Foundations of Programming

The Turtle, Lists and Tuples

Announcements

- These slides are on the FoCS website—have you found them?
- What is the role of your mentors?
- Partner expectations…
- Processes that might seem strange in SPIS are preparing you for fall
- Depth vs Breadth: how to choose
    - Depth: 2154 (here!) with Gary this week
    - Breadth: 4258 (4th floor) with Curt this week

Learning outcomes/key ideas

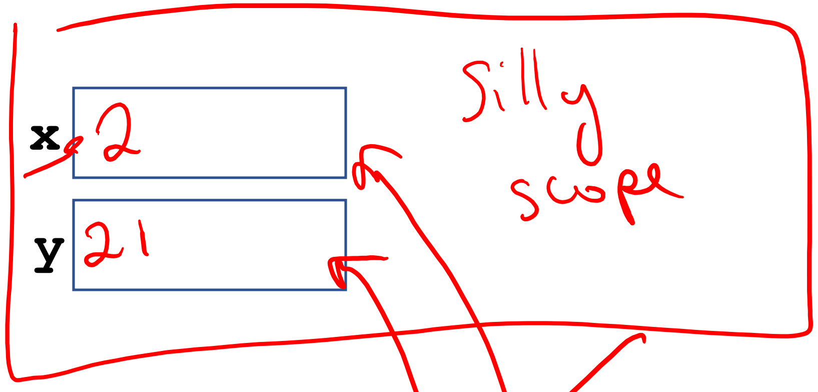
- Write more complex functions in Python
- Explain how the Turtle works in Python
- Explain the concept of a reference and draw memory model diagrams that use references
- Use the data types list and tuple

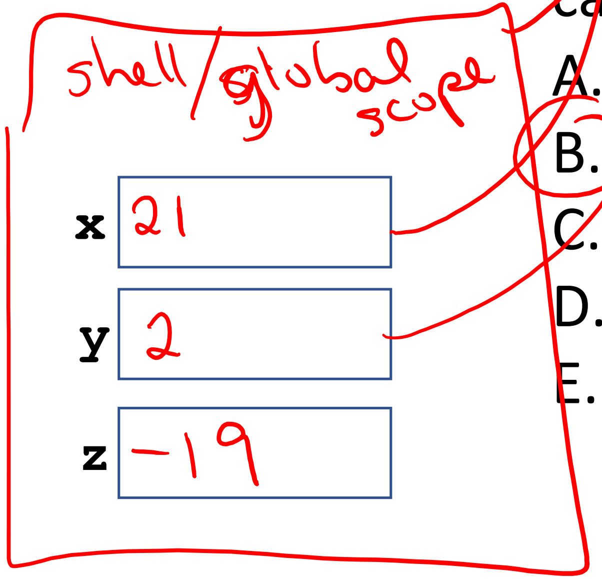
Review on parameters

```
# my own function!

def silly(x, y):
    """ returns x-y """
             2  21
    return x-y

>>> x = 21
>>> y = 2
>>> z = silly( y, x )
```





What is the value of z after the call to silly?

A. 19

[✓ B. -19]

C. 2

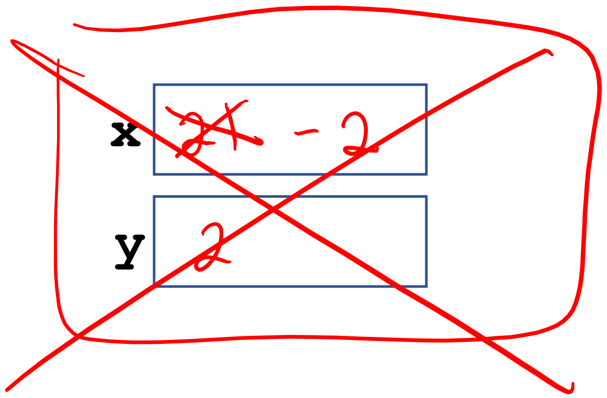
D. 21

E. Nothing

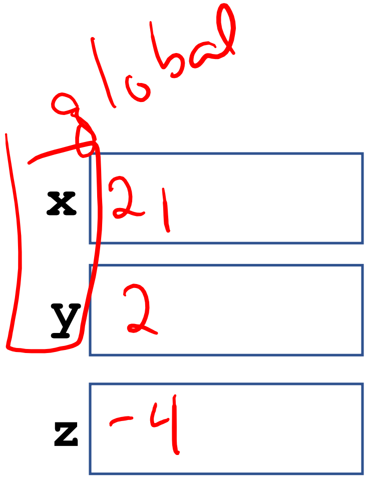
Review on parameters

```
# my own function!

def silly(x, y):
    """ does something silly """
    x = y-4
    return x-y
```



```
>>> x = 21
>>> y = 2
>>> z = silly(x, y)
>>> print(x, ",", y)
```



What is printed?

[✓ A. 21 , 2]

B. 17 , 2

C. -2 , 2

D. -2 , -2

E. Something else

Flow of execution

```
# my own function!

def greeting(personToGreet):
    """ prints a friendly greeting """
    print("Hello " + str(personToGreet))
    print("Welcome to SPIS!")
```

I can load this function by pressing F5.
I can then call it as follows:

```
>>> name = "Christine"
>>> value = greeting("name")
```

What will be displayed after the last line in the code to the left?

A. Hello Christine
   Welcome to SPIS!

[✓ B.] Hello name
   Welcome to SPIS!

C. Nothing

D. It will cause an error

Flow of execution

```
# my own function!

def greeting(personToGreet):
    """ prints a friendly greeting """
    print("Hello " + str(personToGreet))
    print("Welcome to SPIS!")
```

I can load this function by pressing F5.

