PROGRAMMER-DEFINED FUNCTIONS

LECTURE 03-1

JIM FIX, REED COLLEGE CSCI 121

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")

PROGRAMMER-DEFINED FUNCTIONS

- You introduce new functions, and their code, with a `def` statement.
- The code below defines a squaring function:

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

- Here it is in use:

```
>>> square(4)
16
>>> y = 5
>>> square(y)
25
>>> square(y+2)
49
```

- It takes a single value as its parameter. It returns back the square of that value.

PROGRAMMER-DEFINED FUNCTIONS

- The code below computes the distance between two locations on a map:

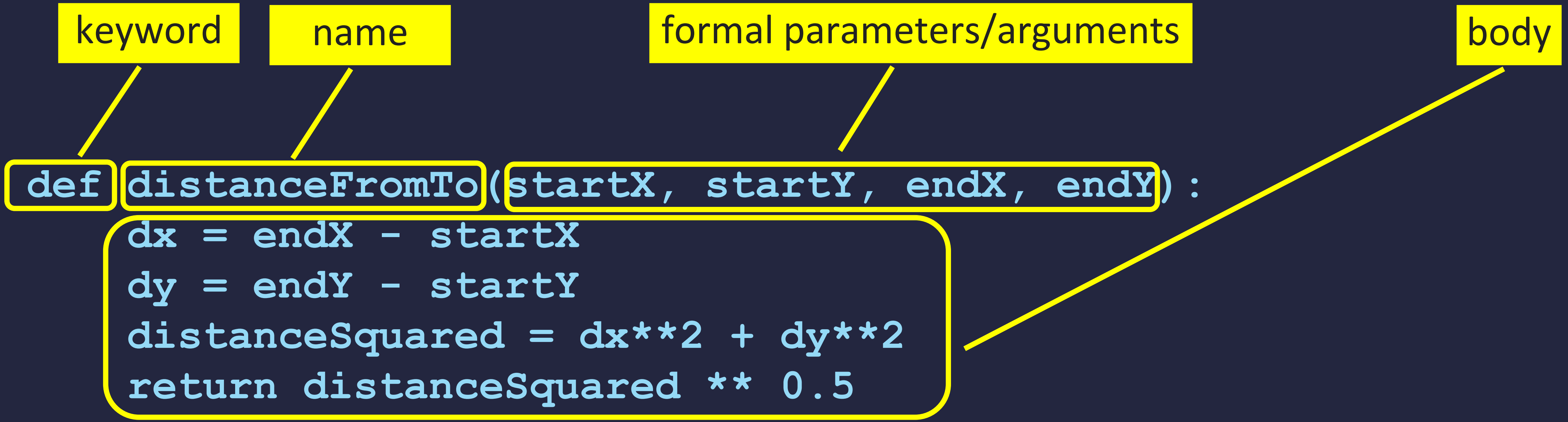
```
def distanceFromTo(startX, startY, endX, endY):
    dx = endX - startX
    dy = endY - startY
    distanceSquared = dx**2 + dy**2
    return distanceSquared ** 0.5
```

- Here it is in use:

```
>>> distanceFromTo(1.5,2,4.5,6)
5.0
```

- It takes four values as parameters, and returns a value back.

PARTS OF A FUNCTION



```
def distanceFromTo(startX, startY, endX, endY):
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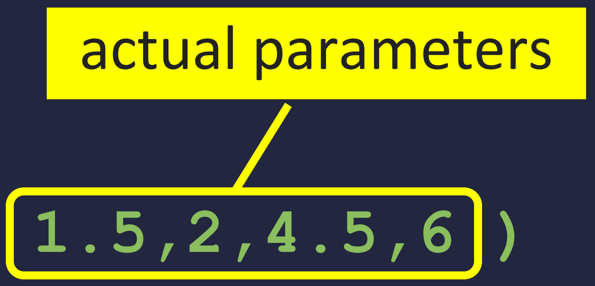
- Here it is in use:



```
>>> distanceFromTo(1.5,2,4.5,6)
5.0
```

PROGRAMMER-DEFINED FUNCTIONS

- This calculates the gains on an amount due to a yearly rate of interest:

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

- Here it is in use:

```
>>> gains(100,5,2)
10.25
>>> print(gains(100,5,1))
5.0
>>> a0 = 100
>>> a1 = a0 + gains(a0,5,1)
>>> a2 = a1 + gains(a1,5,1)
>>> a2
110.25
```

INDENTATION

- Python reads the functions, looking for its indented lines of code

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

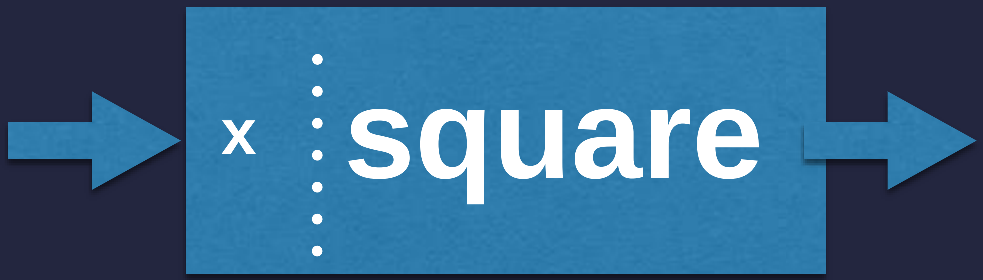
def gains(initial, yearly_rate, years):
    multiplier = 1.0 + yearly_rate / 100.0
    growth = multiplier ** years
    amount = initial * growth
    return amount - initial

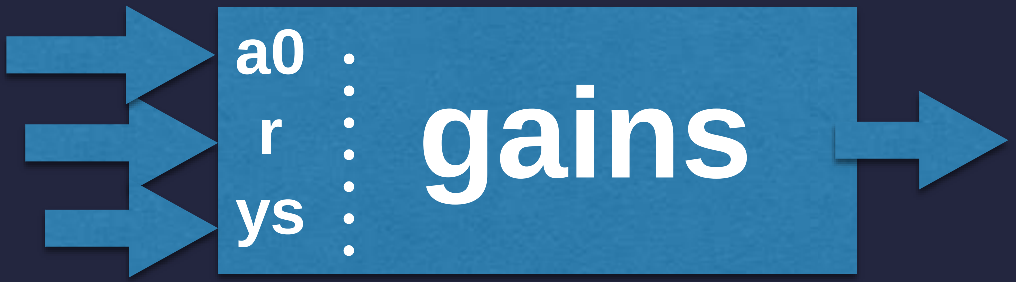
def distanceFromTo(startX, startY, endX, endY):
    dx = endX - startX
    dy = endY - startY
    distanceSquared = dx**2 + dy**2
    return distanceSquared ** 0.5
```

each function's lines are indented by 4 spaces

FUNCTIONS COMPUTE VALUES FROM THEIR PARAMETERS

- A function takes one or more *parameter* values.
- It uses those values to compute its result.
- It then *returns* the result back to the calling expression.
- Functions can be thought of as “value factories” of a program:





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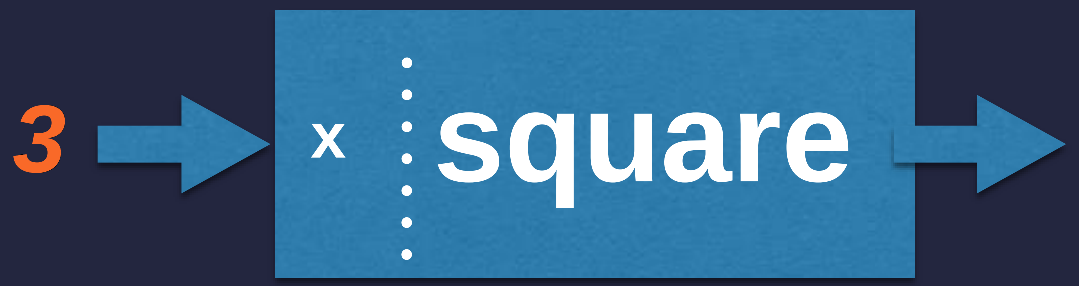

