Lists
Intro. to Functions

Computer Science 111
Boston University

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Lists

Recall: A string is a sequence of characters.

'hello'

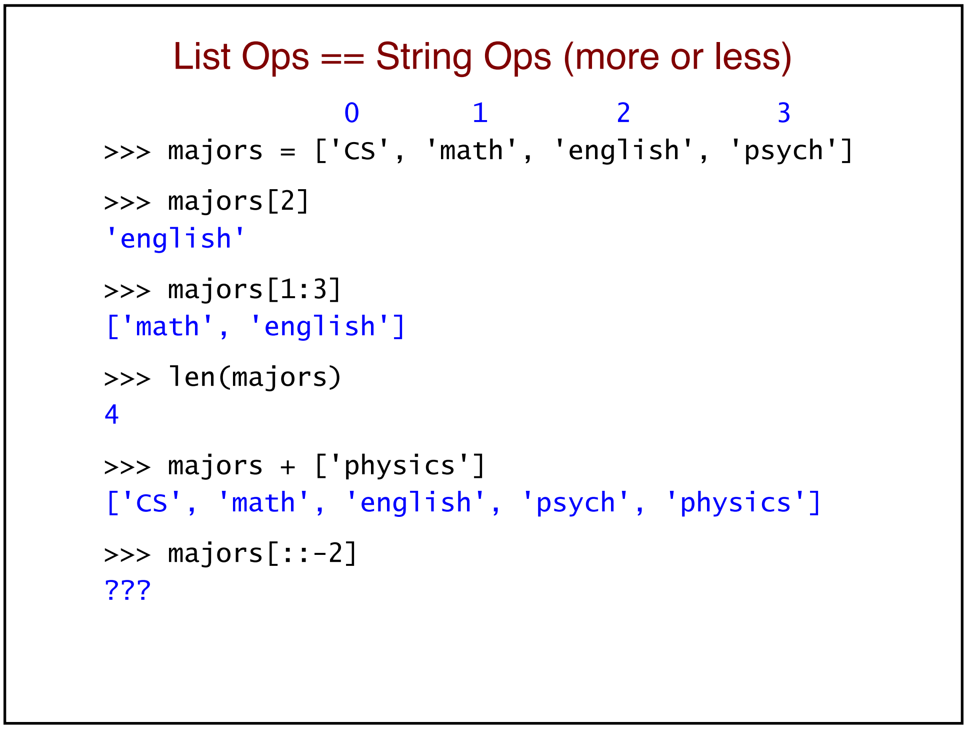
A list is a sequence of *arbitrary* values (the list's *elements*).

[2**,** 4**,** 6**,** 8**]**

['CS'**,** 'math'**,** 'english'**,** 'psych'**]**

A list can include values of different types:

['Star Wars', 1977, 'PG', [35.9, 460.9]]



List Ops == String Ops (more or less)

```
               0       1        2         3
>>> majors = ['CS', 'math', 'english', 'psych']

>>> majors[2]
'english'

>>> majors[1:3]
['math', 'english']

>>> len(majors)
4

>>> majors + ['physics']
['CS', 'math', 'english', 'psych', 'physics']

>>> majors[::-2]
???
```

List Ops == String Ops (more or less)

```
>>> majors = ['CS', 'math', 'english', 'psych']
>>> majors[2]
'english'
>>> majors[1:3]
['math', 'english']
>>> len(majors)
4
>>> majors + ['physics']
['CS', 'math', 'english', 'psych', 'physics']
>>> majors[::-2]
['psych', 'math']
```

What is the output of the following program?

```
mylist = [1, 2, [3, 4, 5]]
print(mylist[1], mylist[1:2])
```