I can then call it as follows:

```
>>> name = "Christine"
>>> value = greeting("name")
Hello name
Welcome to SPIS!
>>> value
```

What will be displayed after the last line in the code to the left?

A. Welcome to SPIS!

B. Hello name
   Welcome to SPIS!

[✓ C. Nothing]

D. It will cause an error

Flow of execution

```
# my own function!
def greetingReturn(personToGreet):
    """ prints a friendly greeting """
    print("Hello " + str(personToGreet))
    return("Welcome to SPIS!")
```

I can load this function by pressing F5.

I can then call it as follows:

```
>>> name = "Christine"
>>> value = greetingReturn(name)
```

What will be displayed after the last line in the code to the left?

A. Welcome to SPIS!

B. Hello Christine
   Welcome to SPIS!

C. Nothing

D. It will cause an error

E. Hello Christine

Flow of execution

```
# my own function!
def greetingReturn(personToGreet):
    """ prints a friendly greeting """
    print("Hello " + str(personToGreet))
    return("Welcome to SPIS!")
```

I can load this function by pressing F5.
I can then call it as follows:

```
>>> name = "Christine"
>>> value = greetingReturn(name)
Hello Christine
>>> value
```

What will be displayed after the last line in the code to the left?

[✓ A.] 'Welcome to SPIS!'
B. 'Hello Christine'
C. 'Hello Christine
   Welcome to SPIS!'
D. Nothing
E. It will cause an error

Key ideas so far

- Variables have their own scope. When a function is called the *values* are passed in, not the variables themselves.
- Returning is not the same as printing. Only returning passes data back from a function.

More practice with Booleans and Conditionals

74

```
def isHurricane(windSpeed):
    ''' Determine if the windSpeed is strong enough to make a hurricane'''
    if windSpeed >= 74:
        hurricane = True
        print("There is a hurricane!")
    else:
        hurricane = False
        print("Don't panic.  It's not a hurricane")
    return hurricane

wind = 74
hurricane = isHurricane(wind)
```

74

condition, must be bool

True

what to do if the if condition is false

false

What gets printed by this code?

A. There is a hurricane!
True

B. Don't panic. It's not a hurricane
False

[✓ C.] There is a hurricane!

D. Don't panic. It's not a hurricane

E. There is a hurricane!
Don't panic. It's not a hurricane

More practice with Booleans and Conditionals

```
def isHurricane(windSpeed):
   ''' Determine if the windSpeed is strong enough for a hurricane'''
   if windSpeed >= 74:
      hurricane = True
      print("There is a hurricane!")
   else:
      hurricane = False
      print("Don't panic.  It's not a hurricane")
   return hurricane

wind = 74
isAHurricane = isHurricane(wind)
```

What is the value of `isAHurricane`

[✓ A.] True

B. False

C. Nothing

D. Something else

More practice with Booleans and Conditionals

```
                           100
def isHurricane2(windSpeed):
   ''' Determine if the windSpeed is strong enough for a hurricane'''
   if windSpeed >= 74:
      hurricane = True
      print("There is a hurricane!")
   if windSpeed >= 157:
                   False
      hurricane = True
      print("It's a category 5!")
   else:
      hurricane = False
   return hurricane

wind = 100
isAHurricane = isHurricane2(wind)
```

What is the value of `isAHurricane`

(Also, write what is printed)

A. True

[✓ B. False]

C. Nothing

D. Something else

Compound booleans

```
def isHurricane(windSpeed):
   ''' Determine if the windSpeed is strong enough to make it a hurricane'''
   if windSpeed >= 74 and windSpeed < 96:
      hurricane = True
      print("There is a category 1 hurricane")
   elif windSpeed >= 96 and windSpeed < 111:
      hurricane = True
      print("There is a category 2 hurricane")
   …

wind = 100
isAHurricane = isHurricane(wind)
```

```
def choice(x):
    if x > 10:
        print("A")
    if x > 5:
        print("B")
    if x > 0:
        print("C")

>>> ans = choice(8)
```

What will this function *return?*

A. 'A'

B. 'B'

C. 'C'

D. More than one of these

[✓ E. None of these]

```
def choice(x):
    if x > 10:
        print("A")
    if x > 5:
        print("B")
    if x > 0:
        print("C")

>>> ans = choice(8)
```

What will this function *print?*

A. A

B. B

C. C

[✓ D.] More than one of these

E.None of these

```
def choice(x):
    if x > 10:
        print("A")
    elif x > 5:
        print("B")
    else x > 0:
        print("C")

>>> ans = choice(8)
```

What will this function *print?*

A.A

B.B

C.C

D.More than one of these

[✓ E.]None of these

```
def choice(x):
    if x > 10:
        print("A")
    elif x > 5:
        print("B")
    else:
        print("C")

>>> ans = choice(8)
```

What will this function *print?*

A.A

[✓ B.B]

C.C

D.More than one of these

E.None of these

```
def choice(x):
    if x > 10:
        return "A"
    if x > 5:
        return "B"
    if x > 0:
        return "C"
>>> ans = choice(8)
```

What will this function *print?*

A. A

B. B

C. C

D. More than one of these

[✓ E. None of these]

What if x is <= 0?

```
def choice(x):
    if x > 10:
        return "A"
    if x > 5:
        return "B"
    if x > 0:
        return "C"
>>> ans = choice(8)
```

What will this function *return?*

A. A

[✓ B.] B

C. C

D. More than one of these

E. None of these

What if x is <= 0?

Key ideas so far

- Variables have their own scope. When a function is called the *values* are passed in, not the variables themselves.
- Returning is not the same as printing. Only returning passes data back from a function.
- Conditional statements can be tricky! Practice, practice, practice!

