MORE PYTHON FUNCTIONS: PROCEDURES; NONE

LECTURE 03-1

THE NONE VALUE
PROCEDURES

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QUIZ TODAY

- Today there will be ***a short quiz*** on
  - basic Python scripting
  - `input` with prompts
  - formatting output with `print`
  - integer division (using `//` and `%`)
  - string arithmetic

READING

- Today's lecture material can be supplemented with:
  - **Reading:**
    - Ch. 3, 6 (functions)
    - CP 1.3-1.4 (user-defined functions); 1.5 ("control")

RECALL: FUNCTION DEFINTIONS

- Here is Python source defining three functions:

```
def square(x):
    return x * x

def gains(initial, yearly_rate, years):
    multiplier = 1.0 + yearly_rate / 100.0
    growth = multiplier ** years
    amount = initial * growth
    return amount - initial

def distanceFromTo(startX, startY, endX, endY):
    changeX = endX - startX
    changeY = endY - startY
    distanceSquared = changeX**2 + changeY**2
    return distanceSquared ** 0.5
```

SYNTAX: FUNCTION DEFINITION

Below gives a template for function definitions:

```
def function-name(formal-parameter-list):
    lines of statements that compute using the parameters
    ...
    return the-computed-value
```

- Each line of the function's body is *indented with 4 spaces*.
  - ➡ This code is executed when the function is called.
- Each function takes several parameters as values.
  - ➡ These are passed into "local" variables, the ***formal parameters***.
- The last line is often a `return` statement.

SCRIPTING WITH FUNCTIONS

- We can define functions in scripts.
- Lay out a series of useful function definitions at the top.
  - We call them in the main lines of the script…
  - … but we might perhaps also call them in other functions.

SCRIPTING WITH FUNCTIONS

Why should we define functions?

- Makes code readable.
- Creates reusable code components.
- Makes debugging and testing easier.
- Allows you to hide implementation.

With coding its good to take a "client/service" mentality:

- Write functions that serve other parts of the code well.
- The client code doesn’t need to know the internals of a function, just the interface.

EXAMPLE SCRIPT WITH FUNCTIONS

```
from math import pi, sqrt

def getFloat(prompt):
    return float(input(prompt))

def getArea():
    a = getFloat(“Circle area? “)
    while a < 0.0:
        a = get_float(“Not an area. Try again: ”)
    return a

def radiusOfCircle(A):
    return sqrt(A / pi)

area = getArea()
radius = radiusOfCircle(area)
print("That circle’s radius is “+str(radius)+”.”)
```

LOADING PYTHON FUNCTIONS

- You can also have Python files that only contain function definitions.
- You can load a Python file and interact with it using `-i`

```
C02MX1KLFH04:examples jimfix$ python3 -i example_functions.py
>>> square(3)
9
>>> gains(100,5,2)
10.25
>>> distanceFromTo(-1.0, 2.5, 2.0, 6.5)
5.0
>>>
```

THE FLOW OF CONTROL WITH FUNCTIONS

- Function calls are another kind of “control flow”. Python “jumps around.”
- Below is an example with two: **`getArea`** and **`radiusOfCircle`**.

```
def getArea():
    a = float(input("Circle area? “))
    while a < 0.0:
        a = float(input(“Not an area. Try again:”))
    return a

def radiusOfCircle(someArea):
    from math import pi, sqrt
    return sqrt(someArea / pi)

area = getArea()
radius = radiusOfCircle(area)
print("That circle’s radius is “+str(radius)+”.”)
```