A. `2 2 3`

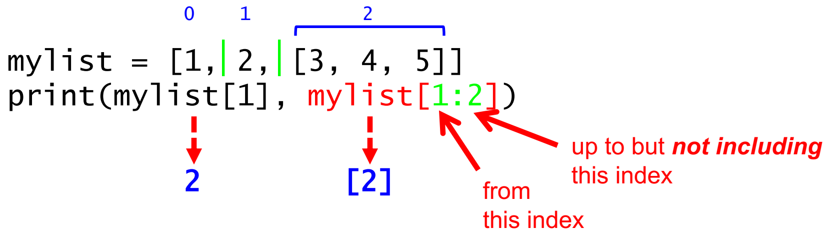
B. `2 [2, 3]`

C. `2 2`

D. `2 2 [3, 4, 5]`

E. none of these

What is the output of the following program?



```
          0   1        2
mylist = [1, 2, [3, 4, 5]]
print(mylist[1], mylist[1:2])
```

2

[2]

from
this index

up to but ***not including***
this index

A. `2 2 3`

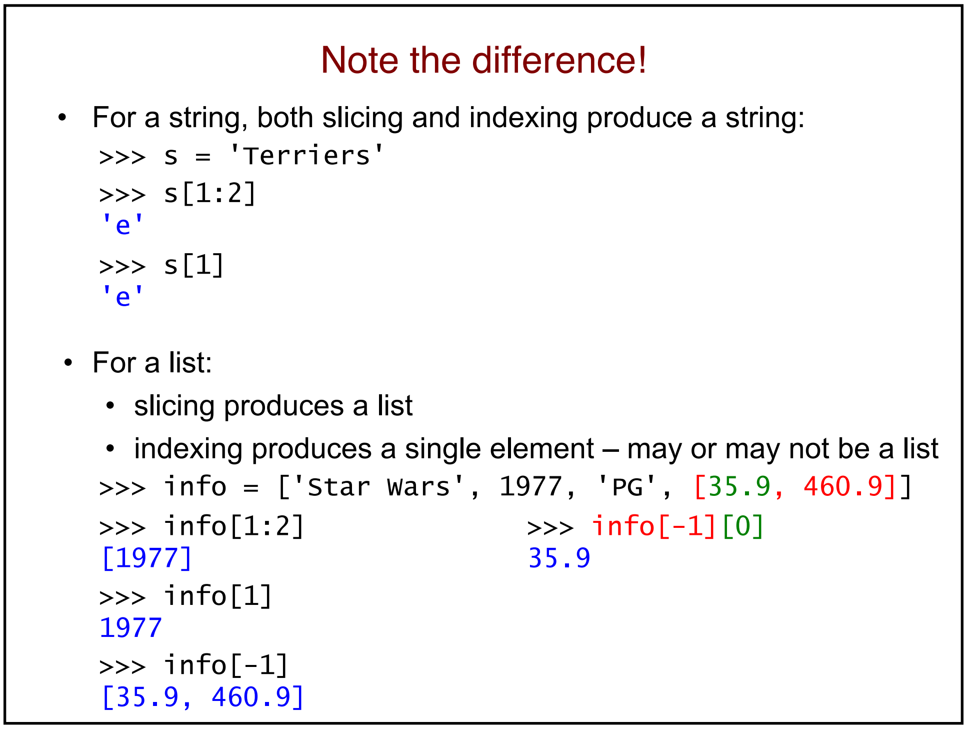
B. `2 [2, 3]`

C. `2 2`

D. `2 2 [3, 4, 5]`

E. **none of these!!** **`2 [2]`**

Slicing a list always
produces a list!



