01-24-2022

CS051A

INTRO TO COMPUTER SCIENCE WITH TOPICS IN AI

2: Functions

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Lectures

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Lectures

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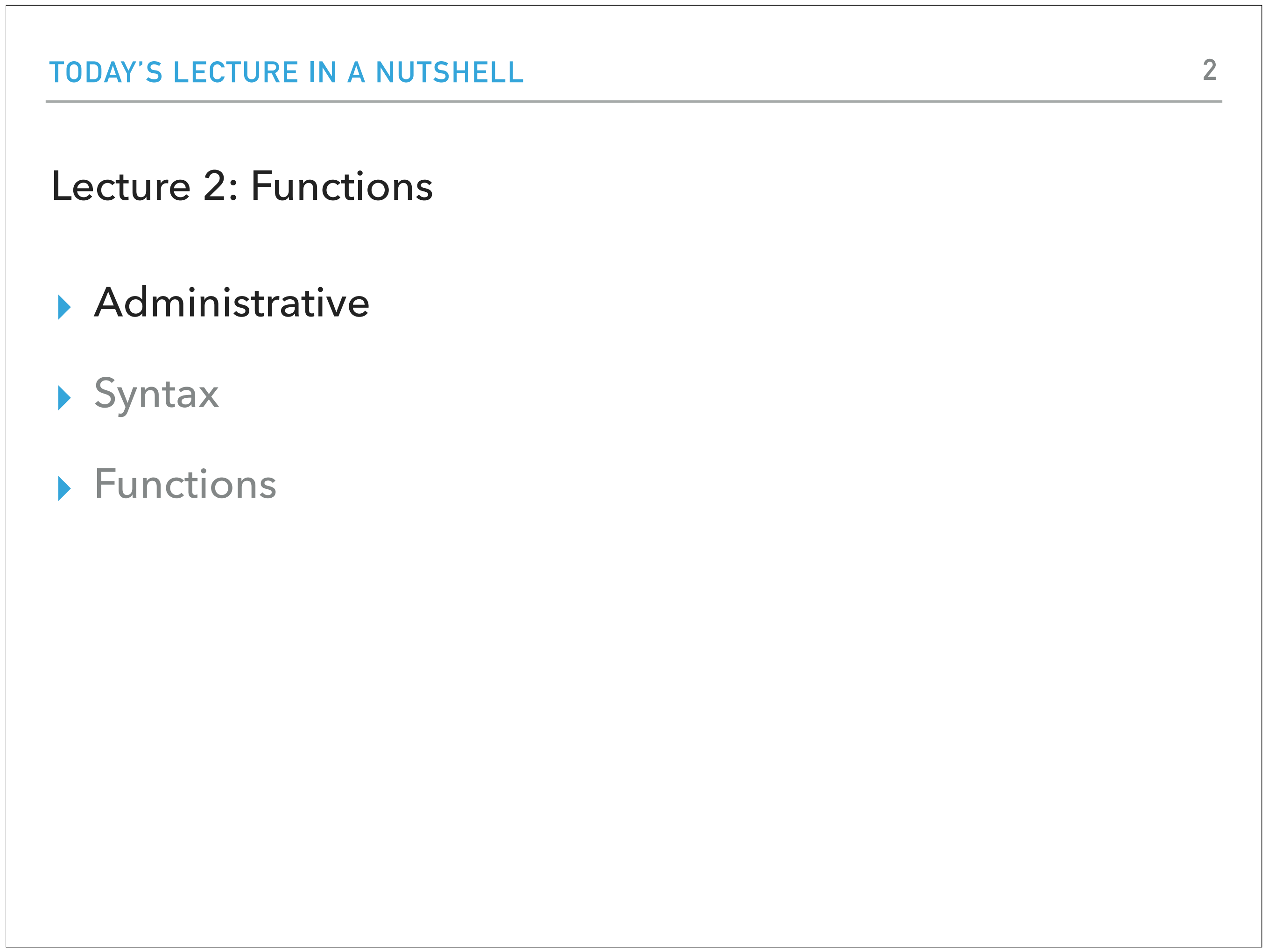
he/him/his

Labs

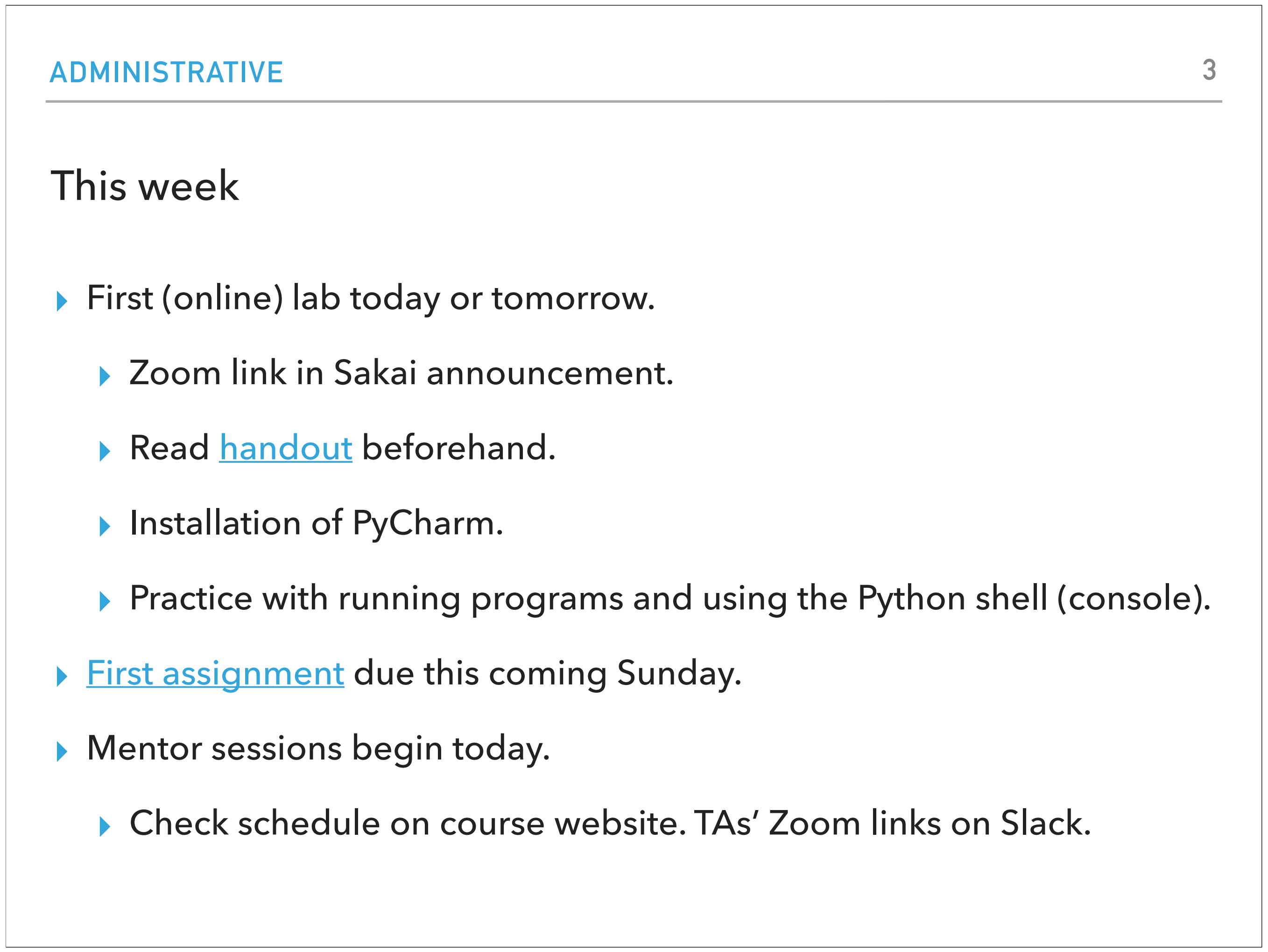
[ASK TO RECORD]
Welcome to lecture 2, everyone! Are there any questions?