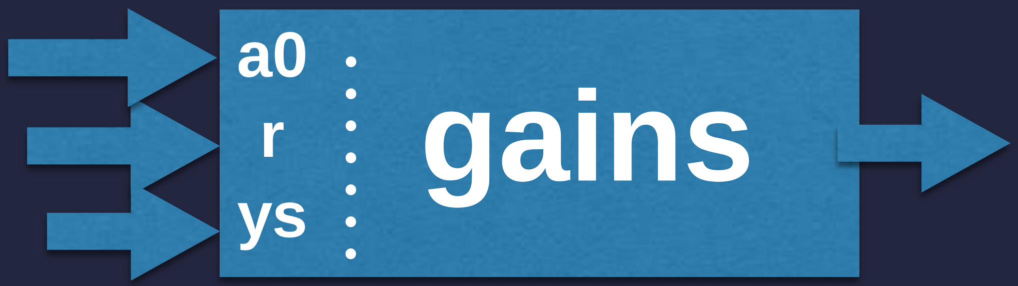

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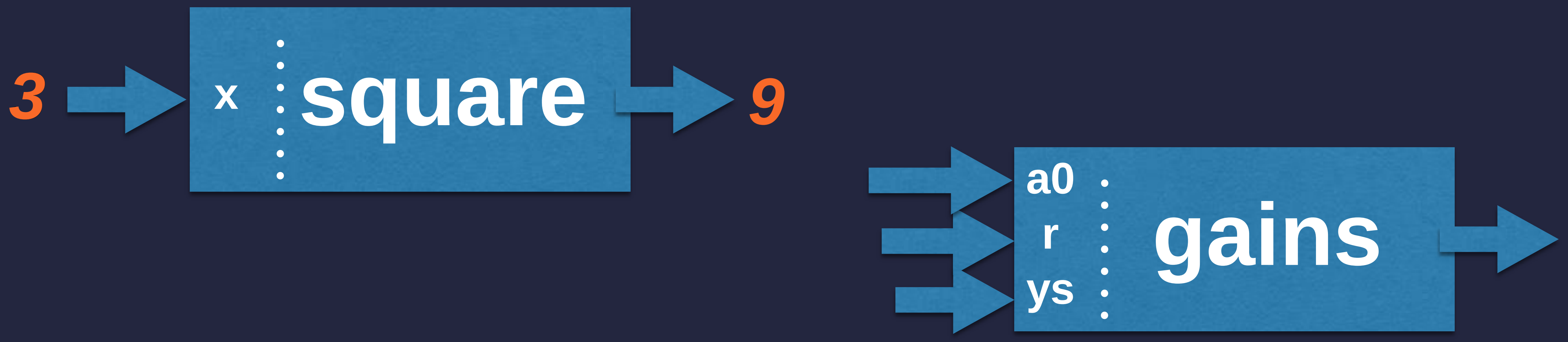

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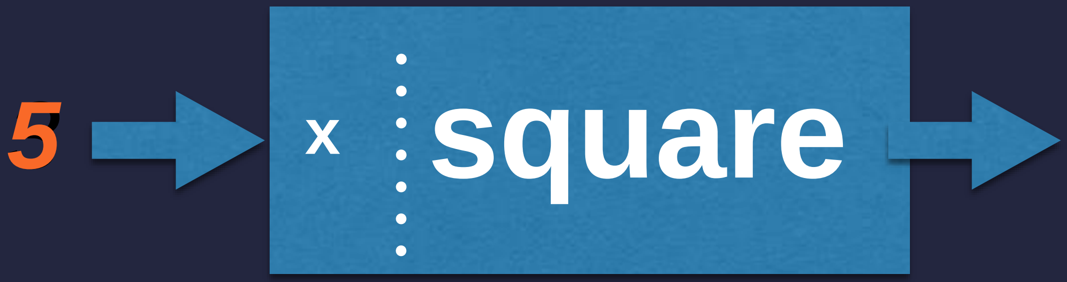

