' ')
        print()

Ln: 7 Col: 0
```

This short IDLE session showcases `myfunc3`:

Works with no arguments

Works with a combination of a list and keyword arguments →

```
Python 3.5.1 Shell

>>>
>>> myfunc3()
>>> myfunc3(1, 2, 3) ← Works with a list
1 2 3
>>> myfunc3(a=10, b=20, c=30) ← Works with keyword arguments
a->10 b->20 c->30
>>> myfunc3(1, 2, 3, a=10, b=20, c=30)
1 2 3
a->10 b->20 c->30
>>> |

Ln: 68 Col: 4
```

A Recipe for Creating a Function Decorator

<input checked="" type="checkbox"/>	Pass a function to a function.
<input checked="" type="checkbox"/>	Return a function from a function.
<input checked="" type="checkbox"/>	Process any number/type of arguments.

NOTE

We're ready to have a go at writing our own decorator.

With three items marked in the checklist on the right, you now have an understanding of the Python language features that allow you to create a decorator. All you need to know now is how you take these features and combine them to create the decorator you need.

Just like when you created your own context manager (in the last chapter), creating a decorator conforms to a set of rules or *recipe*. Recall that a decorator allows you to augment an existing function with extra code, without requiring you to change the existing function's code (which, we'll admit, still sounds freaky).

To create a function decorator, you need to know that:

1. A decorator is a function

In fact, as far as the interpreter is concerned, your decorator is *just another function*, albeit one that manipulates an existing function. Let's refer to this existing function as *the decorated function* from here on in. Having made it this far in this book, you know that creating a function is easy: use Python's `def` keyword.

2. A decorator takes the decorated function as an argument

A decorator needs to accept the decorated function as an argument. To do this, you simply pass the decorated function as a *function object* to your decorator. Now that you've worked through the last 10 pages, you know that this too is easy: you arrive at a function object by referring to the function *without* parentheses (i.e., using just the function's name).

3. A decorator returns a new function

A decorator returns a new function as its return value. Much like when `outer` returned `inner` (a few pages back), your decorator is going to do something similar, except that the function it returns needs to *invoke* the decorated function. Doing this is—*dare we say it?*—easy but for one small complication, which is what Step 4 is all about.

4. A decorator maintains the decorated function's signature

A decorator needs to ensure that the function it returns takes the same number and type of arguments as expected by the decorated function. The number and type of any function's arguments is known as its **signature** (as each function's `def` line is unique).

It's time to grab a pencil and put this information to work creating your first decorator.

Recap: We Need to Restrict Access to Certain URLs



We've been working with the `simple_webapp.py` code, and we need our decorator to check to see whether the user's browser is logged in or not. If it is logged in, restricted web pages are visible. If the browser isn't logged in, the webapp should advise the user to log in prior to viewing any restricted pages. We'll create a decorator to handle this logic. Recall the `check_status` function, which demonstrates the logic we want our decorator to mimic:

We want to avoid copying and pasting this code.

```
@app.route('/status')
def check_status() -> str:
    if 'logged_in' in session:
        return 'You are currently logged in.'
    return 'You are NOT logged in.'
```

Remember: this code returns a different message based on whether or not the user's browser is logged in.

Creating a Function Decorator

To comply with item 1 in our list, you had to create a new function. Remember:

1. A decorator is a function

In fact, as far as the interpreter is concerned, your decorator is *just another function*, albeit one that manipulates an existing function. Let's refer to this existing function as *the decorated function* from here on in. You know that creating a function is easy: use Python's `def` keyword.

Complying with item 2 involves ensuring your decorator accepts a function object as an argument. Again, remember:

2. A decorator takes the decorated function as an argument

Your decorator needs to accept the decorated function as an argument. To do this, you simply pass the decorated function as a *function object* to your decorator. You arrive at a function object by referring to the function *without* parentheses (i.e., using the function's name).

SHARPEN YOUR PENCIL



Let's put your decorator in its own module (so that you can more easily reuse it). Begin by creating a new file called `checker.py` in your text editor.

You're going to create a new decorator in `checker.py` called `check_logged_in`. In the space below, provide your decorator's `def` line. Hint: use `func` as the name of your function object argument:

Put the decorator's
"def" line here.

THERE ARE NO DUMB QUESTIONS

Q: Q: Does it matter where on my system I create checker.py?

- A:** A: Yes. Our plan is to import `checker.py` into `webapps` that need it, so you need to ensure that the interpreter can find it when your code includes the `import checker` line. For now, put `checker.py` in the same folder as `simple_webapp.py`.

SHARPEN YOUR PENCIL SOLUTION



We decided to put your decorator in its own module (so that you can more easily reuse it).

You began by creating a new file called `checker.py` in your text editor.

Your new decorator (in `checker.py`) is called `check_logged_in` and, in the space below, you were to provide your decorator's `def` line:

```
def check_logged_in(func):
```

The “`check_logged_in`” decorator takes
a single argument: the function object of
the decorated function.

THAT'S ALMOST TOO EASY, ISN'T IT?

Remember: a decorator is *just another function*, which takes a function object as an argument (`func` in the above `def` line).

Let's move on to the next item in our “create a decorator” recipe, which is a little more involved (but not by much). Recall what you need your decorator to do:

3. A decorator returns a new function

Your decorator returns a new function as its return value. Just like when `outer` returned `inner` (a few pages back), your decorator is going to do something similar, except that the function it returns needs to *invoke* the decorated function.

Earlier in this chapter, you met the `outer` function, which, when invoked, returned the `inner` function. Here's `outer`'s code once more:

```

def outer():
    def inner():
        print('This is inner.')
    print('This is outer, returning inner.')
    return inner

```

All of this code is in the "outer" function's suite.

The "inner" function is nested inside "outer".

The "inner" function object is returned as the result of invoking "outer". Note the lack of parentheses after "inner", as we're returning a function object. We are **not** invoking "inner".

SHARPEN YOUR PENCIL



Now that you've written your decorator's `def` line, let's add some code to its suite. You need to do four things here.

1. Define a nested function called `wrapper` that is returned by `check_logged_in`. (You could use any function name here, but, as you'll see in a bit, `wrapper` is a pretty good choice.)
2. Within `wrapper`, add some of the code from your existing `check_status` function that implements one of two behaviors based on whether the user's browser is logged in or not. To save you the page-flip, here's the `check_status` once more (with the important bits highlighted):

```

@app.route('/status')
def check_status() -> str:
    if 'logged_in' in session:
        return 'You are currently logged in.'
    return 'You are NOT logged in.'

```

3. As per item 3 of our decorator-creating recipe, you need to adjust the nested function's code so that it invokes the decorated function (as opposed to returning the "You are currently logged in" message).
4. With the nested function written, you need to return its function object from `check_logged_in`.

Add the required code to `check_logged_in`'s suite in the spaces provided below:

```
def check_logged_in(func):
```

1. Define your nested function.

4. Don't forget to return the nested function.

2 and 3. Add the code you want the nested function to execute.

SHARPEN YOUR PENCIL SOLUTION



With your decorator's `def` line written, you were to add some code to its suite. You needed to do four things:

1. Define a nested function called `wrapper` that is returned by `check_logged_in`.
2. Within `wrapper`, add some of the code from your existing `check_status` function that implements one of two behaviors based on whether the user's browser is logged in or not.
3. As per item 3 of our decorator-creating recipe, adjust the nested function's code so that it invokes the decorated function (as opposed to returning the "You are currently logged in" message).
4. With the nested function written, return its function object from `check_logged_in`.

You were to add the required code to `check_logged_in`'s suite in the spaces provided:

```
def check_logged_in(func):  
    def wrapper():  
        if 'logged_in' in session:  
            return func()  
        return 'You are NOT logged in.'  
    return wrapper
```

A nested "def" line starts the "wrapper" function.

If the user's browser is logged in... ...invoke the decorated function.

Did you remember to return the nested function?

If the user's browser isn't logged in, return an appropriate message.

CAN YOU SEE WHY THE NESTED FUNCTION IS CALLED “WRAPPER”?

If you take a moment to study the decorator’s code (so far), you’ll see that the nested function not only invokes the decorated function (stored in `func`), but also augments it by *wrapping* extra code around the call. In this case, the extra code is checking to see if the `logged_in` key exists within your webapp’s `session`. Critically, if the user’s browser is *not* logged in, the decorated function is *never* invoked by `wrapper`.

The Final Step: Handling Arguments

We are nearly there—the “guts” of the decorator’s code is in place. What remains is to ensure the decorator handles the decorated function’s arguments properly, no matter what they might be. Recall item 4 from the recipe:

4. A decorator maintains the decorated function’s signature

Your decorator needs to ensure that the function it returns takes the same number and type of arguments as expected by the decorated function.

When a decorator is applied to an existing function, any calls to the existing function are **replaced** by calls to the function returned by the decorator. As you saw in the solution on the previous page, to comply with item 3 of our decorator-creation recipe, we return a wrapped version of the existing function, which implements extra code as needed. This wrapped version *decorates* the existing function.

But there’s a problem with this, as doing the wrapping on its own is not enough; the *calling characteristics* of the decorated function need to be maintained, too. This means, for instance, that if your existing function accepts two arguments, your wrapped function also has to accept two arguments. If you could know ahead of time how many arguments to expect, then you could plan accordingly. Unfortunately, you can’t know this ahead of time because your decorator can be applied to any existing function, which could have—quite literally—any number and type of arguments.

Remember: `*args` and `kwargs` support any number and type of arguments.**

What to do? The solution is to go “generic,” and arrange for the `wrapper` function to support any number and type of arguments. You already know how to do this, as you’ve already seen what `*args` and `**kwargs` can do.

SHARPEN YOUR PENCIL



Let's adjust the `wrapper` function to accept any number and type of arguments. Let's also ensure that when `func` is invoked, it uses the same number and type of arguments as were passed to `wrapper`. Add in the argument code in the spaces provided below:

What do you need to add to the "wrapper" function's signature?

```
def check_logged_in(func):  
    def wrapper( ..... ):  
        if 'logged_in' in session:  
            return func( ..... )  
        return 'You are NOT logged in.'  
    return wrapper
```

SHARPEN YOUR PENCIL SOLUTION



You were to adjust the `wrapper` function to accept any number and type of arguments, as well as ensure that, when `func` is invoked, it uses the same number and type of arguments as were passed to `wrapper`:

Using a generic signature does the trick here, as it supports any number and type of arguments. Note how we invoke "func" with the same arguments supplied to "wrapper", no matter what they are.

```
def check_logged_in(func):  
    def wrapper( *args, **kwargs ..... ):  
        if 'logged_in' in session:  
            return func( *args, **kwargs ..... )  
        return 'You are NOT logged in.'  
    return wrapper
```

WE'RE DONE...OR ARE WE?

If you check our decorator-creating recipe, you'd be forgiven for believing that we're done. We are...almost. There are two issues that we still need to deal with: one has to do with all decorators, whereas the other has to do with this specific one.

Let's get the specific issue out of the way first. As the `check_logged_in` decorator is in its own module, we need to ensure that any modules its code refers to are also imported into `checker.py`. The `check_logged_in` decorator uses `session`, which has to be imported from Flask to avoid errors. Handling this is straightforward, as all you need to do is add this `import` statement to the top of `checker.py`:

```
from flask import session
```

The other issue, which affects *all* decorators, has to do with how functions identify themselves to the interpreter. When decorated, and if due care is not taken, a function can forget its identity, which can lead to problems. The reason why this happens is very technical and a little exotic, and it requires a knowledge of Python's internals that most people don't need (or want) to know. Consequently, Python's standard library comes with a module that handles these details for you (so you need never worry about them). All you have to do is remember to import the required module (`functools`), then call a single function (`wraps`).

When creating your own decorators, always import, then use, the “`functools`” module’s “`wraps`” function.

Perhaps somewhat ironically, the `wraps` function is implemented as a decorator, so you don't actually call it, but rather use it to decorate your `wrapper` function *inside* your own decorator. We've already gone ahead and done this for you, and you'll find the code to the completed `check_logged_in` decorator at the top of the next page.

Your Decorator in All Its Glory

Before continuing, make sure your decorator code *exactly* matches ours:

```
checker.py - /Users/paul/Desktop/_NewBook/ch10/checker.py (3.5.1)

from flask import session
from functools import wraps

def check_logged_in(func):
    @wraps(func)
    def wrapper(*args, **kwargs):
        if 'logged_in' in session:
            return func(*args, **kwargs)
        return 'You are NOT logged in.'
    return wrapper
```

Be sure to import "session" from the "flask" module.

Import the "wraps" function (which is itself a decorator) from the "functools" module (which is part of the standard library).

Decorate the "wrapper" function with the "wraps" decorator (being sure to pass "func" as an argument).

Now that the `checker.py` module contains a completed `check_logged_in` function, let's put it to use within `simple_webapp.py`. Here is the current version of the code to this webapp (which we're showing here over two columns):

```
from flask import Flask, session
```

```
app = Flask(__name__)

@app.route('/')
def hello() -> str:

    return 'Hello from the simple webapp.'

@app.route('/page1')
def page1() -> str:

    return 'This is page 1.'

@app.route('/page2')
def page2() -> str:

    return 'This is page 2.'

@app.route('/page3')
def page3() -> str:

    return 'This is page 3.'

@app.route('/login')
def do_login() -> str:

    session['logged_in'] = True

    return 'You are now logged in.'
```

```

@app.route('/logout')

def do_logout() -> str:

    session.pop('logged_in')

    return 'You are now logged out.'


@app.route('/status')

def check_status() -> str:

    if 'logged_in' in session:

        return 'You are currently logged in.'

    return 'You are NOT logged in.'


app.secret_key = 'YouWillNeverGuess...'

if __name__ == '__main__':
    app.run(debug=True)

```

NOTE

Recall that our goal here is to restrict access to the `/page1`, `/page2`, and `/page3` URLs, which are currently accessible to any user's browser (based on this code).

Putting Your Decorator to Work

Adjusting the `simple_webapp.py` code to use the `check_logged_in` decorator is not difficult. Here's a list of what needs to happen:

- 1. Import the decorator**

The `check_logged_in` decorator needs to be imported from the `checker.py` module. Adding the required `import` statement to the top of our webapp's code does the trick here.

2. Remove any unnecessary code

Now that the `check_logged_in` decorator exists, we no longer have any need for the `check_status` function, so it can be removed from `simple_webapp.py`.

3. Use the decorator as required

To use the `check_logged_in` decorator, apply it to any of our webapp's functions using the `@` syntax.

Here's the code to `simple_webapp.py` once more, with the three changes listed above applied. Note how the `/page1`, `/page2`, and `/page3` URLs now have two decorators associated with them: `@app.route` (which comes with Flask), and `@check_logged_in` (which you've just created):

```
from flask import Flask, session
from checker import check_logged_in

app = Flask(__name__)

@app.route('/')
def hello() -> str:
    return 'Hello from the simple webapp.'

@app.route('/page1')
@check_logged_in
def page1() -> str:
    return 'This is page 1.'

@app.route('/page2')
@check_logged_in
def page2() -> str:
    return 'This is page 2.'

@app.route('/page3')
@check_logged_in
def page3() -> str:
    return 'This is page 3.'

@app.route('/login')
def do_login() -> str:
    session['logged_in'] = True
    return 'You are now logged in.'

@app.route('/logout')
def do_logout() -> str:
    session.pop('logged_in')
    return 'You are now logged out.'

app.secret_key = 'YouWillNeverGuess...'