Lecture 2: Functions

- Administrative
- Syntax
- Functions

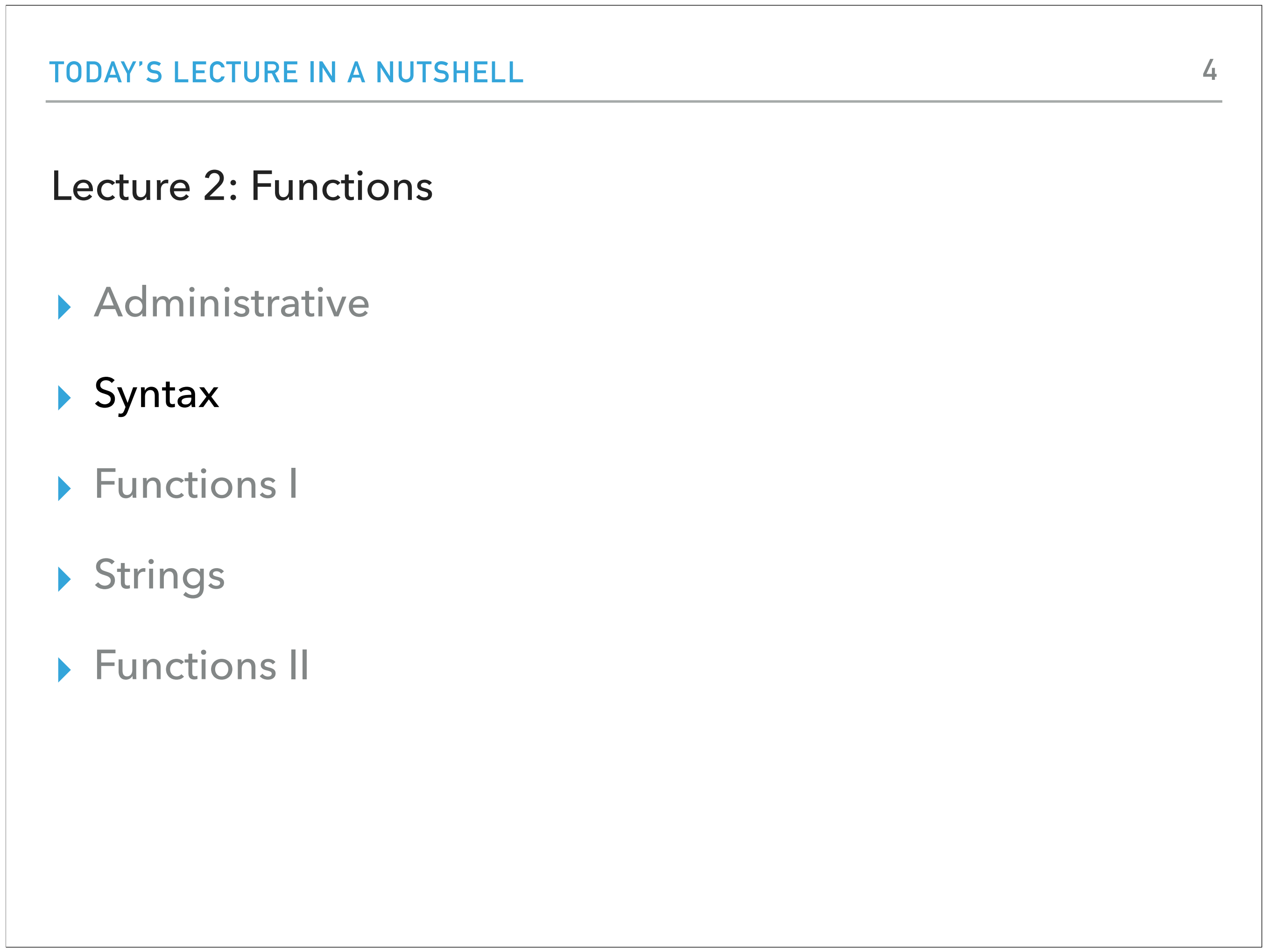
Let me start with some announcements about class logistics and then we will proceed with learning more Python!



This week

- First (online) lab today or tomorrow.
  - Zoom link in Sakai announcement.
  - Read handout beforehand.
  - Installation of PyCharm.
  - Practice with running programs and using the Python shell (console).
- First assignment due this coming Sunday.
- Mentor sessions begin today.
  - Check schedule on course website. TAs' Zoom links on Slack.

This week we will have our first lab. Depending on which lab you have registered for, this will take place on Monday or Tuesday evening. I have sent you an announcement on Sakai with the Zoom link to use. Professor Ye has asked you, if possible, to read the handout beforehand. You will get to install PyCharm, the IDE we will use in this course to interact with the Python interpreter. You will get to see the two main modes of interaction, the shell (Python console in PyCharm) and how to run source code files. We also have the first assignment due this coming Sunday. It will be on topics we will cover today and on Wednesday. Finally, mentor sessions begin today. The schedule is posted on the course website and TAs will be posting the Zoom links for this week on Slack. We will notify you about in-person mentor sessions later on as we are trying to coordinate with the entire department to spread out TAs.



Lecture 2: Functions

- Administrative
- Syntax
- Functions I
- Strings
- Functions II

Are there any questions on class logistics? Let's continue with learning Python and specifically thinking about the Python syntax.

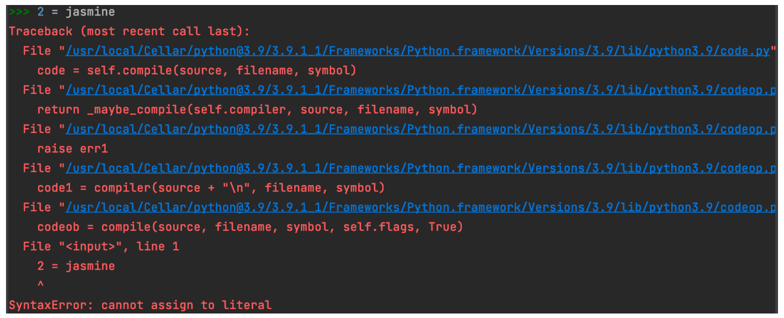
Syntax in English and in programming languages

- In English: arrangement of words and phrases to create well-formed sentences.
  - "I like dogs" is syntactically correct
  - "I dog like" is not syntactically correct
- Programming languages also have their own syntax, that is their own rules of what code valid in that language.
- In contrast to English, programming languages are less forgiving to syntax errors: the computer won't get the gist of our program

In English (and other natural languages), syntax is the arrangement of words and phrases to create well-formed sentences. For example, the sentence "I like dogs" is syntactically correct, while the sentence "I dog like" is not. But you probably get the gist of the sentence even if it sounds off. Programming languages also have their own syntax, that is their own rules of what code is valid in that language. In contrast to English, programming languages are less forgiving to syntax errors: the computer won't get what our program wants it to do unless we strictly adhere to Python syntax rules.

Syntax errors

- In our brief Python adventures, have we seen any examples of syntax?
  - All of the math operations have implicit syntax, e.g., we can't just write 4 + and leave it as is.
  - Similar issues can arise if we flip an assignment.



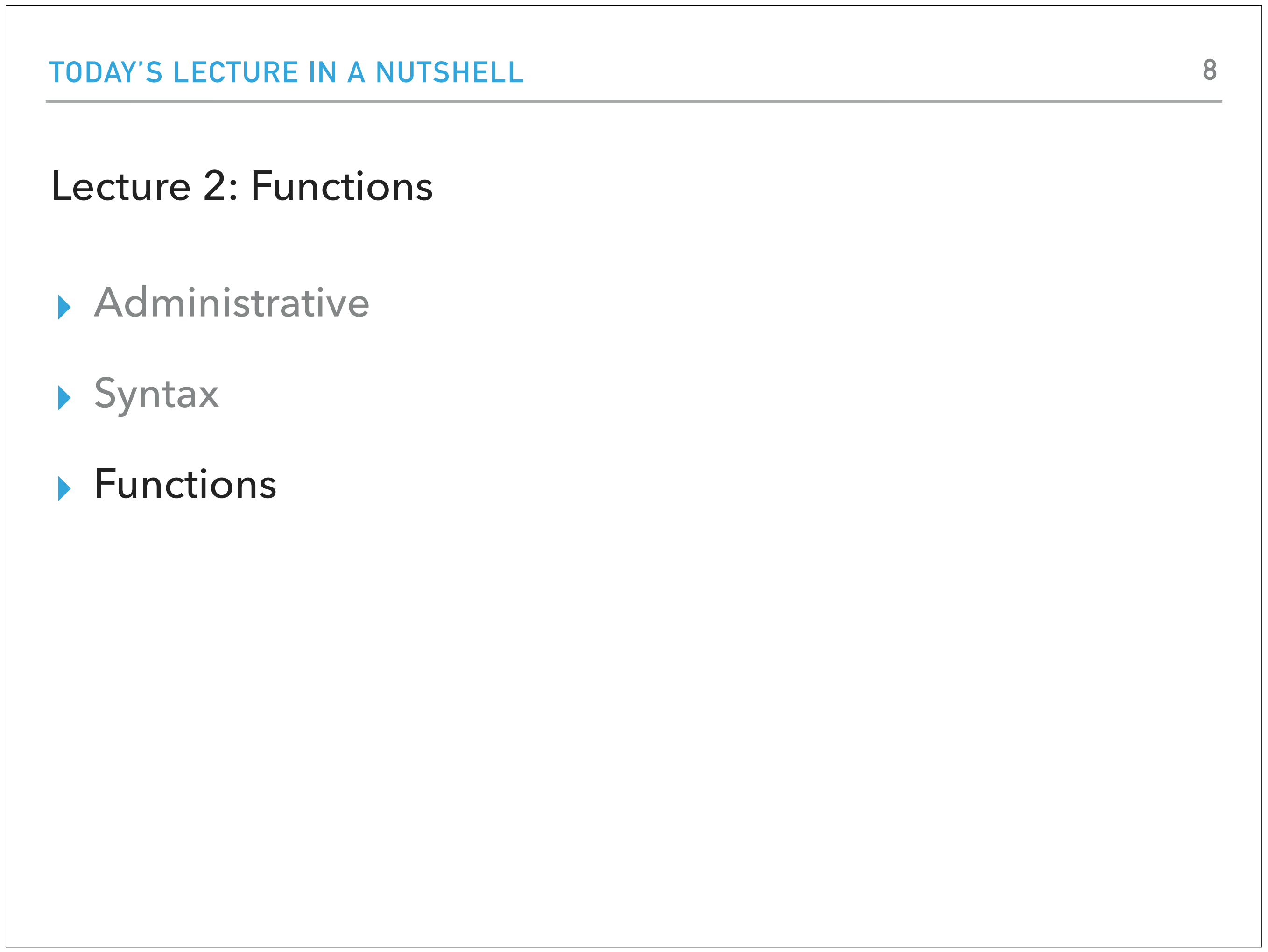
```
>>> 2 = jasmine
Traceback (most recent call last):
  File "/usr/local/Cellar/python@3.9/3.9.1_1/Frameworks/Python.framework/Versions/3.9/lib/python3.9/code.py"
    code = self.compile(source, filename, symbol)
  File "/usr/local/Cellar/python@3.9/3.9.1_1/Frameworks/Python.framework/Versions/3.9/lib/python3.9/codeop.p
    return _maybe_compile(self.compiler, source, filename, symbol)
  File "/usr/local/Cellar/python@3.9/3.9.1_1/Frameworks/Python.framework/Versions/3.9/lib/python3.9/codeop.p
    raise err1
  File "/usr/local/Cellar/python@3.9/3.9.1_1/Frameworks/Python.framework/Versions/3.9/lib/python3.9/codeop.p
    code1 = compiler(source + "\n", filename, symbol)
  File "/usr/local/Cellar/python@3.9/3.9.1_1/Frameworks/Python.framework/Versions/3.9/lib/python3.9/codeop.p
    codeob = compile(source, filename, symbol, self.flags, True)
  File "<input>", line 1
    2 = jasmine
    ^
SyntaxError: cannot assign to literal
```