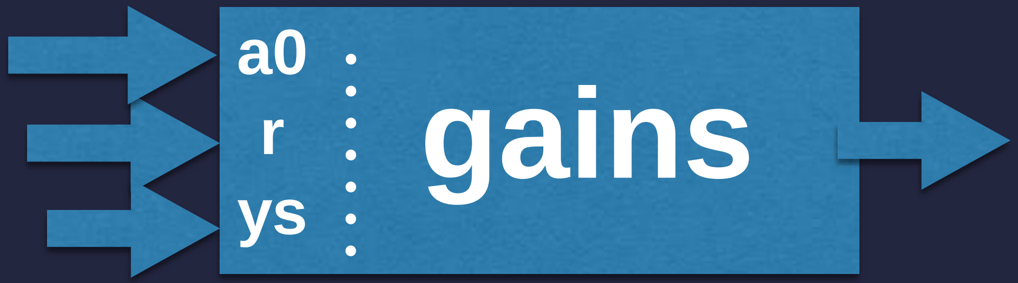

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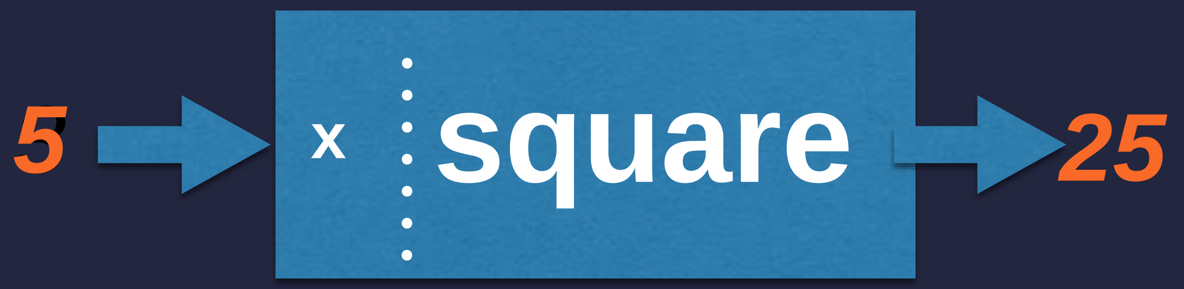

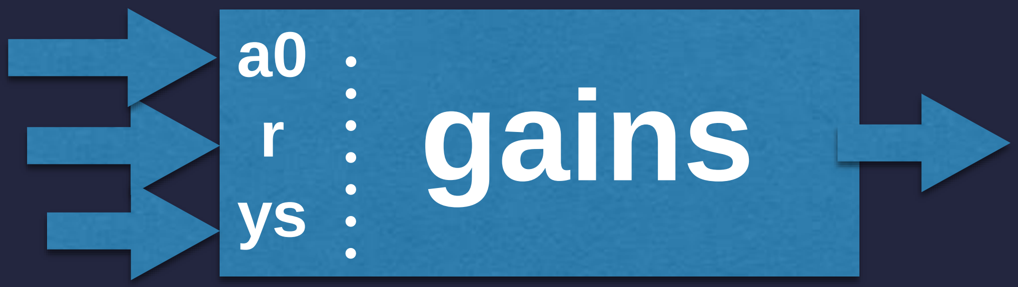

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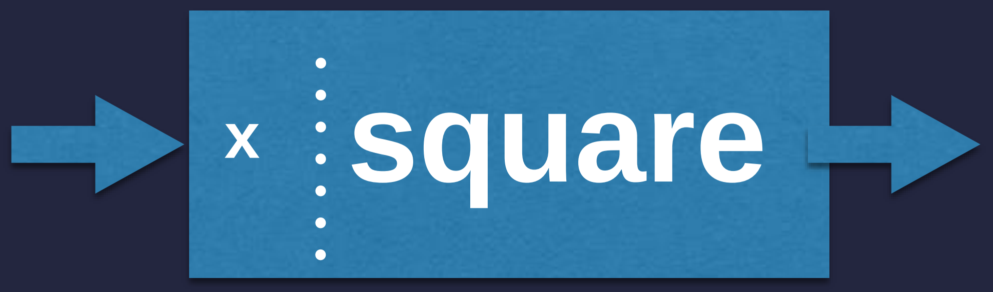