if __name__ == '__main__':
    app.run(debug=True)
```

Apply a decorator to an existing function using the `@` syntax.

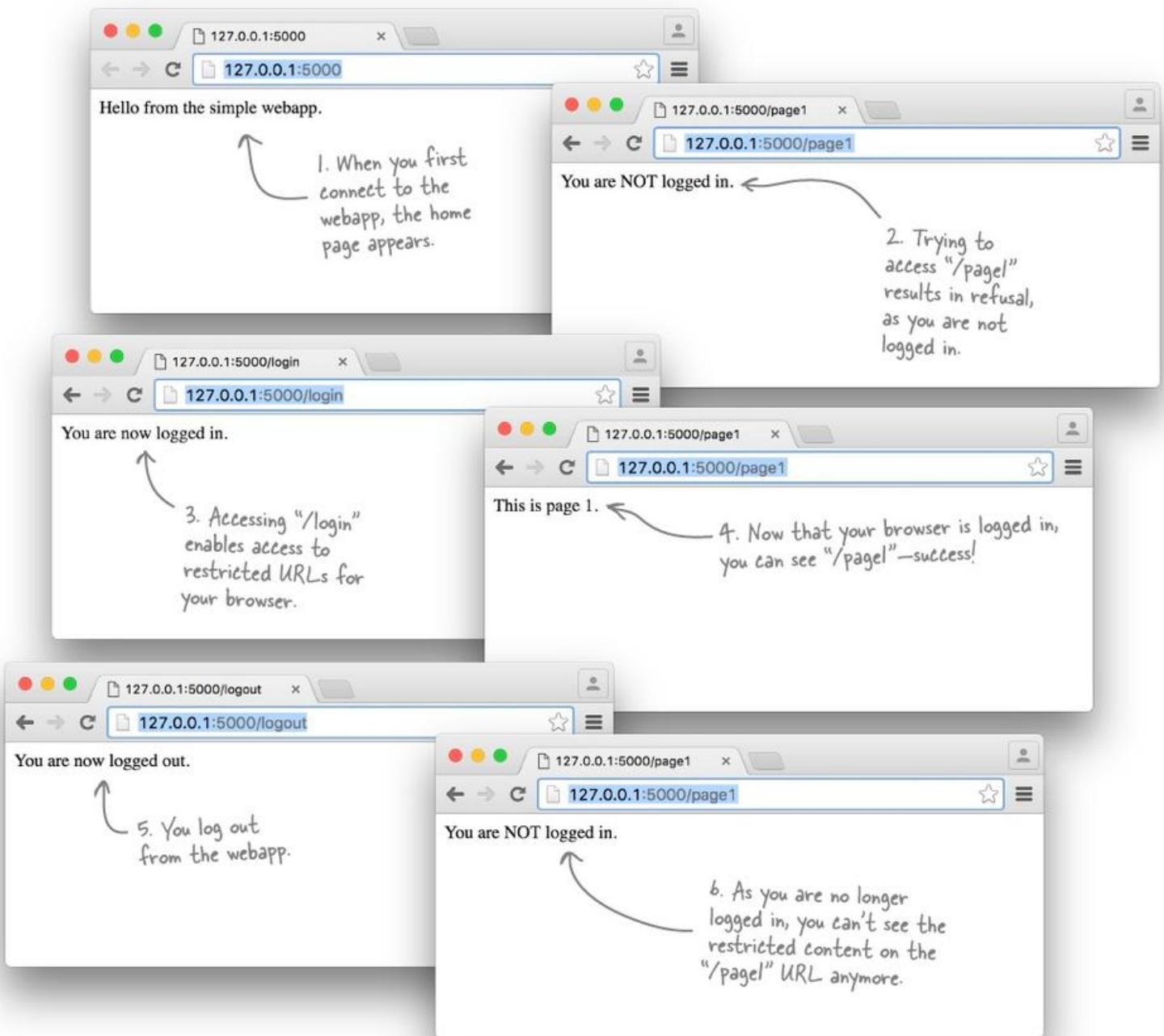
Don't forget to apply these highlighted edits to your webapp *before* continuing.

TEST DRIVE



To convince ourselves that our login-checking decorator is working as required, let's take the decorator-enabled version of `simple_webapp.py` for a spin.

With the webapp running, use a browser to try to access `/page1` prior to logging in. After logging in, try to access `/page1` again and then, after logging out, try to access the restricted content once more. Let's see what happens:



The Beauty of Decorators

Take another look at the code for your `check_logged_in` decorator. Note how it abstracts the logic used to check if a user's browser is logged in, putting this (potentially complex) code in one place—*inside* the decorator—and then making it available throughout your code, thanks to the `@check_logged_in` decorator syntax:

```
from flask import session
from functools import wraps

def check_logged_in(func):
    @wraps(func)
    def wrapper(*args, **kwargs):
        if 'logged_in' in session:
            return func(*args, **kwargs)
        return 'You are NOT logged in.'
    return wrapper
```

Ln: 13 Col: 0

Abstracting code in a decorator makes the code that uses it easier to read. Consider this usage of our decorator on the /page2 URL:

```
@app.route('/page2')
@check_logged_in
def page2():
    return 'This is page 2.'
```

Ln: 1 Col: 0

Note how the `page2` function's code is only concerned with what it needs to do: display the `/page2` content. In this example, the `page2` code is a single, simple statement; it would be harder to read and understand if it *also* contained the logic required to check whether a user's browser is logged in or not. Using a decorator to separate out the login-checking code is a big win.

Decorators aren't freaky; they're fun.

This “logic abstraction” is one of the reasons the use of decorators is popular in Python. Another is that, if you think about it, in creating the `check_logged_in` decorator, you've managed to write code that *augments an existing function with extra code, by changing the*

behavior of the existing function without changing its code. When it was first introduced earlier in this chapter, this idea was described as “freaky.” But, now that you’ve done it, there’s really nothing to it, is there?

Creating More Decorators

With the process of creating the `check_logged_in` decorator behind you, you can use its code as the basis of any new decorators you create from here on in.

To make your life easier, here’s a generic code template (in the file `tmpl_decorator.py`) that you can use as the basis of any new decorators you write:

```
from functools import wraps

def decorator_name(func):
    @wraps(func)
    def wrapper(*args, **kwargs):
        # 1. Code to execute BEFORE calling the decorated function.

        # 2. Call the decorated function as required, returning its
        #    results if needed.
        return func(*args, **kwargs)

        # 3. Code to execute INSTEAD of calling the decorated function.
    return wrapper
```

Ln: 15 Col: 0

Replace these
comments with your
new decorator's
code.

This code template can be adjusted as needed to suit your needs. All you need to do is give your new decorator an appropriate name, then replace the three comments in the template with your decorator’s specific code.

If it makes sense for your new decorator to invoke the decorated function without returning its results, that’s fine. After all, what you put in your `wrapper` function is your code, and you are free to do whatever you want to.

THERE ARE NO DUMB QUESTIONS

Q: Q: Aren't decorators just like the last chapter's context manager in that they both let me wrap code with additional functionality?

A: A: That's a great question. The answer is: yes and no. Yes, both decorators and context managers augment existing code with additional logic. But no, they are not the same. Decorators are specifically concerned with augmenting existing functions with additional functionality, whereas context managers are more interested in ensuring your code executes within a specific context, arranging for code to run before a `with` statement as well as ensuring that code **always** executes after a `with` statement. You can do something similar with decorators, but most Python programmers would regard you as a little mad if you were to attempt this. Also, note that your decorator code is under no obligation to do anything after it invokes the decorated function (as is the case with the `check_logged_in` decorator, which does nothing). This decorator behavior is very different from the protocol that context managers are expected to adhere to.

Back to Restricting Access to /viewlog



Now that you've created a mechanism that lets you restrict access to certain URLs in `simple_webapp.py`, it's a no-brainer to apply the same mechanism to any other webapp.

This includes `vsearch4web.py`, where you had a requirement to restrict access to the `/viewlog` URL. All you need to do is copy the `do_login` and `do_logout` functions from `simple_webapp.py` into `vsearch4web.py`, import the `checker.py` module, and then decorate the `view_the_log` function with `check_logged_in`. Granted, you may want to add some sophistication to `do_login` and `do_logout` (by, perhaps, checking user credentials against those stored in a database), but—as regards restricting access to certain URLs—the `check_logged_in` decorator does most of the heavy lifting for you.

What's Next?

Rather than spend a bunch of pages doing to `vsearch4web.py` what you've just spent a chunk of time doing to `simple_webapp.py`, we're going to leave adjusting `vsearch4web.py` for you to do *on your own*. At the start of the next chapter, we'll present an updated version of the `vsearch4web.py` webapp for you to compare with yours, as our updated code is used to frame the discussion in the next chapter.

To date, all of the code in this book has been written under the assumption that nothing bad ever happens, and nothing ever goes wrong. This was a deliberate strategy on our part, as we wanted to ensure you had a good grasp of Python before getting into topics such as error correction, error avoidance, error detection, exception handling, and the like.

We have now reached the point where we can no longer follow this strategy. The environments within which our code runs are real, and things can (and do) go wrong. Some things are fixable (or avoidable), and some aren't. If at all possible, you'll want your code to handle most error situations, only resulting in a crash when something truly exceptional happens that is beyond your control. In the next chapter, we look at various strategies for deciding what's a reasonable thing to do when stuff goes wrong.

Prior to that, though, here's a quick review of this chapter's key points.

BULLET POINTS



- When you need to store server-side state within a Flask webapp, use the `session` dictionary (and don't forget to set a hard-to-guess `secret_key`).
- You can pass a function as an argument to another function. Using the function's name (without the parentheses) gives you a **function object**, which can be manipulated like any other variable.

- When you use a function object as an argument to a function, you can have the receiving function **invoke** the passed-in function object by appending parentheses.
- A function can be **nested** inside an enclosing function's suite (and is only visible within the enclosing scope).
- In addition to accepting a function object as an argument, functions can **return** a nested function as a return value.
- ***args** is shorthand for “expand to a list of items.”
- ****kwargs** is shorthand for “expand to a dictionary of keys and values.” When you see “kw,” think “keywords.”
- Both * and ** can also be used “on the way in,” in that a list or keyword collection can be passed into a function as a single (expandable) argument.
- Using **(*args, **kwargs)** as a **function signature** lets you create functions that accept any number and type of arguments.
- Using the new function features from this chapter, you learned how to create a **function decorator**, which changes the behavior of an existing function without the need to change the function's actual code. This sounds freaky, but is quite a bit of fun (and is very useful, too).

Chapter 10's Code, 1 of 2