Let's think of what we covered in Lecture 1, where we mostly saw Python as a mathematical calculator. In that case, we were probably comfortable with the idea that math operations have implicit syntax (operand operator operand, e.g., 4+5). We can't just write 4 + and leave it as is. We also wrote our first Python program to calculate the number of hot dogs we would need at a BBQ party and we utilized variables. The syntax for variable assignments needs to be followed precisely. On the left hand, we have the name of the variable, followed by the equals sign, and then the value we want to assign to it. E.g., jasmine = 2. We cannot write 2 = jasmine! This would cause a syntax error and the Python interpreter would complain and stop reading our code.

Syntax errors in PyCharm

- Both the Python shell (console) and program mode will recognize syntax errors.
- Luckily, *most of the times,* Python will indicate the correct line that the syntax error occurred.
  - Sometimes though, an error might be elsewhere, probably before the line that is highlighted.

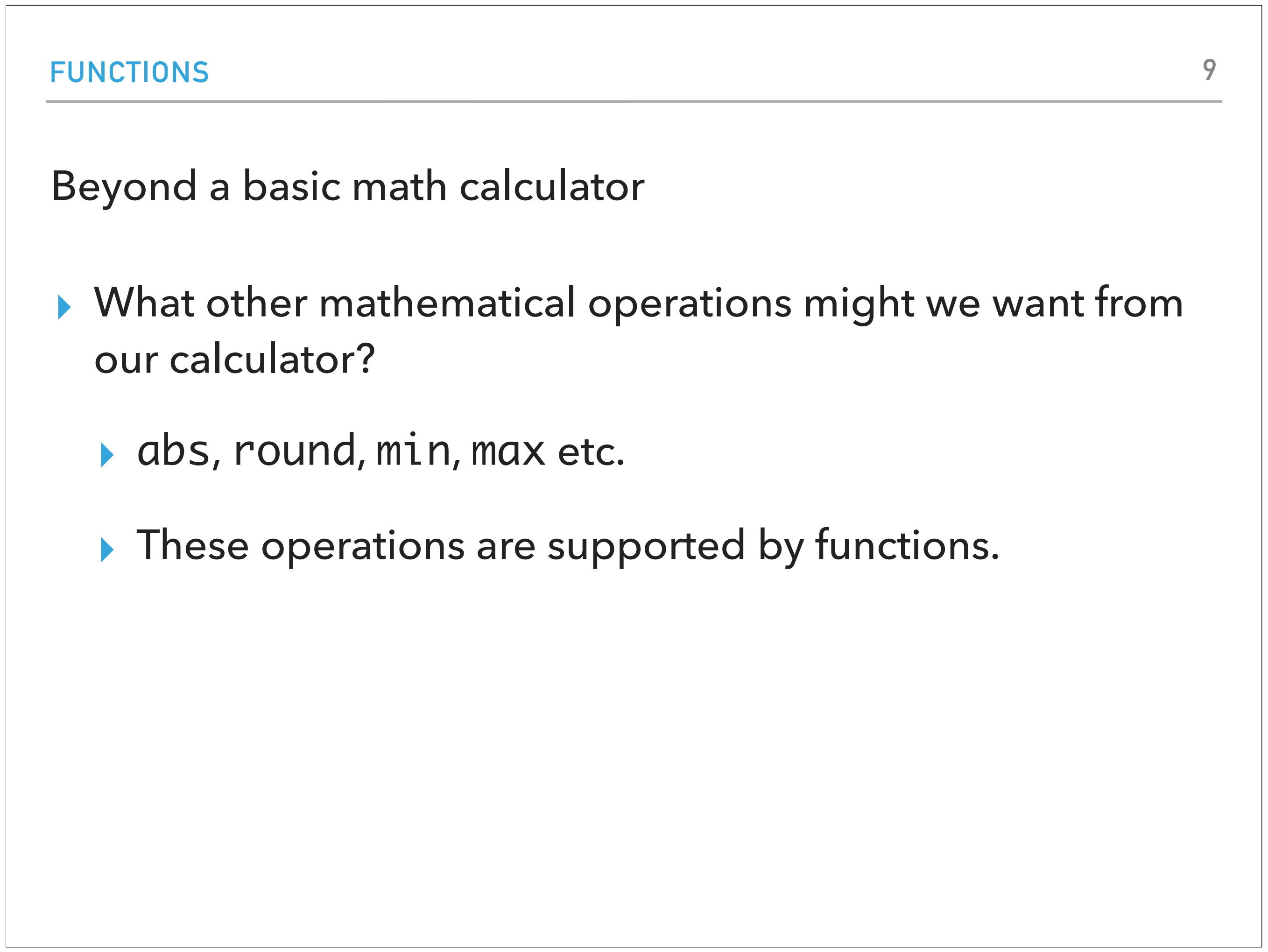
The good thing in an IDE like PyCharm is that both the Python shell and program mode will recognize syntax errors. Luckily, most of the times, the Python interpreter will indicate the correct line that the syntax error occurred. Sometimes though, an error might be elsewhere, probably before the line that is highlighted.