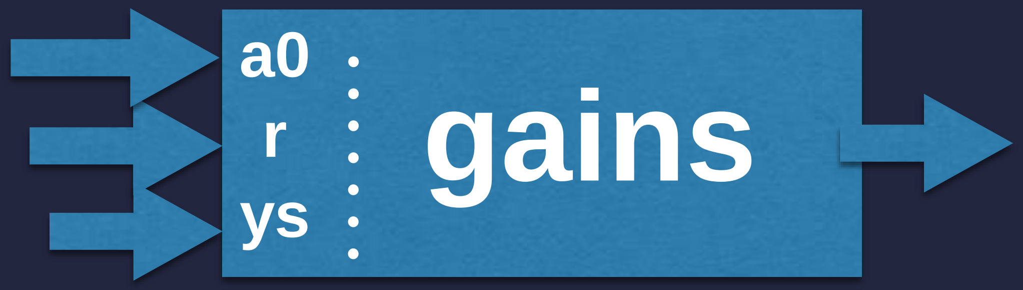

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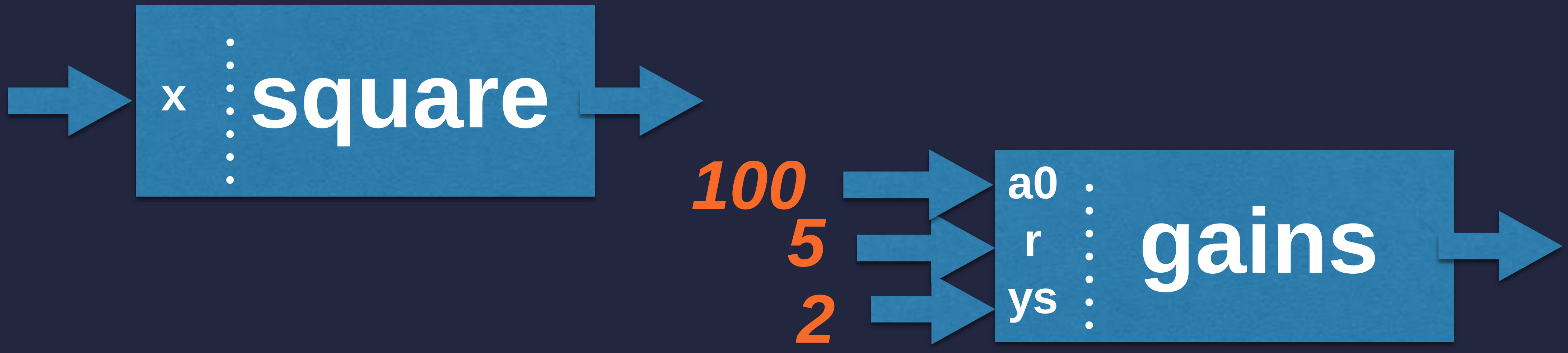

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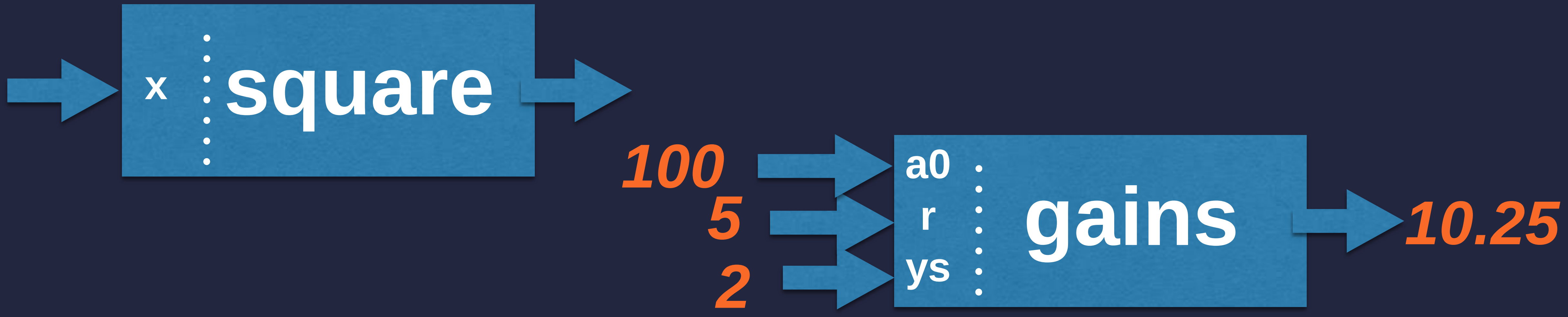