Python's Turtle Package

```
import turtle

turtle.forward(100)
turtle.right(90)
turtle.backward(200)
```

Python's Turtle Package

```
import turtle

turtle.forward(100)
turtle.right(90)
turtle.backward(200)
print(turtle.position())
```

What happens if I remove the parentheses from turtle.position() on the last line? I.e.

```
print(turtle.position)
```

Turtles, Turtles everywhere (and introducing references)

Object oriented programming

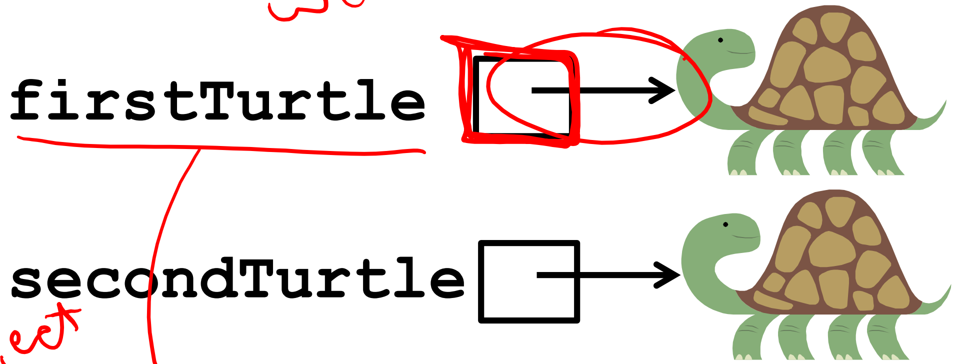
object: packaged up data, with associated functions

```
import turtle

firstTurtle = turtle.Turtle()
secondTurtle = turtle.Turtle()
firstTurtle.forward(100)
secondTurtle.right(90)
secondTurtle.backward(200)
```

creates a new turtle object

creates a new turtle object



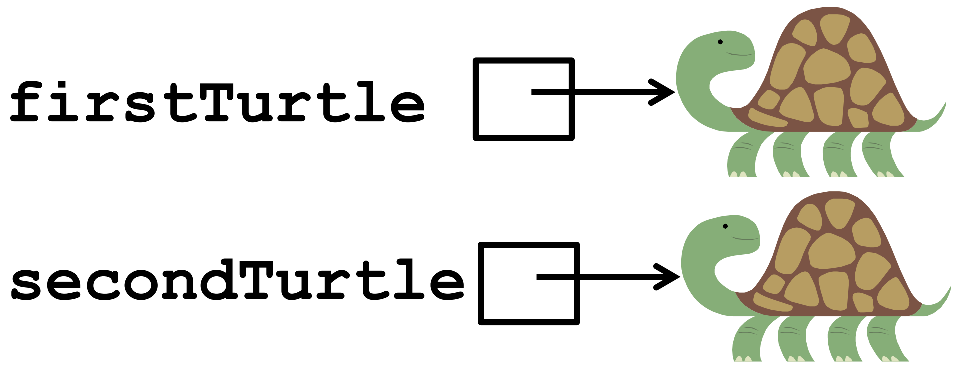
stores a reference to a turtle object

Two different turtle "objects" with the same capabilities
The variables store "references" (location of the Turtle in memory) to each Turtle.

Turtles, Turtles everywhere (and introducing references)

```
import turtle

firstTurtle = turtle.Turtle()
secondTurtle = turtle.Turtle()
secondTurtle = firstTurtle
firstTurtle.forward(100)
secondTurtle.right(90)
secondTurtle.backward(200)
```



firstTurtle

secondTurtle

How does the diagram change with the line in red? How does that change what is drawn?

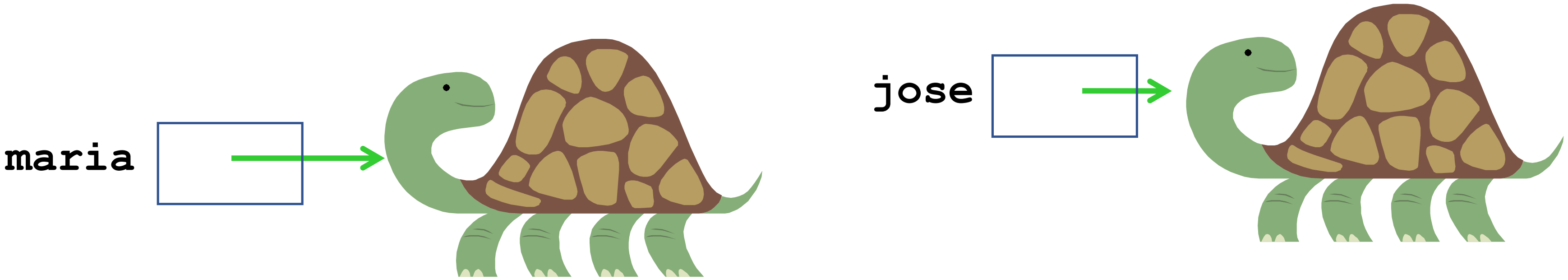
Memory Models in Python, revisited
everything in Python is a reference!

```
x = 42
y = 75
y = x
x = 101
```