Lecture 2: Functions

- Administrative
- Syntax
- Functions

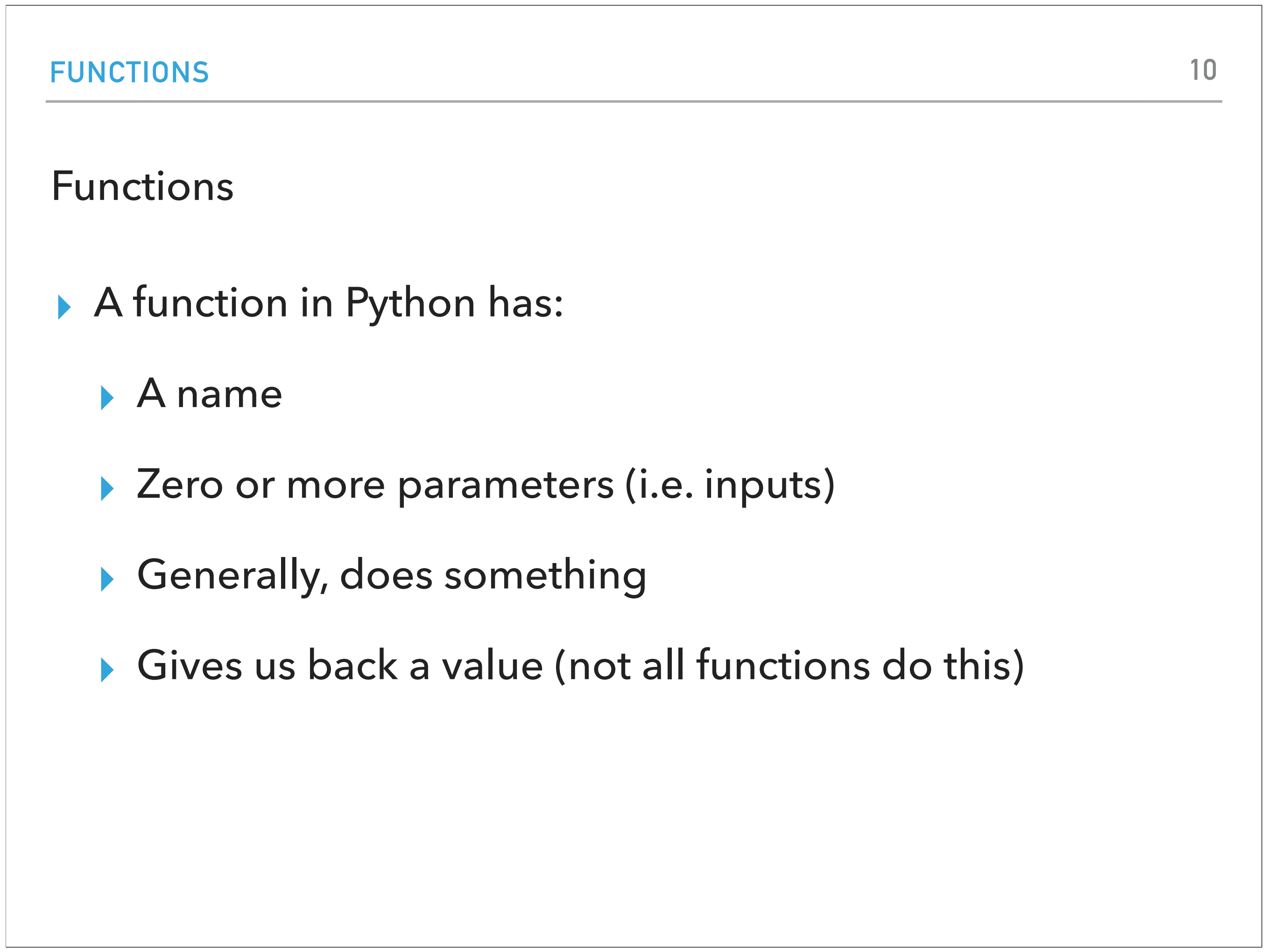
I think we all agree that our computers are more powerful than a calculator that does basic mathematical operations.



Beyond a basic math calculator

- What other mathematical operations might we want from our calculator?
  - `abs`, `round`, `min`, `max` etc.
  - These operations are supported by functions.

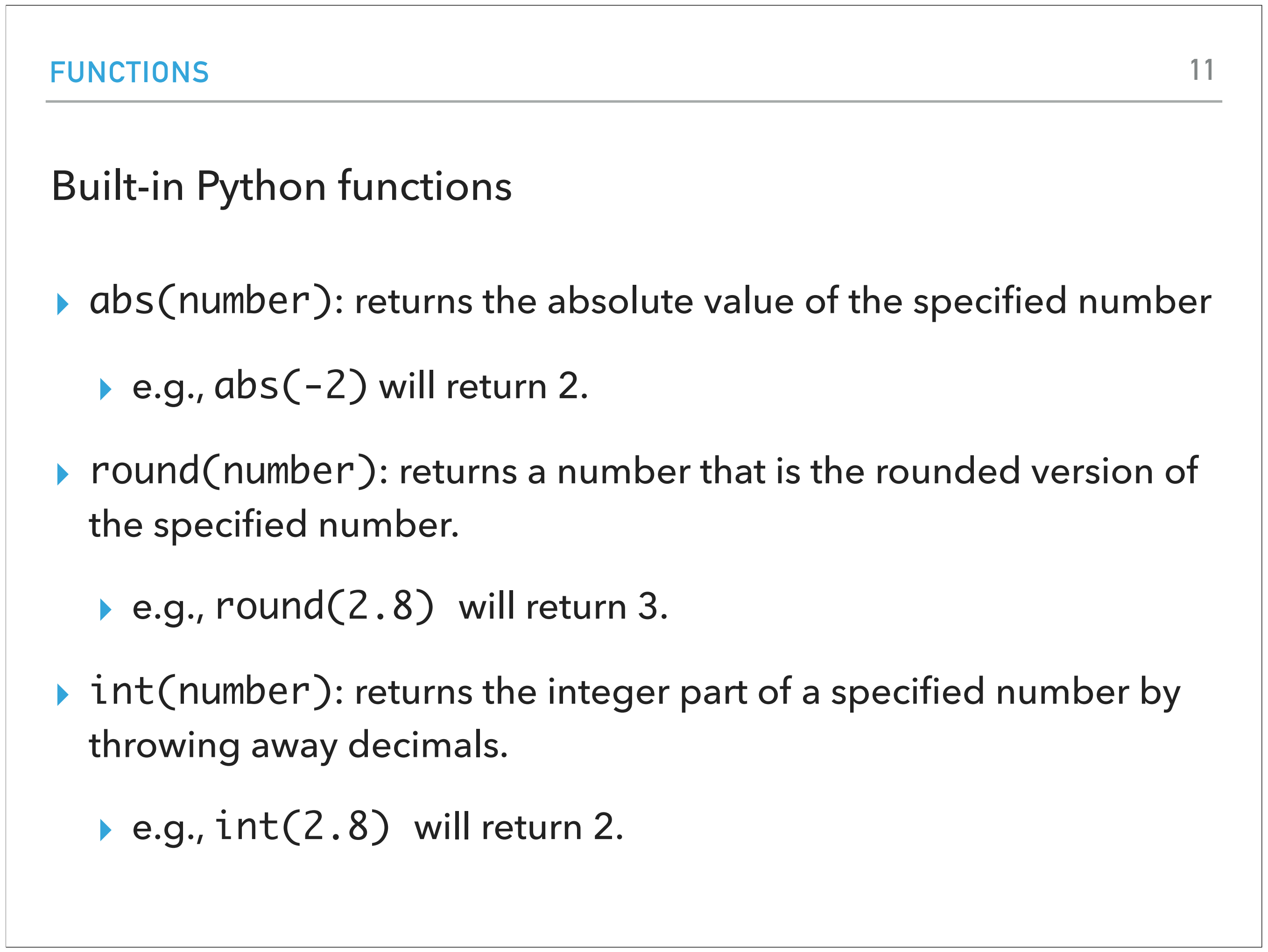
Before we get too excited about the possibilities, what other mathematical operations might we want our calculator to support? We have seen addition, subtraction, multiplication, division, power, and remainder. Some examples of additional functionalities to support are ways to get the absolute value, round a value, calculate the min or max etc. In Python, these operations are supported by functions. But what are functions?



Functions

- A function in Python has:
  - A name
  - Zero or more parameters (i.e. inputs)
  - Generally, does something
  - Gives us back a value (not all functions do this)

A function in Python is a piece of code that has a name, receives input in the form or zero or more parameters, generally does something, and then potentially gives us back a value, although not all functions do this.



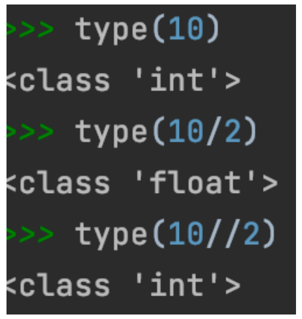
Built-in Python functions

- `abs(number)`: returns the absolute value of the specified number
  - e.g., `abs(-2)` will return 2.
- `round(number)`: returns a number that is the rounded version of the specified number.
  - e.g., `round(2.8)` will return 3.
- `int(number)`: returns the integer part of a specified number by throwing away decimals.
  - e.g., `int(2.8)` will return 2.

Let's look at some built-in Python functions thinking of the more powerful calculator we would like to build. One such function is abs(number) which returns the absolute value of the specified number. For example, abs(-2) will give us back 2. Another one is round(number) which returns a rounded version of the specified number. For example, round(2.8) will return 3. Finally, int(number) will truncate the decimals and return the integer part of the specified number. E.g., int(2.8) will return 2.