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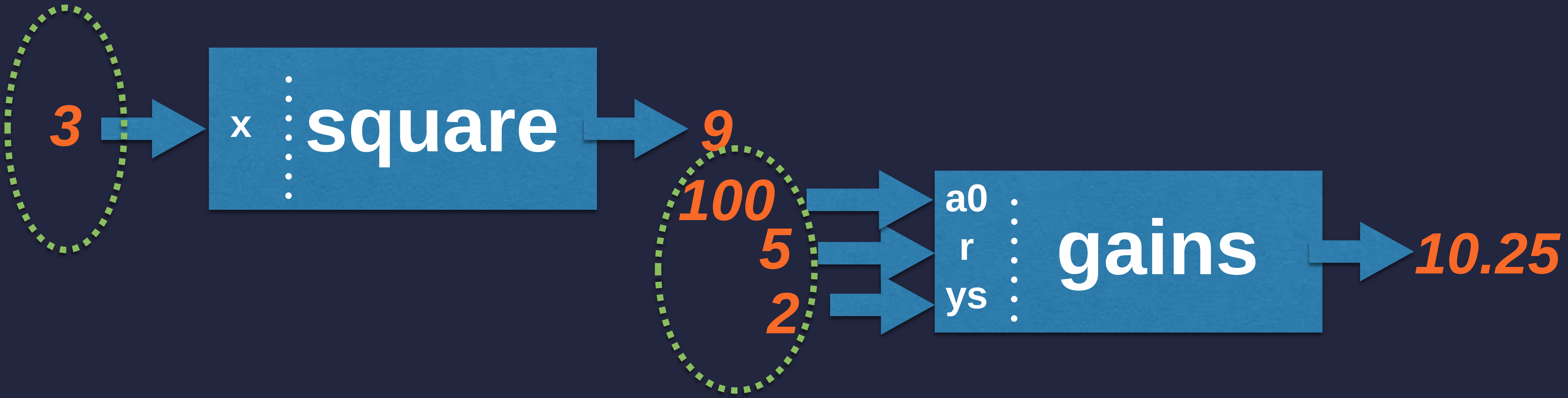

Parameters are fed in.

FUNCTIONS COMPUTE VALUES FROM THEIR PARAMETERS

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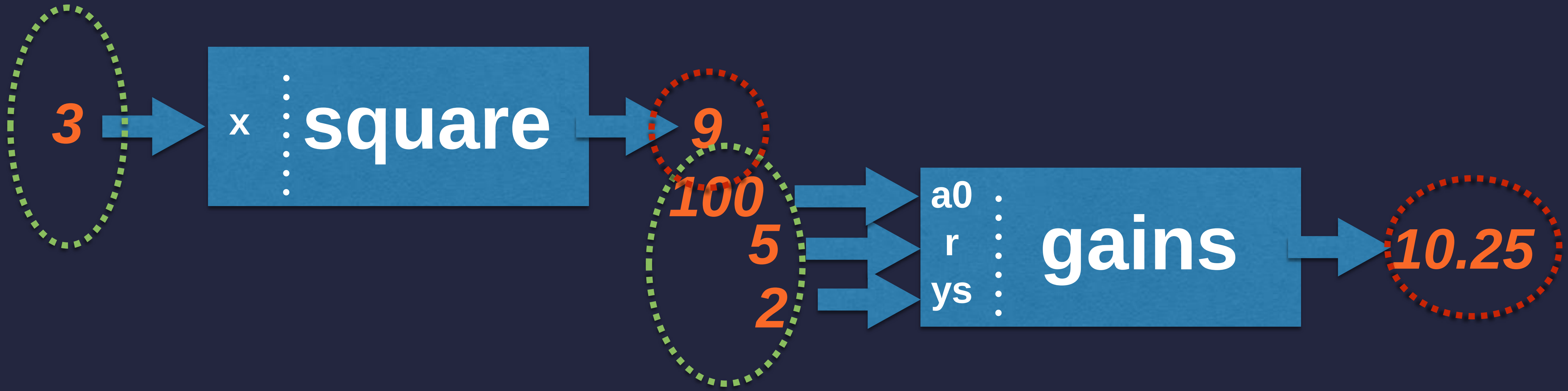

Parameters are fed in.

A returned result comes out.