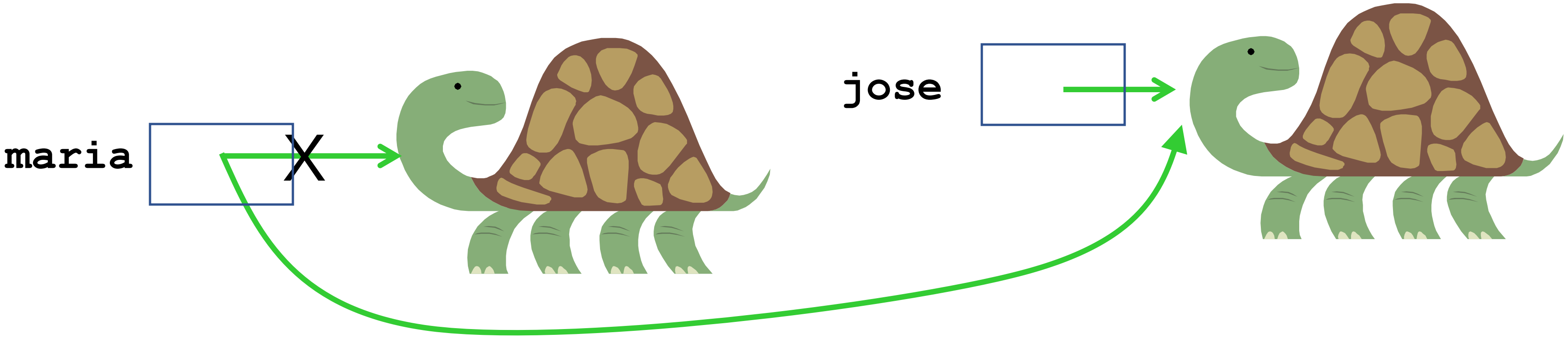
```
maria = turtle.Turtle()
jose = turtle.Turtle();
maria = jose;
jose.forward(100);
```

CS Concepts: References

```
maria = turtle.Turtle()
jose = turtle.Turtle()
```

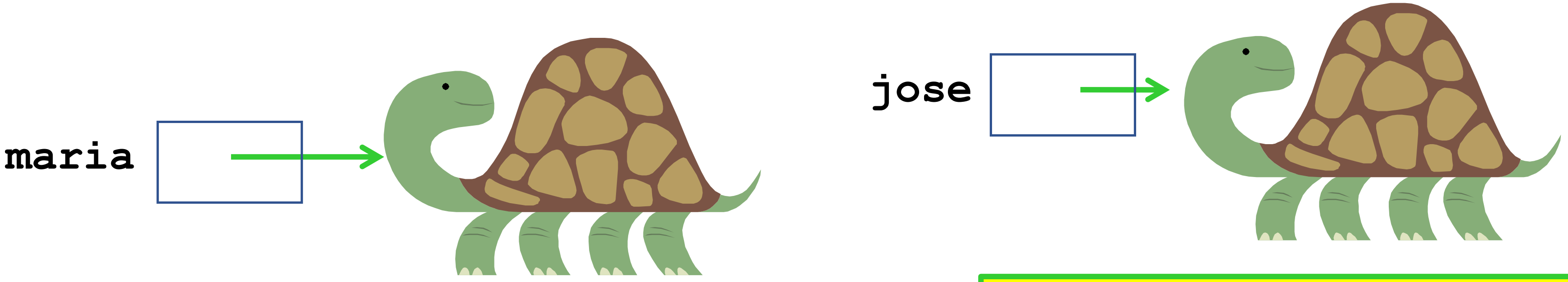


```
maria = jose
```



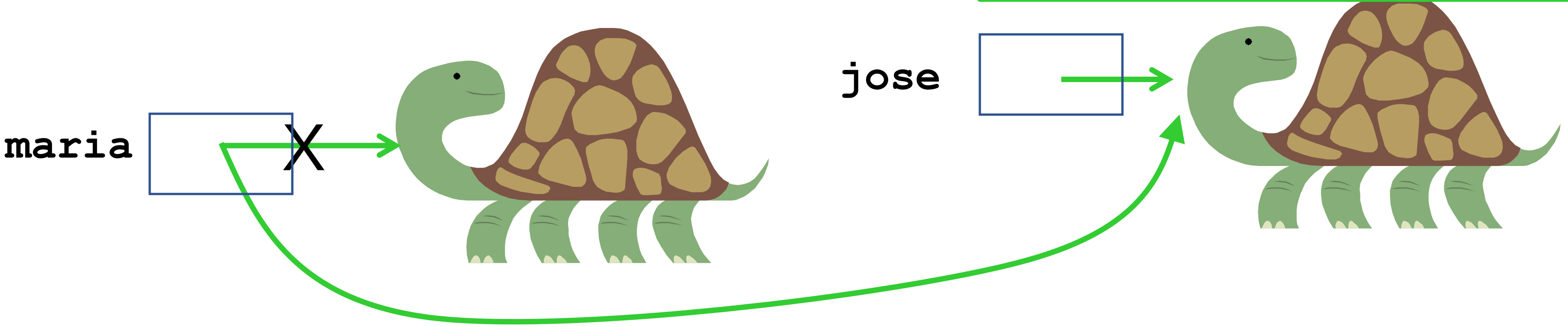
CS Concepts: References

```
maria = turtle.Turtle()
jose = turtle.Turtle()
```



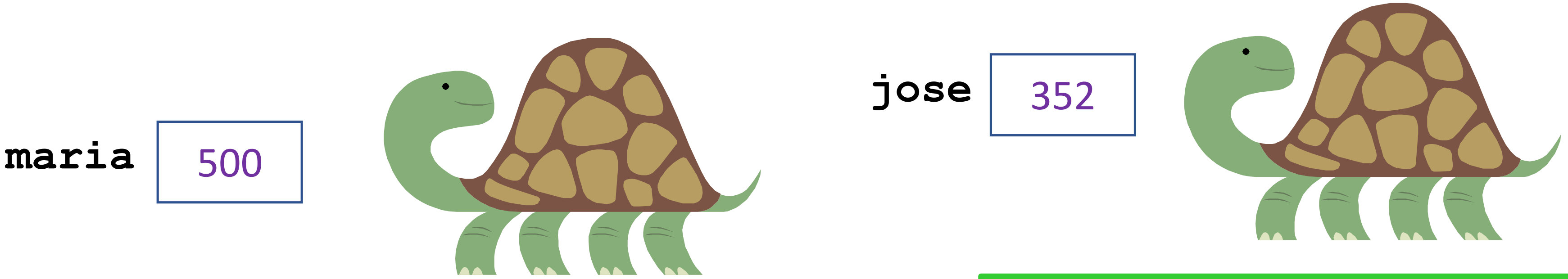
```
maria = jose
```

The arrows in maria and jose’s boxes are just graphical representation of the reference (i.e., location of) the object in memory.