Function type

- type(expression): returns type of the specific expression. E.g.,



```
>>> type(10)
<class 'int'>
>>> type(10/2)
<class 'float'>
>>> type(10//2)
<class 'int'>
```

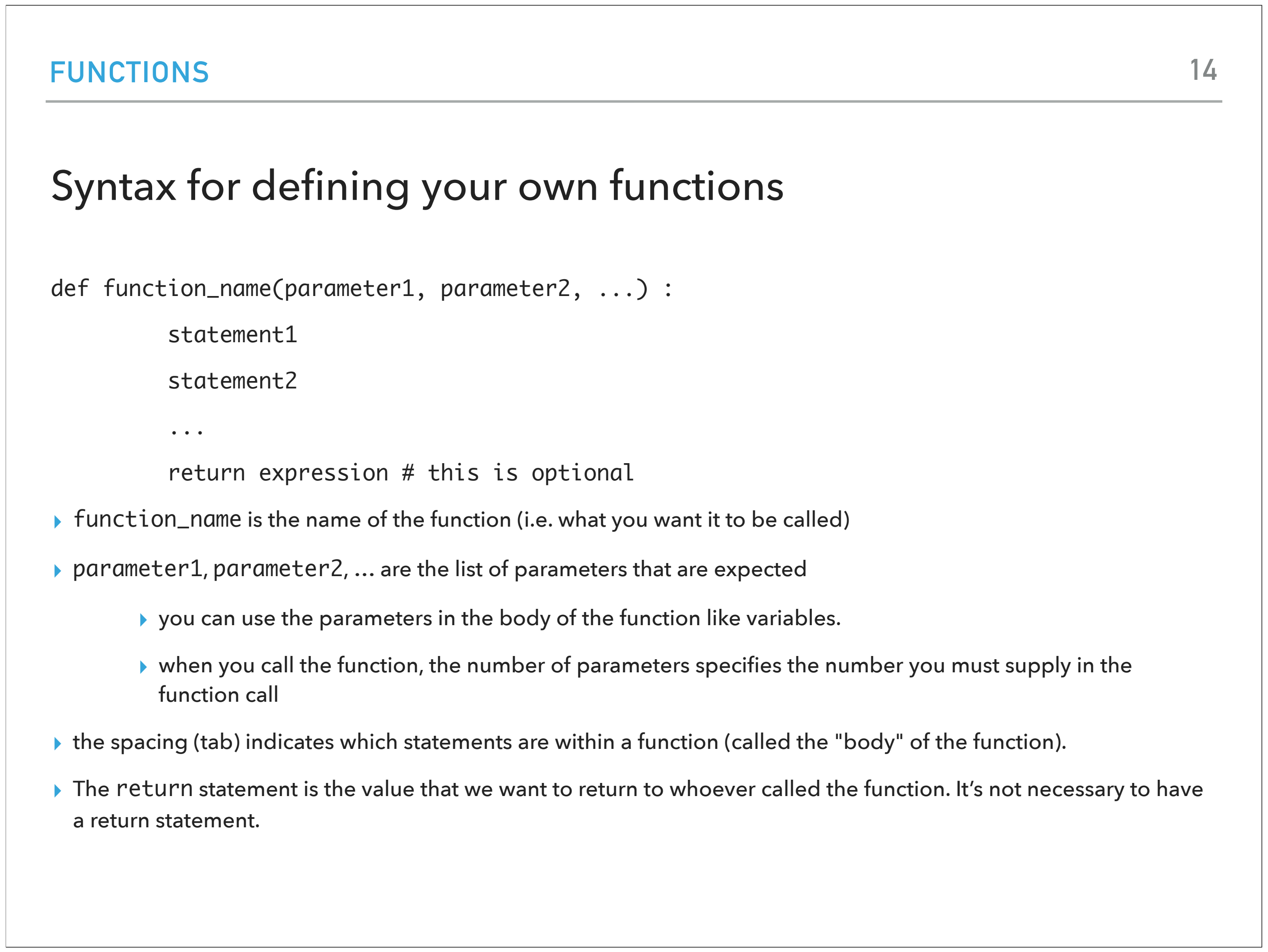
- Note that all of these functions take a single parameter and give us back (return) a value,
- We'll talk more later about what it means to "give back" a value, but some functions will simply "do something" and then not return a value.

Another interesting function is type(expression) which returns the type of the specified expression. For example, type(10) returns int, while type(10/2) returns float (remember 10/2 results to 5.0 because division in Python is ‘real’). But, type(10//2) is int because integer division (//) truncates decimal points. Note that all these functions take a single parameter and give us back (or return) a value. We'll talk more later about what it means to "give back" a value, but some functions will simply "do something" and then not return a value.

Defining your own functions

- Allows you to bundle together code and reuse it.
- Remember, the important components for a function are:
  - the name of the function,
  - how many parameters the function takes,
  - what the function does,
  - what value (if any) it returns/gives you back when it's done.

Beyond its built-in functions, Python allows you to define your own functions. This is great because you can bundle together code and then reuse it. Remember that the important components to define a function are: its name, how many parameters (if any) the function takes, what the function does, and what value (if any) it returns when it's done.



Syntax for defining your own functions

```
def function_name(parameter1, parameter2, ...) :
          statement1
          statement2
          ...
          return expression # this is optional
```

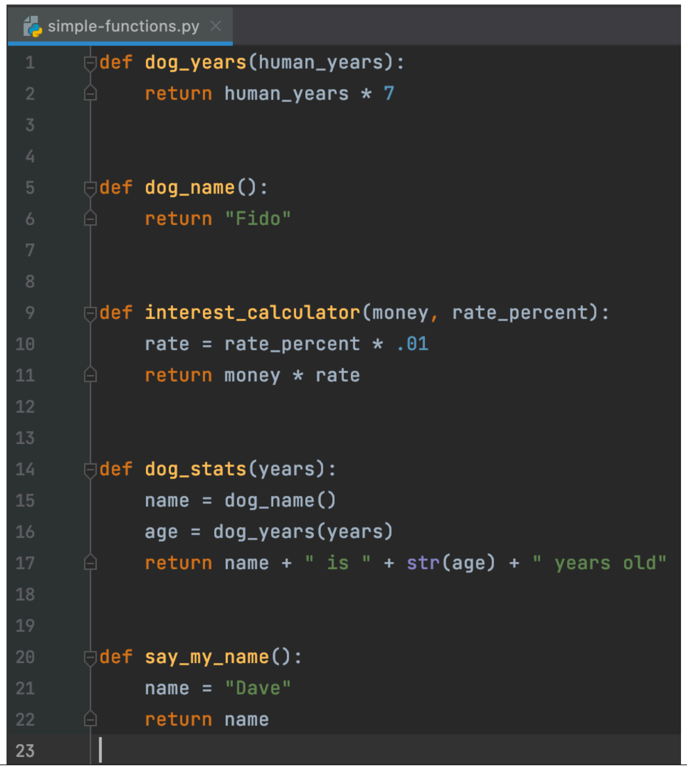
- `function_name` is the name of the function (i.e. what you want it to be called)
- `parameter1`, `parameter2`, … are the list of parameters that are expected
  - you can use the parameters in the body of the function like variables.
  - when you call the function, the number of parameters specifies the number you must supply in the function call
- the spacing (tab) indicates which statements are within a function (called the "body" of the function).
- The `return` statement is the value that we want to return to whoever called the function. It’s not necessary to have a return statement.

The syntax for defining your own functions in Python is:

```
def function_name(parameter1, parameter2, ...) :
      statement1
      statement2
      ...
      return expression # this is optional
```

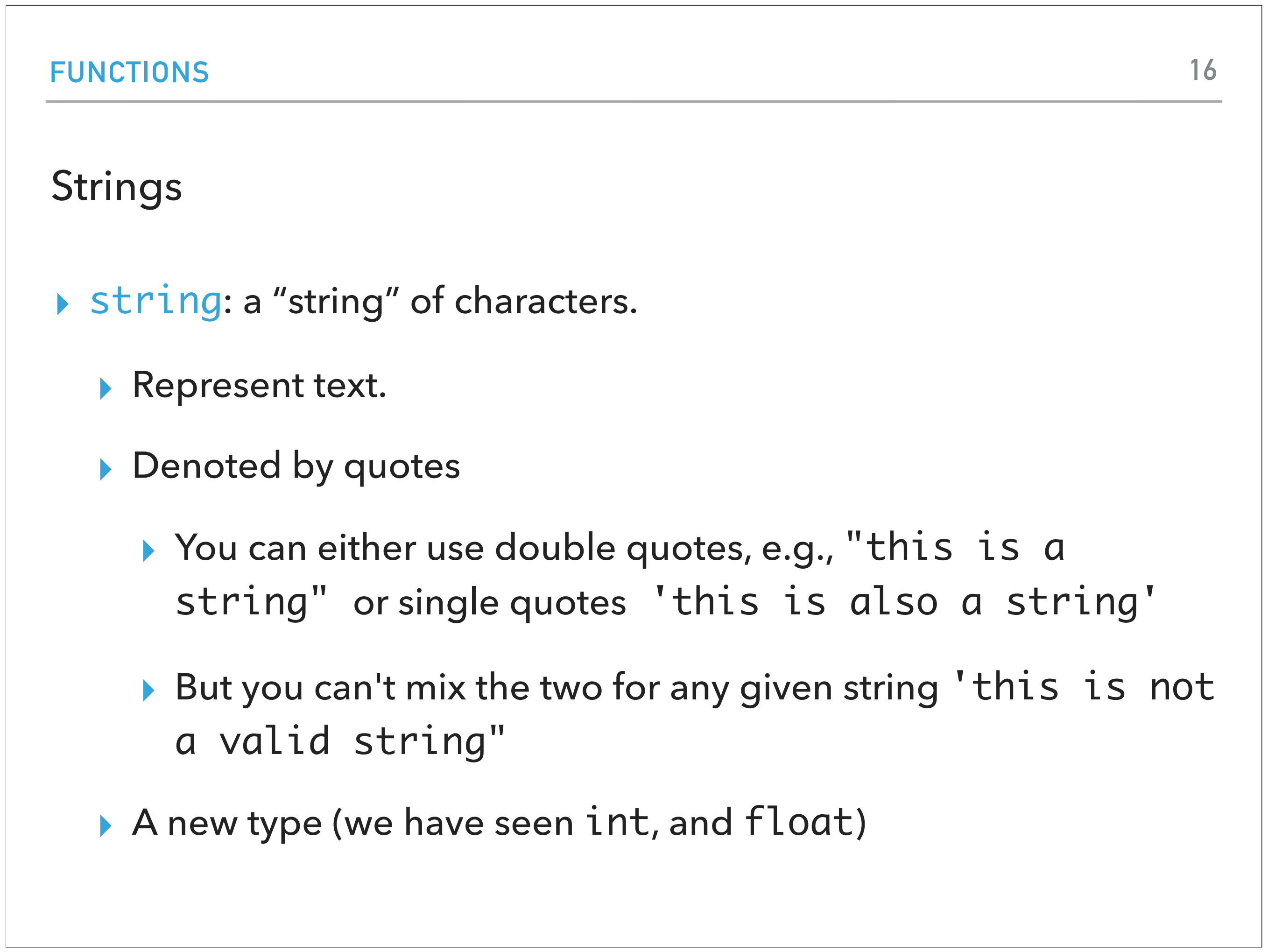
Remember, that:
- function_name is the name of the function (i.e. what you want it to be called)
- parameter1, parameter2, … are the list of parameters that are expected
- You can use the parameters in the body of the function like variables.
- When you call the function, the number of parameters specifies the number you must supply in the function call.
- The spacing (tab) indicates which statements are within a function (called the "body" of the function).
- The return statement is the value that we want to return to whoever called the function. It’s not necessary to have a return statement.