FUNCTIONS COMPUTE VALUES FROM THEIR PARAMETERS

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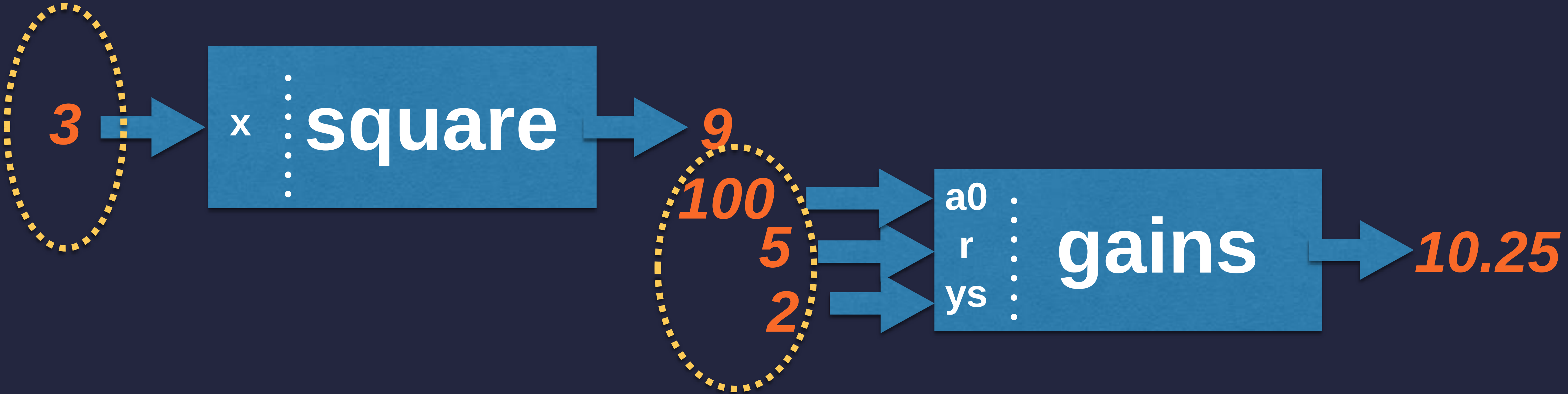

The expected number, type, and ordering of parameters is the function’s *interface*.

FUNCTION CALLS AS EXPRESSIONS

- Because functions compute and return a result, they are used within expressions.
- Can sometimes think of their definitions as being “cut and pasted" in.

For example, the expression

```
>>> square(3) + square(4)
```

- can be viewed as the same as this expression

```
>>> (3 * 3) + (4 * 4)
```

SYNTAX: FUNCTION DEFINITION

Below gives a template for function definitions:

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

- The parameter variables are called its ***formal parameters***.
  - They don't have specific values when the function is defined.
- They represent the values that will get fed in with some call.
  - They vary, in a way, from call to call.

SYNTAX: FUNCTION DEFINITION

Below gives a template for function definitions:

```
def function-name (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.
- The last line is often a `return` statement.

FUNCTION CALLS

Some more terminology:

- Below are two ***calls***, or ***uses***, of our **`square`** function:

```
sqrt(square(3) + square(4))
```

  - Each use of a function occurs at a ***call site*** in the code.
  - 3 is the ***actual parameter*** for its call site. As is 4 for *its* site.

SCRIPTING WITH FUNCTIONS

- We typically 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.

- If the script has bugs you can load it interactively, then test each function:

```
C02MX1KLFH04:examples jimfix$ python3 -i my_script_with_f.py
>>> f(3,4,5)
6789
```

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)+”.”)
```

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.

DECOMPOSITION

ABSTRACTION

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.