CS Concepts: References

```
maria = turtle.Turtle()
jose = turtle.Turtle()
```



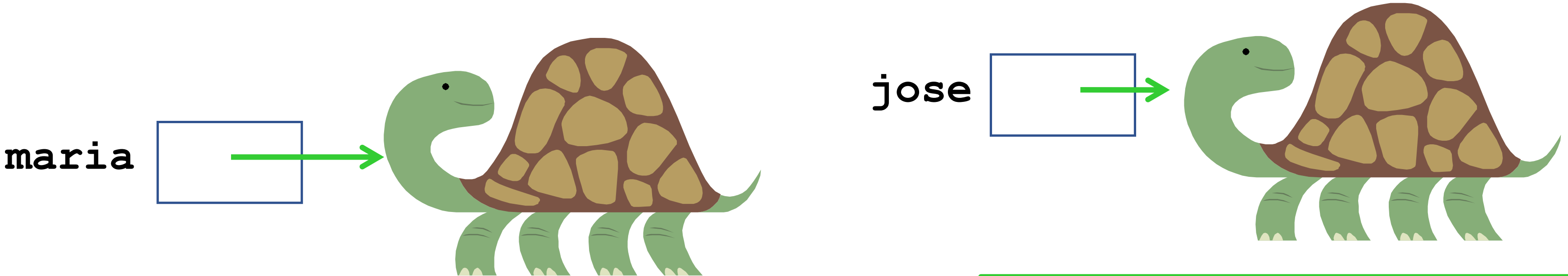
maria 500

jose 352

The arrows in maria and jose’s boxes are just graphical representation of the reference (i.e., location of) the object in memory.

CS Concepts: References

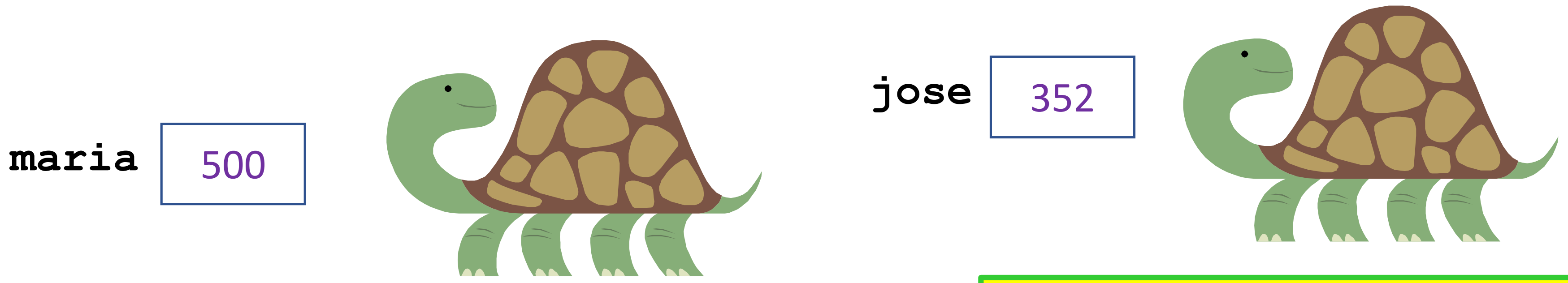
```
maria = turtle.Turtle()
jose = turtle.Turtle()
```



The arrows in maria and jose's boxes are just graphical representation of the reference (i.e., location of) the object in memory.

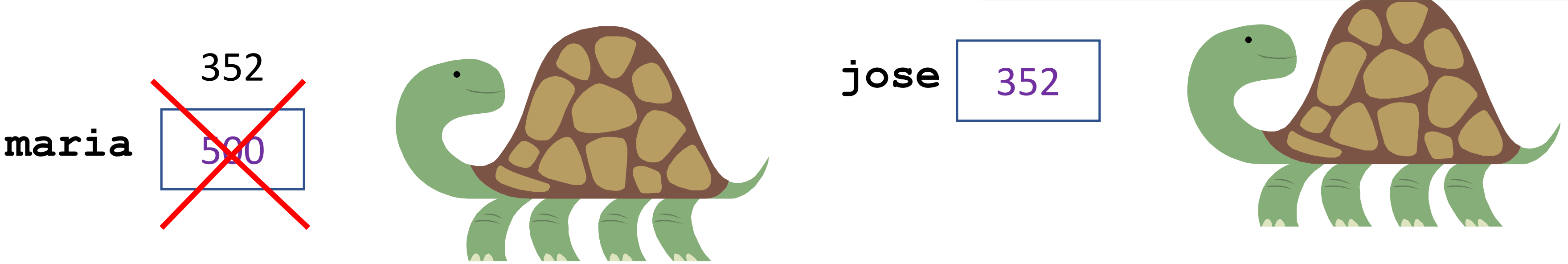
CS Concepts: References

```
maria = turtle.Turtle()
jose = turtle.Turtle()
```



```
maria = jose
```

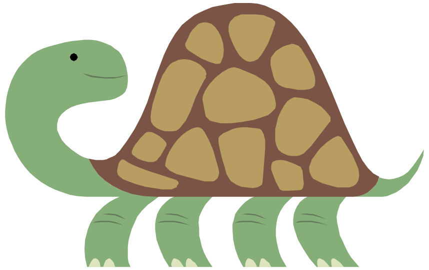
The arrows in maria and jose's boxes are just graphical representation of the reference (i.e., location of) the object in memory.