Anything new here?


simple-functions.py

```python
def dog_years(human_years):
    return human_years * 7


def dog_name():
    return "Fido"


def interest_calculator(money, rate_percent):
    rate = rate_percent * .01
    return money * rate


def dog_stats(years):
    name = dog_name()
    age = dog_years(years)
    return name + " is " + str(age) + " years old"


def say_my_name():
    name = "Dave"
    return name

```

Take a look at the simple-functions.txt file which defines five functions. Do you notice anything new?



Strings

- `string`: a “string” of characters.
    - Represent text.
    - Denoted by quotes
        - You can either use double quotes, e.g., `"this is a string"` or single quotes `'this is also a string'`
        - But you can't mix the two for any given string `'this is not a valid string"`
    - A new type (we have seen `int`, and `float`)

What we have not encountered so far is this new type called string (as a reminder, we have seen int and floats). Strings represent text or a string of characters. They are a very useful type and using them can make Python far more powerful than just a math calculator. If you want to work with strings, you will denote them using quotes. You can either use double or single quotes but you have to be consistent. I personally favor double quotes because they are more universal across other programming languages.

Writing code with strings

- If you want to concatenate (i.e. combine) two strings, you can use the plus sign. E.g.,

```
>>> "this is one string " + "plus another one"
'this is one string plus another one'
```

- If you want to use an `int` or a `float` as a `string`, you need to convert it to a `string` using `str` function.

-
```
>>> x=4
>>> "The value of x is " + str(x)
'The value of x is 4'
>>> "The value of x is " + x
Traceback (most recent call last):
  File "/usr/local/Cellar/python@3.9/3.9.1_1/Frameworks/Python.framework/Versions/3.9/lib/python3.9/code
    exec(code, self.locals)
  File "<input>", line 1, in <module>
TypeError: can only concatenate str (not "int") to str
```

One thing that you can do with strings is that you can concatenate them, that is combine them into one one new string. You can achieve this using the + plus sign. For example, “this one string “ + “plus another one” will result to “this one string plus another one”. If you want to use an int or float as strings, not numbers, you will need to cover them to a string using the str function, e.g., str(3). Notice that you can’t concatenate strings and numbers, you first need to turn the number into a string otherwise you will get an error!

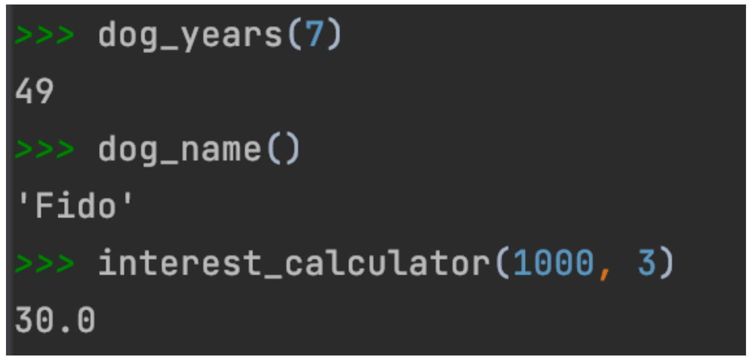
What do the first three functions do?

- `dog_years`: calculates the number of dog years, given human years.
- `dog_name`: returns the name of the dog (in this case “Fido”), as a string.
- `interest_calculator`: calculates the amount of interest earned for a given amount of money at a particular rate.

Looking at the simple-functions.txt source file, what do the first three functions do? dog_years calculates the number of dog years, given human years. dog_name returns the name of the dog (in this case “Fido”), as a string, and finally interest_calculator calculates the amount of interest earned for a given amount of money at a particular rate.

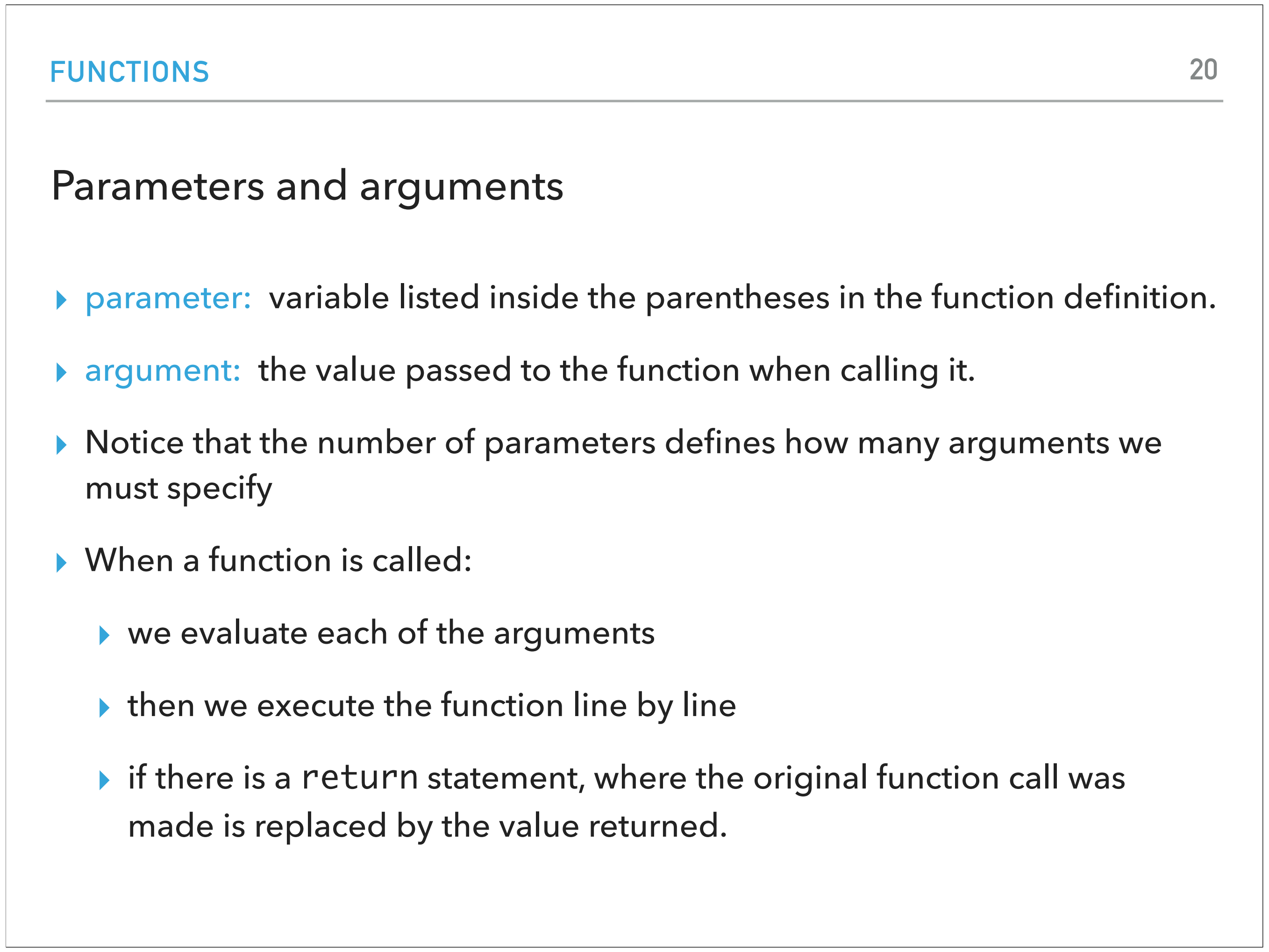
Calling functions

- If we "Run file in Python console", what do you think will happen?
  - nothing gets printed out!
  - but we've now defined new functions that we can use:



```
>>> dog_years(7)
49
>>> dog_name()
'Fido'
>>> interest_calculator(1000, 3)
30.0
```

What do you think if we right-click on our Python file in PyCharm and click on "Run file in Python console"? Well… nothing really. But the neat thing is that we have now defined these functions and we can use or "call" them. For example, dog_years(7) will return 49, dog_name() will return "Fido", and interest_calculator(1000,3) will return 30.0.