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    return a
```

```
def radiusOfCircle(someArea):
    from math import pi, sqrt
    return sqrt(someArea / pi)
```

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area = getArea()
radius = radiusOfCircle(area)
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THE FLOW OF CONTROL WITH FUNCTIONS

- The instruction pointer jumps from the main script code, up to the function's code, and then returns back.

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def getArea():
    a = float(input("Circle area? “))
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LOCAL VS. GLOBAL FRAMES

- When a function gets called, a *local frame* gets created for the function's local variables.

global frame

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def getArea():
    a = float(input("Circle area? “))
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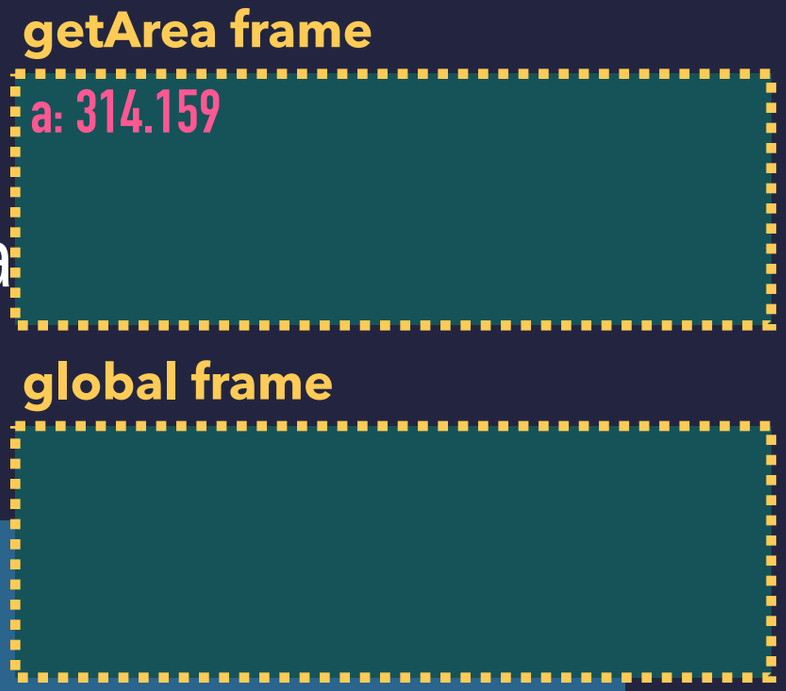


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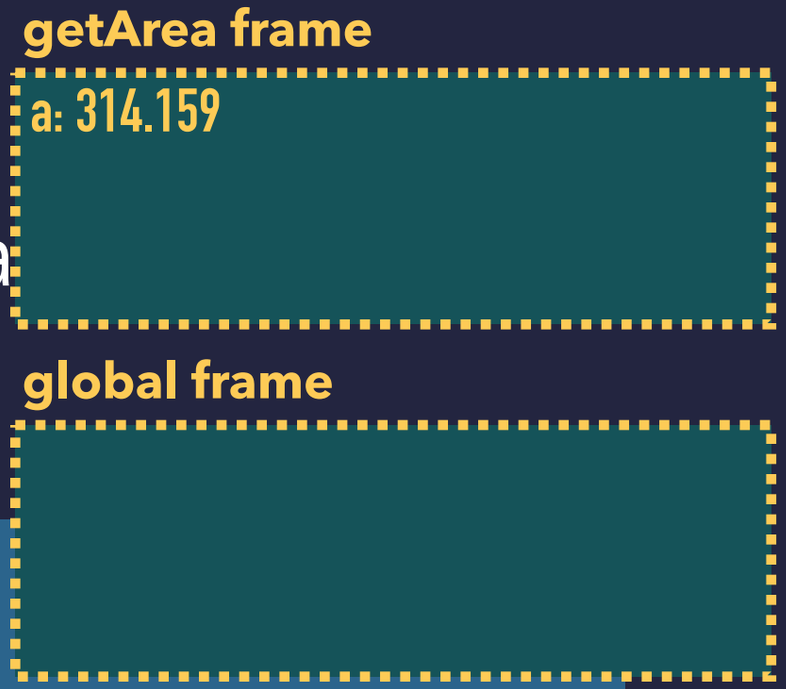

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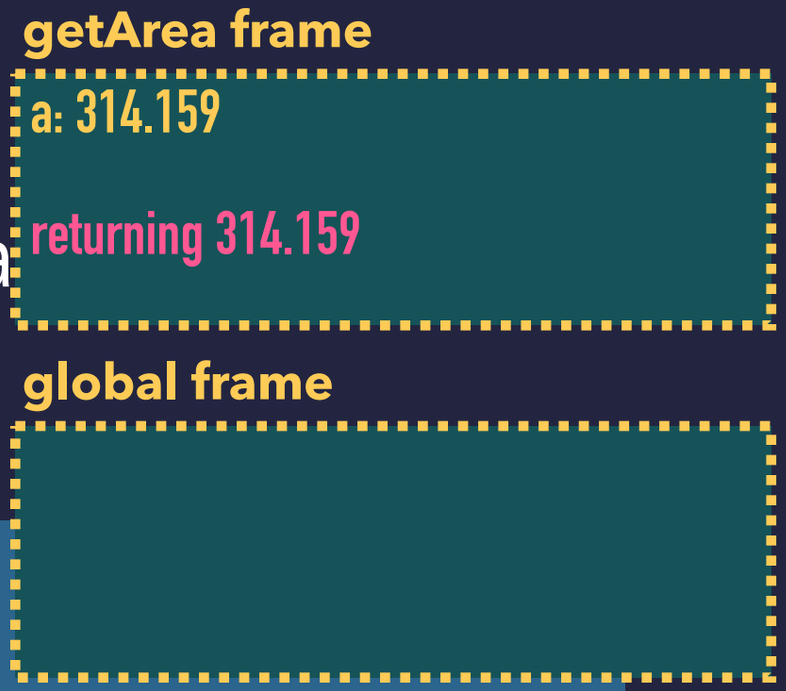


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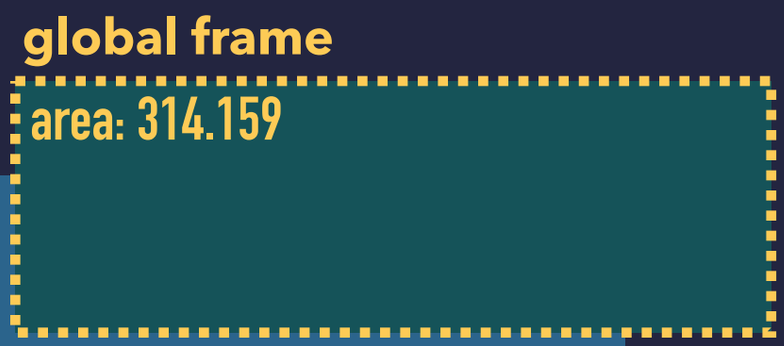


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LOCAL VS. GLOBAL FRAMES

- When a function gets called, a *local frame* gets crea
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radiusOfCircle frame

someArea: 314.159

global frame

area: 314.159