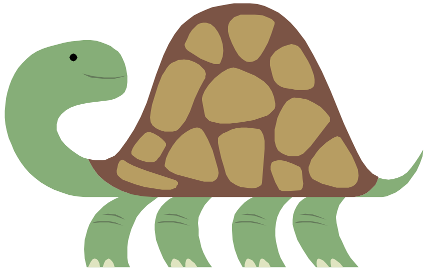
CS Concepts: References

```
maria = turtle.Turtle()
jose = turtle.Turtle()
```

maria 500



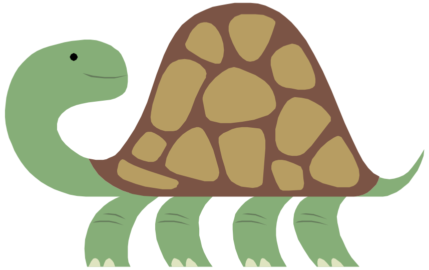
jose 352



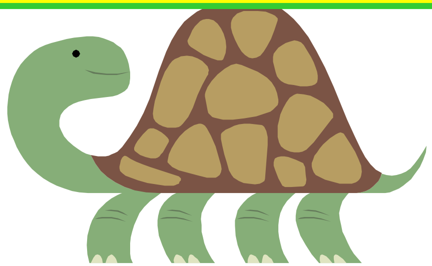
```
maria = jose
```

The arrows in maria and jose’s boxes are just graphical representation of the reference (i.e., location of) the object in memory.

maria 352

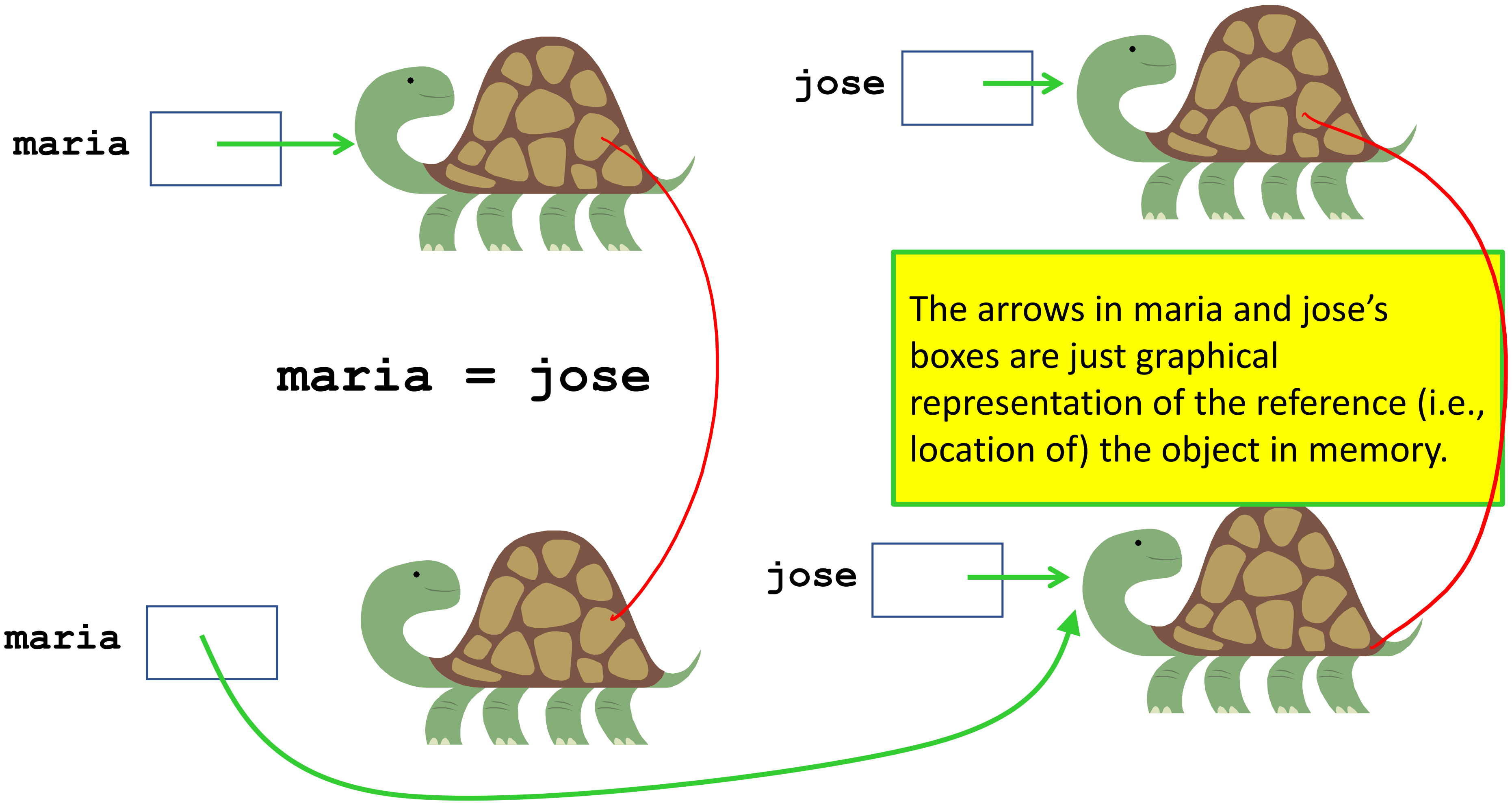


jose 352



CS Concepts: References

```
maria = turtle.Turtle()
jose = turtle.Turtle()
```



```
maria = jose
```

The arrows in maria and jose’s boxes are just graphical representation of the reference (i.e., location of) the object in memory.