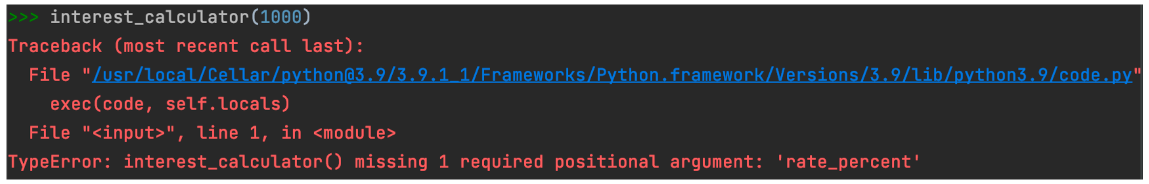
Parameters and arguments

- parameter: variable listed inside the parentheses in the function definition.
- argument: the value passed to the function when calling it.
- Notice that the number of parameters defines how many arguments we must specify
- When a function is called:
  - we evaluate each of the arguments
  - then we execute the function line by line
  - if there is a `return` statement, where the original function call was made is replaced by the value returned.

When I talk about functions you will often hear me use the words parameters and arguments. I might mix them up because they are interconnected but they represent something slightly different. A parameter is a variable listed inside the parentheses in the function definition. Once you call a function, you will need to pass a value to that function. The value that matches a parameter is called an argument. Notice that the number of parameters defines how many arguments we must specify when we call a function. When a function is called, we evaluate each of the arguments, then we execute the function body line by line, and at the end, if there is a return statement, we return this value which is handed to whomever made the original function call.

Number of parameters and arguments have to agree

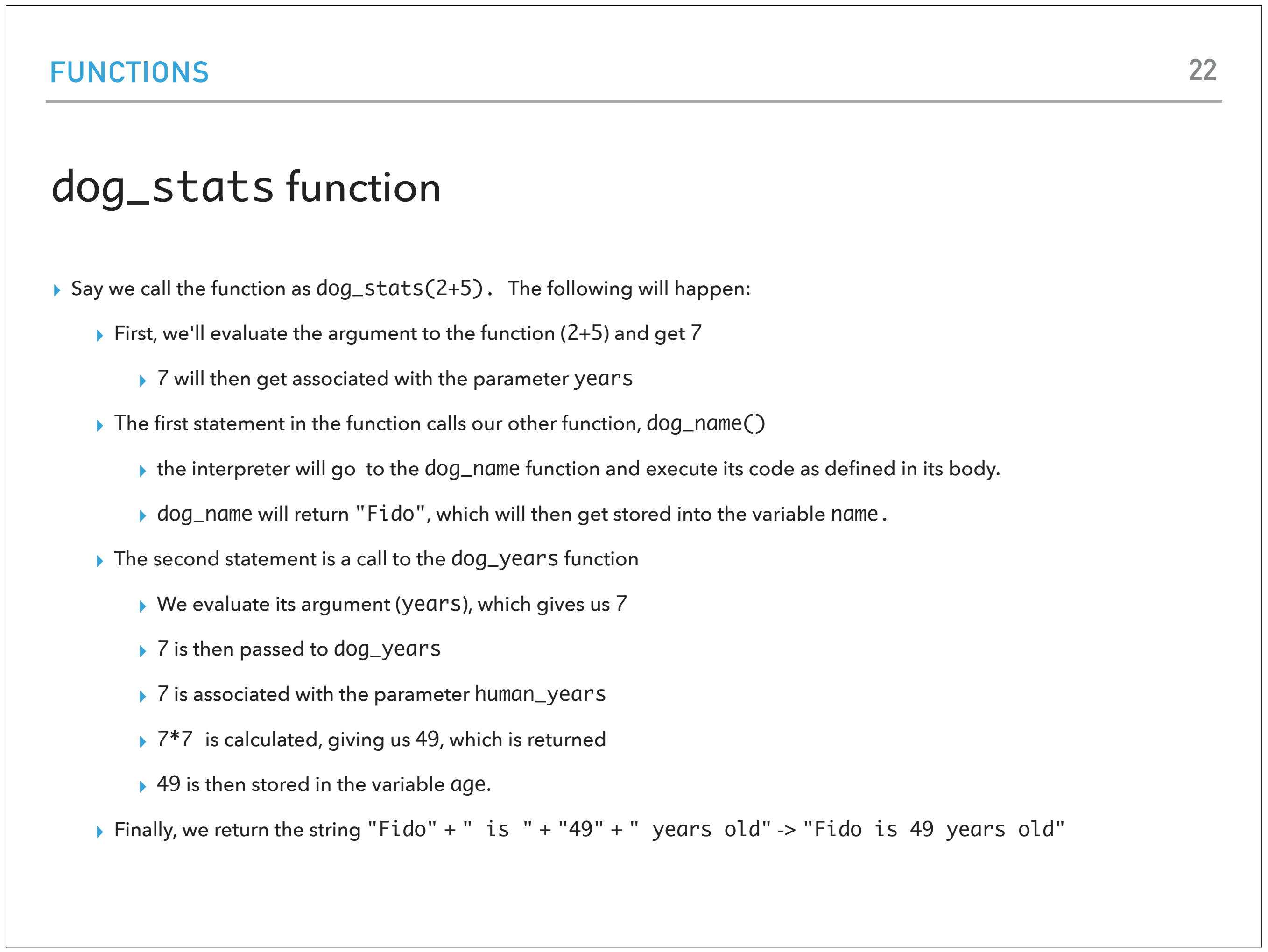
- If we try to call one of our functions with the wrong number of arguments, we get an error.



```
>>> interest_calculator(1000)
Traceback (most recent call last):
  File "/usr/local/Cellar/python@3.9/3.9.1_1/Frameworks/Python.framework/Versions/3.9/lib/python3.9/code.py"
    exec(code, self.locals)
  File "<input>", line 1, in <module>
TypeError: interest_calculator() missing 1 required positional argument: 'rate_percent'
```

- the last line is the most important and tells us what the error was, i.e. that the function takes 2 arguments, but we only gave it 1.
- If we knew that we wanted to call some of these functions, we could also add this code to the end of the file and then that would get executed when we run it.

Keep in mind that the number of parameters and arguments have to agree. If we try to call one of our functions passing it the wrong number of arguments, we will get an error as seen in the example of calling interest_calculator and passing it only one instead of two arguments (this can be seen in the last line of the error message). If we knew that we wanted to call some of these functions, we could also add this code to the end of the file and then that would get executed when we run it.



`dog_stats` function

- Say we call the function as `dog_stats(2+5).` The following will happen:
  - First, we'll evaluate the argument to the function (2+5) and get 7
    - 7 will then get associated with the parameter `years`
  - The first statement in the function calls our other function, `dog_name()`
    - the interpreter will go to the `dog_name` function and execute its code as defined in its body.
    - `dog_name` will return `"Fido"`, which will then get stored into the variable `name`.
  - The second statement is a call to the `dog_years` function
    - We evaluate its argument (`years`), which gives us 7
    - 7 is then passed to `dog_years`
    - 7 is associated with the parameter `human_years`
    - 7*7 is calculated, giving us 49, which is returned
    - 49 is then stored in the variable `age`.
  - Finally, we return the string `"Fido" + " is " + "49" + " years old"` -> `"Fido is 49 years old"`

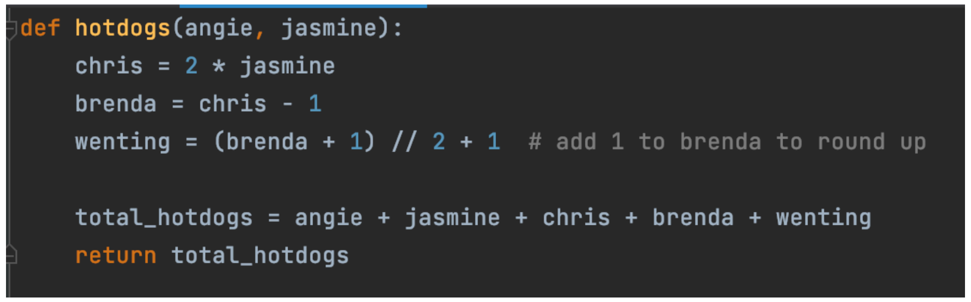
Let's put everything together by looking at what would happen if we were to call the function dog_stats passing it the argument 2+5: First, we'll evaluate the argument to the function (2+5) and get 7. That 7 will then get associated with the parameter years so that we can use it in the function body wherever it says years. The first statement in the function calls our other function, dog_name(). The interpreter will go to the dog_name function and execute its code as defined in its body. dog_name will return "Fido", which will then get stored into the variable name. The second statement is a call to the dog_years function. We evaluate its argument (years), which gives us 7. 7 is then passed to dog_years. 7 is associated with the parameter human_years. 7*7 is calculated, giving us 49, which is returned. 49 is then stored in the variable age. Finally, we return the string "Fido" + " is " + "49" + " years old" -> "Fido is 49 years old". Tadaaa!