```
from flask import Flask, session  
  
app = Flask(__name__)  
  
app.secret_key = 'YouWillNeverGuess'  
  
@app.route('/setuser/<user>')  
def setuser(user: str) -> str:  
    session['user'] = user  
    return 'User value set to: ' + session['user']  
  
@app.route('/getuser')  
def getuser() -> str:  
    return 'User value is currently set to: ' + session['user']  
  
if __name__ == '__main__':  
    app.run(debug=True)
```

This is "quick_session.py".

```
from flask import session  
  
from functools import wraps  
  
def check_logged_in(func):  
    @wraps(func)  
    def wrapper(*args, **kwargs):  
        if 'logged_in' in session:  
            return func(*args, **kwargs)  
        return 'You are NOT logged in.'  
    return wrapper
```

This is "checker.py", which contains the code to this chapter's decorator: "check_logged_in".

```
from functools import wraps  
  
def decorator_name(func):  
    @wraps(func)  
    def wrapper(*args, **kwargs):  
        # 1. Code to execute BEFORE calling the decorated function.  
  
        # 2. Call the decorated function as required, returning its  
        # results if needed.  
        return func(*args, **kwargs)  
  
        # 3. Code to execute INSTEAD of calling the decorated function.  
    return wrapper
```

This is "tmpl_decorator.py", which is a handy decorator-creating template for you to reuse as you see fit.

Chapter 10's Code, 2 of 2

```
from flask import Flask, session  
  
from checker import check_logged_in  
  
app = Flask(__name__)  
  
@app.route('/')  
def hello() -> str:  
    return 'Hello from the simple webapp.'  
  
@app.route('/page1')  
@check_logged_in  
def page1() -> str:  
    return 'This is page 1.'  
  
@app.route('/page2')  
@check_logged_in  
def page2() -> str:  
    return 'This is page 2.'  
  
@app.route('/page3')  
@check_logged_in  
def page3() -> str:  
    return 'This is page 3.'  
  
@app.route('/login')  
def do_login() -> str:  
    session['logged_in'] = True  
    return 'You are now logged in.'  
  
@app.route('/logout')  
def do_logout() -> str:  
    session.pop('logged_in')  
    return 'You are now logged out.'  
  
app.secret_key = 'YouWillNeverGuessMySecretKey'  
  
if __name__ == '__main__':  
    app.run(debug=True)
```

This is "simple_webapp.py", which pulls all of this chapter's code together. When you need to restrict access to specific URLs, base your strategy on this webapp's mechanism.

We think the use of decorators makes this webapp's code easy to read and understand. Don't you? ☺