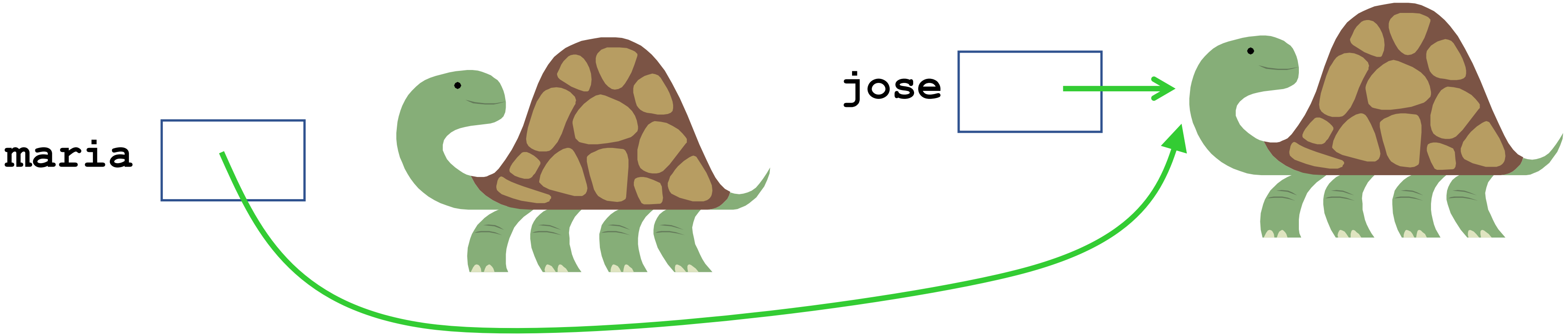
CS Concepts: References

```
maria = turtle.Turtle()
jose = turtle.Turtle()
```

The arrows in maria and jose’s boxes are just graphical representation of the reference (i.e., location of) the object in memory.

This holds for all Object types (not for primitive types)

THIS IS THE HARDEST THING YOU WILL LEARN IN CSE8A/CSE11. MASTER THIS IDEA AND YOU WILL ACE CSE8A/CSE11 (AND MUCH MORE)



Corrected Memory Model

```
x = 42
y = 75
y = x
x = 101
```

Notice the difference!

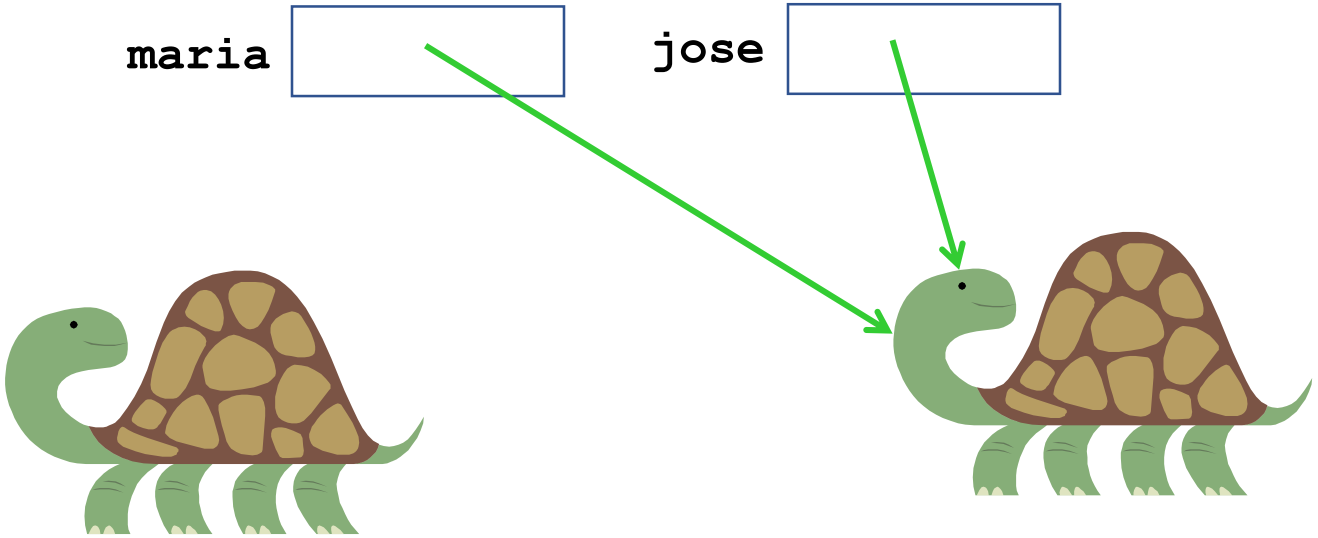
x ~~42~~ 101

y ~~75~~ 42

Variable reassignment

```
maria = turtle.Turtle()
jose = turtle.Turtle()
maria = jose
jose.foward(100)
```

Object manipulation



maria

jose

Variable assignment challenge

- What does this code draw?

```
import turtle
maria = turtle.Turtle()
jose = turtle.Turtle()
maria.penup()
jose.penup()
maria.setpos(-100, 0)
jose.setpos(-100, -50)
maria.pendown()
jose.pendown()
maria = jose
dist1 = 100
dist2 = 200
dist1 = dist2
dist2 += 150
maria.forward(dist1)
jose.forward(dist2)
```

Key ideas so far

- Variables have their own scope. When a function is called the *values* are passed in, not the variables themselves.
- Returning is not the same as printing. Only returning passes data back from a function.
- Conditional statements can be tricky! Practice, practice, practice!
- All variables in Python store references. References are memory addresses where data is located.
- Assignment statements copy the reference stored in the variable
- Two variables can store references to the same piece of data. If that piece of data can change (e.g. the Turtles) then the data seen by BOTH references will change.