Advanced BBQing

- If we look back at our bbq code, we notice that we only need information from some of the people to calculate the number of hot dogs.
    - only `angie` and `jasmine` affect the number of hotdogs required.

If we look back at our bbq code, we notice that we only need information from some of the people to calculate the number of hot dogs. Who? Only angie and jasmine affect the number of hotdogs required. Let's see how we can write a function to simplify our code.

hotdogs method in bbq-functions.py



```
def hotdogs(angie, jasmine):
    chris = 2 * jasmine
    brenda = chris - 1
    wenting = (brenda + 1) // 2 + 1  # add 1 to brenda to round up

    total_hotdogs = angie + jasmine + chris + brenda + wenting
    return total_hotdogs
```

- Look at the hotdogs method in bbq-functions.py. What does it do?
  - same thing as our bbq program, just now we've encapsulated it as a program where we can pass it parameters.

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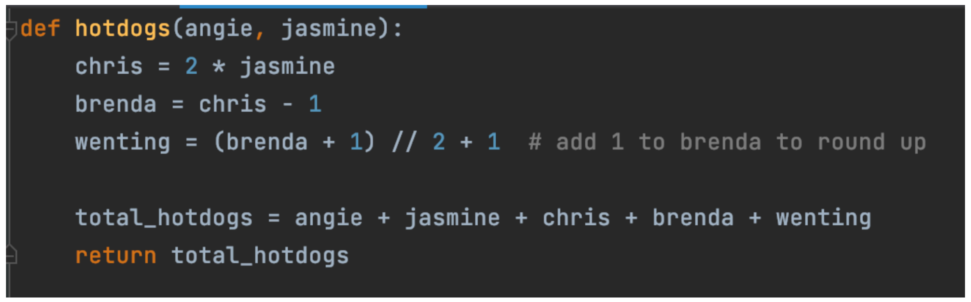
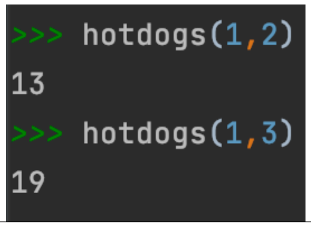
hotdogs method in bbq-functions.py



```python
def hotdogs(angie, jasmine):
    chris = 2 * jasmine
    brenda = chris - 1
    wenting = (brenda + 1) // 2 + 1  # add 1 to brenda to round up

    total_hotdogs = angie + jasmine + chris + brenda + wenting
    return total_hotdogs
```

- Look at the hotdogs method in bbq-functions.py. It does as our bbq program, just now we've encapsulated it as a program where we can pass it parameters.



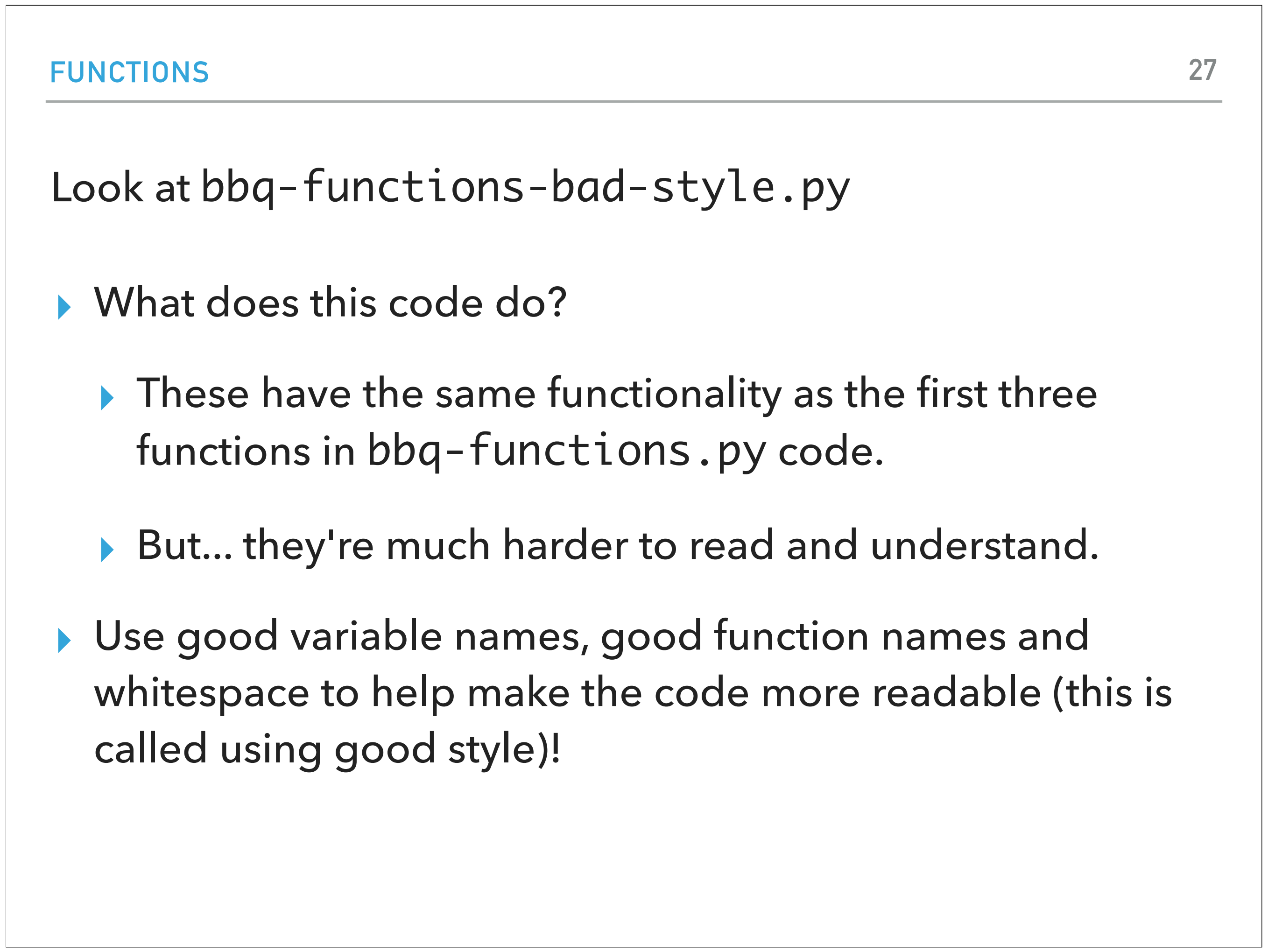
```
>>> hotdogs(1,2)
13
>>> hotdogs(1,3)
19
```

Look at the hotdogs method in bbq-functions.py. What does it do? Same thing as our bbq program, just now we've encapsulated it as a program where we can pass it parameters. We could now call the hotdogs function just passing how many hotdogs Angine and Jasmine want and we would get the new total very easily!

Rest of the methods in `bbq-functions.py`?

- Look at the other functions in `bbq-functions.py` code: what do they do?
  - The rest of these functions don't really have any new features from the ones we've previously seen.
  - Notice that we can build up more complicated functions by using the simpler functions.
  - Don't forget that if you want to combine a `string` and an `int/float`, you need to convert the `int/float` to a `string` using the `str` method.

Look at the other functions in bbq-functions.py code: what do they do? The rest of these functions don't really have any new features from the ones we've previously seen. Notice that we can build up more complicated functions by using the simpler functions. Don't forget that if you want to combine a string and an int/float, you need to convert the int/float to a string using the str method.



Look at `bbq-functions-bad-style.py`

- What does this code do?
    - These have the same functionality as the first three functions in `bbq-functions.py` code.
    - But... they're much harder to read and understand.
- Use good variable names, good function names and whitespace to help make the code more readable (this is called using good style)!

Look now at the file bbq-functions-bad-style.py. What does this code do? These have the same functionality as the first three functions in bbq-functions.py cod e.But… they're much harder to read and understand. Remember to use good variable names, good function names and whitespace to help make the code more readable (this is called using good style)!

Resources

- Textbook: Continue reading Chapter 1 and 2
- simple-functions.txt
- bbq-functions.txt
- bbq-functions-bad-style.txt

Homework

- (Work in progress) - Assignment 1