```
def getArea():
    a = float(input("Circle area? “))
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```

radiusOfCircle frame

someArea: 314.159
pi: 3.141592653589793
sqrt: <function that computes sqrt>

global frame

area: 314.159

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radiusOfCircle frame

someArea: 314.159
pi: 3.141592653589793
sqrt: <function that computes sqrt>

returning 0.9999995776679783

global frame

area: 314.159

LOCAL VS. GLOBAL FRAMES

- When a function gets called, a *local frame* gets created for the function's local variables.

global frame

area: 314.159
radius: 0.9999995776679783

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IMPORT AND DEF CREATE FRAME ENTRIES

- Both **`def`** and **`import`** introduce names.
- These get placed in the frame of the block being executed.

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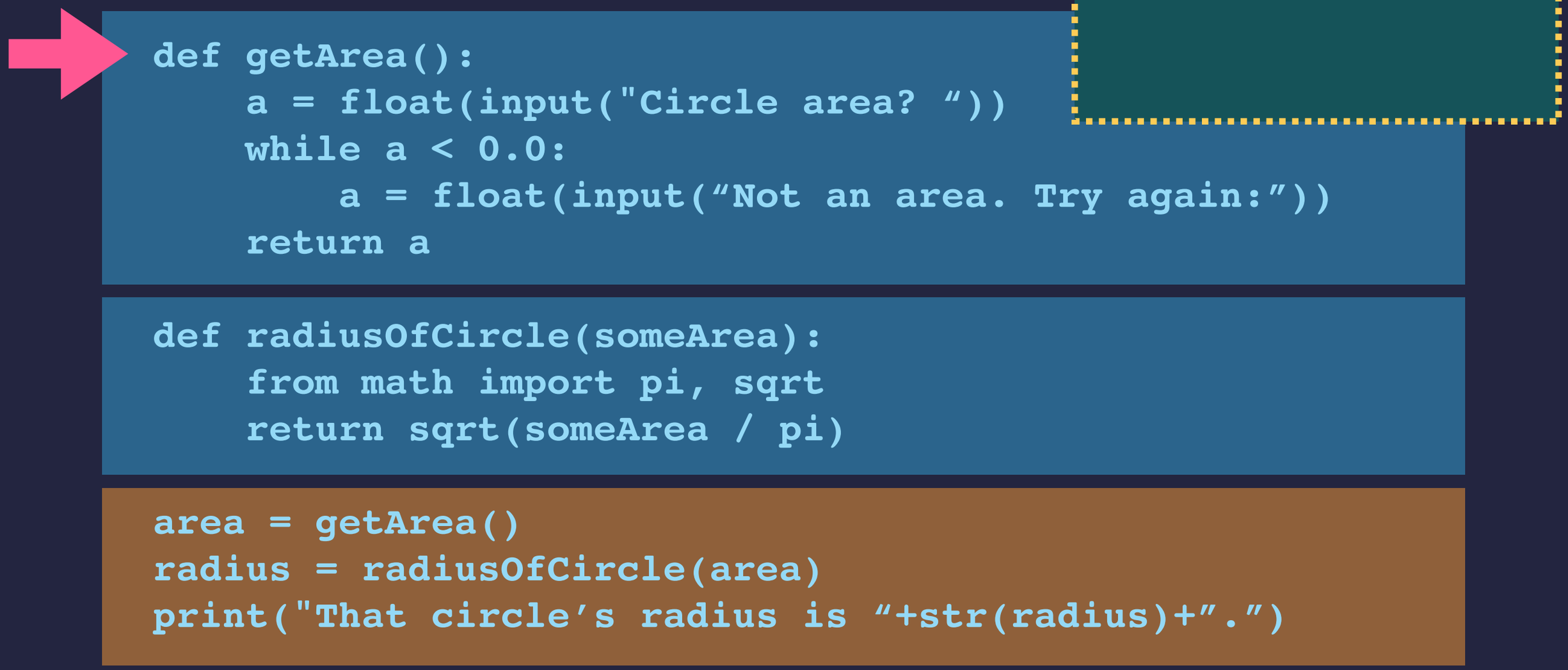
REDO: DEF EXECUTION

- When a block has a **`def`**, a function object gets created.
- The new name's association is added to the frame.



REDO: DEF EXECUTION

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global frame

getArea: <function that requests>
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FUNCTION CALLING MECHANISM

- Functions are passed the values of their arguments.
- Function have their own variables, managed by their ***local frame***.
  - ➡The frame is initialized with a call:
    - ✦The ***formal*** parameters are set to the ***actual*** argument values.
    - ✦Assignment statements can introduce new local variables in the frame.
    - ✦(So do nested `def` and `import` statements.)
- Functions `return` a value back to the calling statement.
  - ➡Upon `return`, the function's local frame goes away.

A local frame's ***lifetime*** is the time between its function's call and return.