Turtles and Functions

```
def drawShape(theTurtle):
    ''' Draw a simple shape with the turtle passed in '''
    theTurtle.forward(100)
    theTurtle.right(90)
    theTurtle.forward(100)
    theTurtle.right(90)
    theTurtle.forward(100)
    theTurtle.right(90)
    theTurtle.forward(100)
    theTurtle.right(90)
```

Introducing Lists
Lists allow you to store multiple values

```
def drawShapeWithLists(theTurtle):
    sideLengths = [100, 200, 50, 200]
    angles = [90, 120, 40, 60]
    theTurtle.forward(sideLengths[0])
    theTurtle.right(angles[0])
    theTurtle.forward(sideLengths[1])
    theTurtle.right(angles[1])
    theTurtle.forward(sideLengths[2])
    theTurtle.right(angles[2])
    theTurtle.forward(sideLengths[3])
    theTurtle.right(angles[3])
```

Introducing Tuples
Tuples *also* allow you to store multiple values (unordered)

```
def drawShapeWithATuple(theTurtle):
    len_angle = (100, 90)
    theTurtle.forward(len_angle[0])
    theTurtle.right(len_angle[1])
    theTurtle.forward(len_angle[0])
    theTurtle.right(len_angle[1])
    theTurtle.forward(len_angle[0])
    theTurtle.right(len_angle[1])
    theTurtle.forward(len_angle[0])
    theTurtle.right(len_angle[1])
```

You can combine Lists and Tuples (or really, any types)

```
def drawShapeWithListAndTuple(theTurtle):
    sides = [(100, 60), (200, 120), (100, 60), (200, 120)]
    side = sides[0]
    theTurtle.forward(side[0])
    theTurtle.right(side[1])
    side = sides[1]
    theTurtle.forward(side[0])
    theTurtle.right(side[1])
    side = sides[2]
    theTurtle.forward(side[0])
    theTurtle.right(side[1])
    side = sides[3]
    theTurtle.forward(side[0])
    theTurtle.right(side[1])
```

Indexing lists and tuples

```
sides = [(100, 60), (200, 120), (100, 60), (200, 120)]
value = sides[2]
```

What is the value of `value` after the assignment statement?

A. 60

B. 200

C. (200, 120)

D. (100, 60)

Indexing lists and tuples

```
sides = [(100, 60), (200, 120), (100, 60), (200, 120)]
value = sides[2]
```

Write as many Python statements (or sets of statements) as you can that will assign the value 120 to value, using the list sides

Key ideas so far

- Variables have their own scope. When a function is called the *values* are passed in, not the variables themselves.
- Returning is not the same as printing. Only returning passes data back from a function.
- Conditional statements can be tricky! Practice, practice, practice!
- All variables in Python store references. References are memory addresses where data is located.
- Assignment statements copy the reference stored in the variable
- Two variables can store references to the same piece of data. If that piece of data can change (e.g. the Turtles) then the data seen by BOTH references will change.
- Lists and tuples are compact ways of storing a "bunch" of data.
- You can access the individual elements in a list of a tuple using the index of that element. Indexes start at 0. The last index is the length of the list minus 1.

Not much is changing… is there an easier way to do this?

```
def drawShapeWithListAndTuple(theTurtle):
    sides = [(100, 60), (200, 120), (100, 60), (200, 120)]
    side = sides[0]
    theTurtle.forward(side[0])
    theTurtle.right(side[1])
    side = sides[1]
    theTurtle.forward(side[0])
    theTurtle.right(side[1])
    side = sides[2]
    theTurtle.forward(side[0])
    theTurtle.right(side[1])
    side = sides[3]
    theTurtle.forward(side[0])
    theTurtle.right(side[1])
```

Not much is changing… is there an easier way to do this? YES! `for` loops!

```
def drawShapeWithLoop(theTurtle):
    sides = [(100, 60), (200, 120), (100, 60), (200, 120)]


    for side in sides:

        theTurtle.forward(side[0])
        theTurtle.right(side[1])
```

Reading from a csv file

```
import csv
…
hurricaneFile = "data/irma.csv"
# The line below is a little magical. It opens the file,
# with awareness of any errors that might occur.
with open(hurricaneFile, 'r') as csvfile:
    # This line gives you an "iterator" you can use to get each line
    # in the file.
    pointreader = csv.reader(csvfile)

    # You'll need to add some code here, before the loop

    for row in pointreader:
        # This code just prints out each row in the file
        # You'll need to change it
        for data in row:
            print(data, ' ', end='')
        print()
```

Key ideas so far

- Variables have their own scope. When a function is called the *values* are passed in, not the variables themselves.
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- Conditional statements can be tricky! Practice, practice, practice!
- All variables in Python store references. References are memory addresses where data is located.
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- Lists and tuples are compact ways of storing a "bunch" of data.
- You can access the individual elements in a list of a tuple using the index of that element. Indexes start at 0. The last index is the length of the list minus 1.
- For loops allow you to repeat an action for each element in type of data that is "iteratable". Lists and tuples are iteratable. (The difference is tuples are not mutable—we'll get to that later).