LOCAL VS. GLOBAL FRAMES

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

getArea frame

pi: 3.14159
area: 314.159
radius: 10.0

global frame

```
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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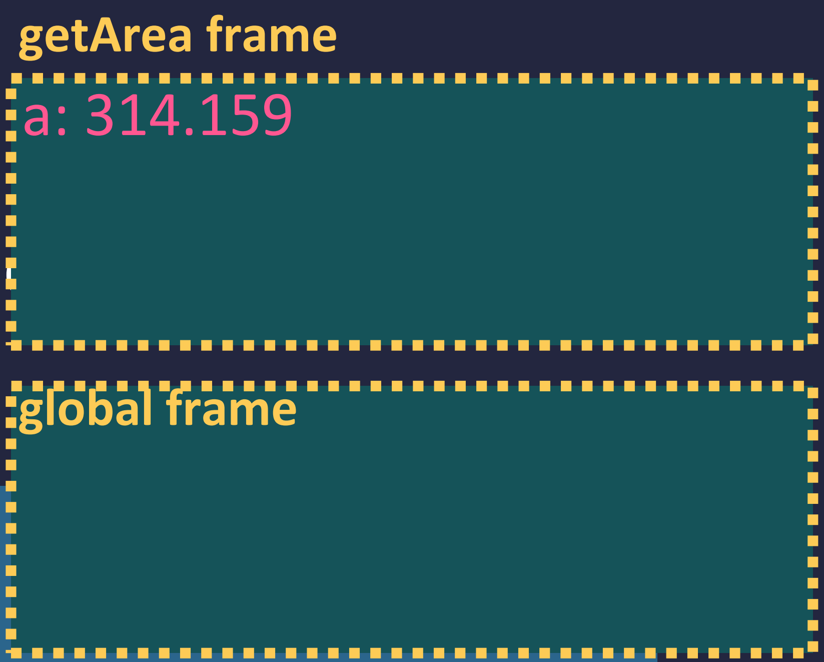

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def getArea():
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    while a < 0.0:
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LOCAL VS. GLOBAL FRAMES

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getArea frame

a: 314.159

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```

LOCAL VS. GLOBAL FRAMES

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getArea frame

a: 314.159

returning 314.159

global frame

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def getArea():
    a = float(input("Circle area? “))
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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)
print("That circle’s radius is “+str(radius)+”.”)
```

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

```
def getArea():
    a = float(input("Circle area? “))
    while a < 0.0:
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    return a
```

```
def radiusOfCircle(someArea):
    from math import pi, sqrt
    return sqrt(someArea / pi)
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```
area = getArea()
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LOCAL VS. GLOBAL FRAMES

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    a = float(input("Circle area? “))
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    return a
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```
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)+”.”)
```

radiusOfCircle frame

someArea: 314.159

global frame

area: 314.159

LOCAL VS. GLOBAL FRAMES

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

radiusOfCircle frame

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

global frame

area: 314.159

```
def getArea():
    a = float(input("Circle area? “))
    while a < 0.0:
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    return a
```

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

```
area = getArea()
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```

LOCAL VS. GLOBAL FRAMES

- When a function gets called, a *local frame* gets c function's local variables.

radiusOfCircle frame

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

returning 0.9999995776679783

global frame

area: 314.159

```
def getArea():
    a = float(input("Circle area? “))
    while a < 0.0:
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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

```
area: 314.159
radius: 0.9999995776679783
```

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

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def radiusOfCircle(someArea):
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area = getArea()
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LOCAL VS. GLOBAL FRAMES

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

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```

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

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

IMPORT AND DEF CREATE FRAME ENTRIES

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

```
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)+”.”)
```

REDO: DEF EXECUTION

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

global frame

getArea: <function that requests>

```
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()
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REDO: DEF EXECUTION

- When a block has a def, a function object gets created.
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global frame

getArea: <function that requests>
radiusOfCircle: <function that sqrts>

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```

```
area = getArea()
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```

REDO: DEF EXECUTION

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global frame

getArea: <function that requests>
radiusOfCircle: <function that sqrts>
area: 314.159

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```

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

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: ABSOLUTE VALUE USES IF

- Python allows us to reason about values and act on them *conditionally*.
- For example, consider this function:

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

- When fed a negative value, it returns the value with its sign flipped.
  - i.e. the positive value with the same magnitude. `-5.5` ~> `5.5`
- Otherwise, if positive or `0.0`, it just returns that value.

MORE EXAMPLES: PARITY FUNCTION USES IF

- 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: 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:
        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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        elif value < 0:
            return "negative"
```

- 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:
        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
```

- 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
>>> print(example(4))
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)
+----+
|    |
+----+
>>>
```

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
>>> greetThenReturnNone("Jim")
Hello, Jim.
>>> print(greetThenReturnNone("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.
  - When a procedure's work is done, Python continues executing after the line where it was called. (Control "jumps" then returns.)

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 can be ***called*** several times within a program’s code.
  - With each call, different values are passed to the function.
- Procedures are like functions, defined using `def`.
  - They perform some work but don’t return a value.