FUNCTION CALLING MECHANISM (CONT'D)

- Each function call leads to creation of a new frame.
- Frames due to calls ***stack up***.
  - ➡This happens when the script calls a function...
  - ➡...and that function calls a function. Etc.

We'll examine this more later after you've had some practice writing them.

MORE EXAMPLES: A PARITY FUNCTION

- Here is a function that returns the *parity* of a number as a string:

```
def getTheParityOf(n):
    if n % 2 == 0:
        return “even”
    else:
        return “odd”
```

MORE EXAMPLES: ABSOLUTE VALUE COMPUTATION AS A FUNCTION

- A `return` can appear within the function, not just as its last statement.
- For example, consider this function:

```
def absoluteValueOf(x):
    if x < 0:
        return -x
    else:
        return x
```

MORE EXAMPLES: ABSOLUTE VALUE COMPUTATION AS A FUNCTION

- A `return` can appear within the function, not just as its last statement.
- This version works too:

```
def absoluteValueOf(x):
    if x < 0:
        return -x
    return x
```

- If `x` is negative, the function returns immediately with `-x`.
  - ➡ Otherwise it continues to the next line where it then instead returns `x`.

MORE EXAMPLES: PRIMENESS COMPUTATION

- A *prime number* is a positive integer with exacrtly two positive divisors.
- Write a function that determines whether or not an integer is prime:

```
def isPrime(number):
    ????
```

MORE EXAMPLES: PRIMENESS COMPUTATION

- A *prime number* is a positive integer with exacrtly two positive divisors.
- Here is a function that determines whether or not a number is prime:

```
def isPrime(number):
    if number <= 1:
        return False

    # Look for a divisor…
    check = 2
    while check < number:
        if number % check == 0:
            return False
        check = check + 1

    # We've tried all the possible factors.
    return True
```

- Note that we might **`return`** before the loop.
- Or we might even **`return`** in the middle of the loop.
  - ➡ That return behaves like a **`break`** statement.

SUMMARY

- A function's code consists of an indented ***body*** of statements.
  - ➡ These statements are ones like the top-level ones used in scripts.
- The function's lines of code compute using the ***parameter*** variables.
- The last line executed is a `return` statement.
  - ➡ It computes a value that gets "handed" back or *returned*.
- A function might `return` within the middle of its code, not the end.
  - ➡ In that case, it exits immediately with that value
- A function can be ***called*** several times within a program's code.
  - ➡ With each call, different values are passed to the function.

BREAK

MORE EXAMPLES: MIXING TYPES WITH WHAT'S RETURNED

- The function below determines whether an integer `rating` is from 1 to 10.
- It returns either the integer or a string:

```
def assessRating(rating):
    if (rating > 0) and (rating <= 10):
        return rating
    else:
        return “not a rating”
```

- Below is it in use:

```
>>> assessRating(3)
3
>>> assessRating(11)
"not a rating"
```

MISSING CASES?

- What happens if you (accidentally) forget a case?

```
def example(value):
    if value > 0:
        return "positive"
    elif value < 0:
        return "negative"
```

- What happens in the missing case?

```
>>> example(3)
'positive'
>>> example(-4)
'negative'
>>> example(0)
????
```

MISSING CASES?

- What happens if you (accidentally) forget a case?

```
def example(value):
    if value > 0:
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- What happens in the missing case?

```
>>> example(3)
'positive'
>>> example(-4)
'negative'
>>> example(0)
>>>
```

- Python's interactive session doesn't show the `None` value!

MISSING CASES

- What happens if you (accidentally) forget a case:

```
def example(value):
    if value > 0:
        return "positive"
    elif value < 0:
        return "negative"
```

- What happens in the missing case?

```
>>> print(example(3))
positive
>>> print(example(4))
negative
>>> print(example(0))
None
```

MISSING CASES

- What happens if you (accidentally) forget a case:

```
def example(value):
    if value > 0:
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```

- What happens in the missing case?

```
>>> print(repr(example(3)))
'positive'
>>> print(repr(example(4)))
'negative'
>>> print(repr(example(0)))
'None'
```

MISSING CASES

- What happens if you (accidentally) forget a case:

```
def example(value):
    if value > 0:
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```

- What happens in the missing case?

```
>>> print(example(3))
positive
>>> print(example(4))
negative
>>> print(example(0))
None
```

- There is a special Python value `None` that is implicitly returned.
- Confusingly, the interpreter does not display the `None` value.

MISSING CASES

- What happens if you (accidentally) forget a case:

```
def example(value):
    if value > 0:
        return "positive"
    elif value < 0:
        return "negative"
```

- What happens in the missing case?

```
>>> print(example(3))
positive
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negative
>>> print(example(0))
None
```

- There is a special Python value `None` that is implicitly returned.
- *Make sure in your functions you've an explicit* `return` *for every case!*

PROGRAMMER-DEFINED PROCEDURES

- Python has the same **`def`** syntax for defining ***procedures***
  - ➡ This is my term for a "function that does not return a value."
  - ➡ Instead, it does some stuff, performs some actions.
- For example

```
def printBoxTop(size):
    dashes = "-" * size
    print("+" + dashes + "+")

def printBox(width):
    printBoxTop(width)
    print("|" + (" "*width) + "|")
    printBoxTop(width)
```

- Below is its use. It's as if we've invented a **`printBox`** statement.

```
>>> printBox(4)
+----+
|    |
+----+
>>>
```

SYNTAX: PROCEDURE DEFINITION

Below gives a template for procedure definitions:

```
def procedure-name(parameter-list):
    lines of statements that compute using the parameters
    ...
    return
```

- The last line is often a `return` statement, but it isn't needed.
- There can also be `return` statements within the code.
  - ➡ These lead Python to exit the procedure as soon as they are reached.
  - ➡ Control returns back to where the procedure was called, continues there.

EXAMPLE SCRIPT WITH PROCEDURES

```
def printBoxTop(size):
    dashes = "-" * size
    print("+" + dashes + "+")

def greetTheUser(name):
    print("Hi, " + name + ". Nice to meet ya!")
def printBox(w):
    printBoxTop(w)
   print("|" + (" " * w) + "|")
    printBoxTop(w)

user = input("What's your name? ")
greetTheUser(user)
print("I'd like to make you a box.")
width = int(input("How wide of a box would you like? "))
printBox(width)
print("Here is one that is twice as wide:")
printBox(width * 2)
```

PROCEDURES RETURN THE NONE VALUE

- All three of these procedures do the exact same thing:

```
def greetThenReturn_version1(name):
    print("Hi, " + name + ".")

def greetThenReturn_version2(name):
    print("Hi, " + name + ".")
    return

def greetThenReturn_version3(name):
    print("Hi, " + name + ".")
    return None
```

- The first implicitly returns `None`. The first explictly returns but implictly returns `None`. The third explicitly returns the `None` value.

NONE IS WEIRDLY HANDLED BY THE PYTHON INTERPRETER

- Here is some fun with `None`, and with procedures (that return `None`):

```
>>> print("hello")
hello
>>> print(None)
None
>>> "hello"
'hello'
>>> None
>>> 3+4
7
>>> print(print("hello"))
hello
None
>>> greetThenReturn("Jim")
Hello, Jim.
>>> print(greetThenReturn("Jim"))
Hello, Jim.
None
```

FUNCTIONS VS. PROCEDURES

- In Python, procedures are really just functions.
  - Python doesn't distinguish procedures from functions.
  - This is just my personal dichotomy, from older languages (Pascal, C).
- "**Function**":
  - A function gets passed some parameters, executes, and then returns a result.
  - A function is used within an expression.
- "**Procedure**":
  - A procedure is something that (typically) performs some action/work but does not return a value.
  - A procedure is used as a statement of a line of code.
  - When a procedure's work is done, Python continues executing after the line where it was called. (Control "jumps" then returns.)