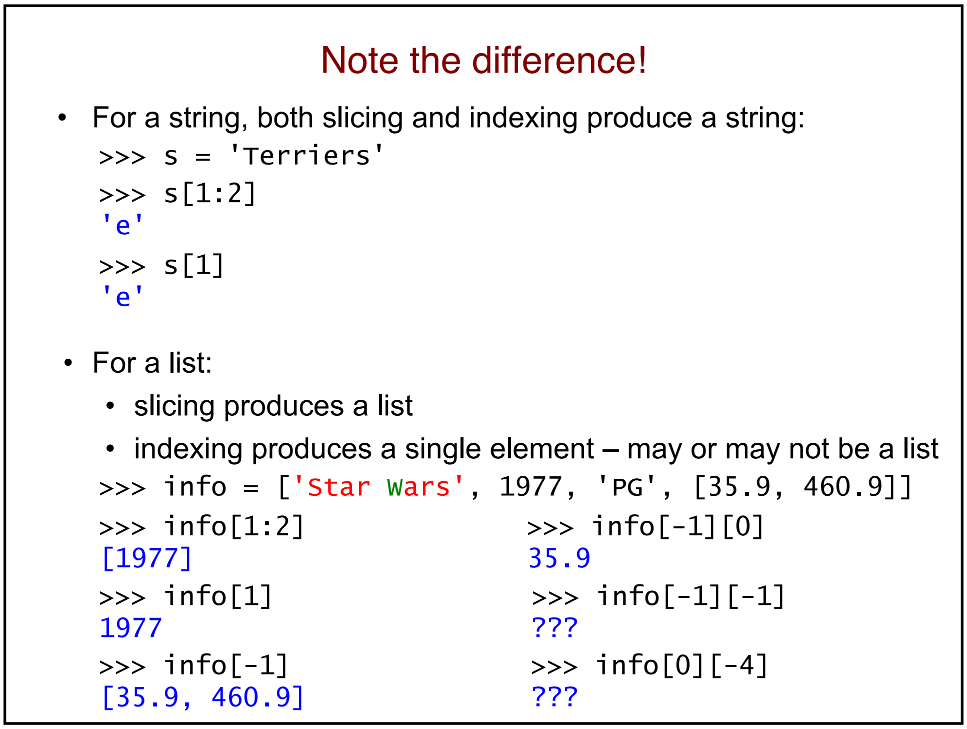
Note the difference!

- For a string, both slicing and indexing produce a string:

```
>>> s = 'Terriers'
>>> s[1:2]
'e'
>>> s[1]
'e'
```

- For a list:
  - slicing produces a list
  - indexing produces a single element – may or may not be a list

```
>>> info = ['Star Wars', 1977, 'PG', [35.9, 460.9]]
>>> info[1:2]                 >>> info[-1][0]
[1977]                        35.9
>>> info[1]
1977
>>> info[-1]
[35.9, 460.9]
```



Note the difference!

- For a string, both slicing and indexing produce a string:

```
>>> s = 'Terriers'
>>> s[1:2]
'e'
>>> s[1]
'e'
```

- For a list:
  - slicing produces a list
  - indexing produces a single element – may or may not be a list

```
>>> info = ['Star Wars', 1977, 'PG', [35.9, 460.9]]
>>> info[1:2]                 >>> info[-1][0]
[1977]                        35.9
>>> info[1]                   >>> info[-1][-1]
1977                          ???
>>> info[-1]                  >>> info[0][-4]
[35.9, 460.9]                 ???
```

Note the difference!

- For a string, both slicing and indexing produce a string:

```
>>> s = 'Terriers'
>>> s[1:2]
'e'
>>> s[1]
'e'
```

- For a list:
  - slicing produces a list
  - indexing produces a single element – may or may not be a list

```
>>> info = ['Star Wars', 1977, 'PG', [35.9, 460.9]]
>>> info[1:2]                >>> info[-1][0]
[1977]                       35.9
>>> info[1]                  >>> info[-1][-1]
1977                         460.9
>>> info[-1]                 >>> info[0][-4]
[35.9, 460.9]                ???
```

Note the difference!

- For a string, both slicing and indexing produce a string:

```
>>> s = 'Terriers'
>>> s[1:2]
'e'
>>> s[1]
'e'
```

- For a list:
  - slicing produces a list
  - indexing produces a single element – may or may not be a list

```
>>> info = ['Star Wars', 1977, 'PG', [35.9, 460.9]]
>>> info[1:2]                >>> info[-1][0]
[1977]                       35.9
>>> info[1]                  >>> info[-1][-1]
1977                         460.9
>>> info[-1]                 >>> info[0][-4]
[35.9, 460.9]                'W'
```

How could you fill in the blank to produce [103, 111]?

```
intro_cs = [101, 103, 105, 108, 109, 111]

vahid_courses = ______________________
```

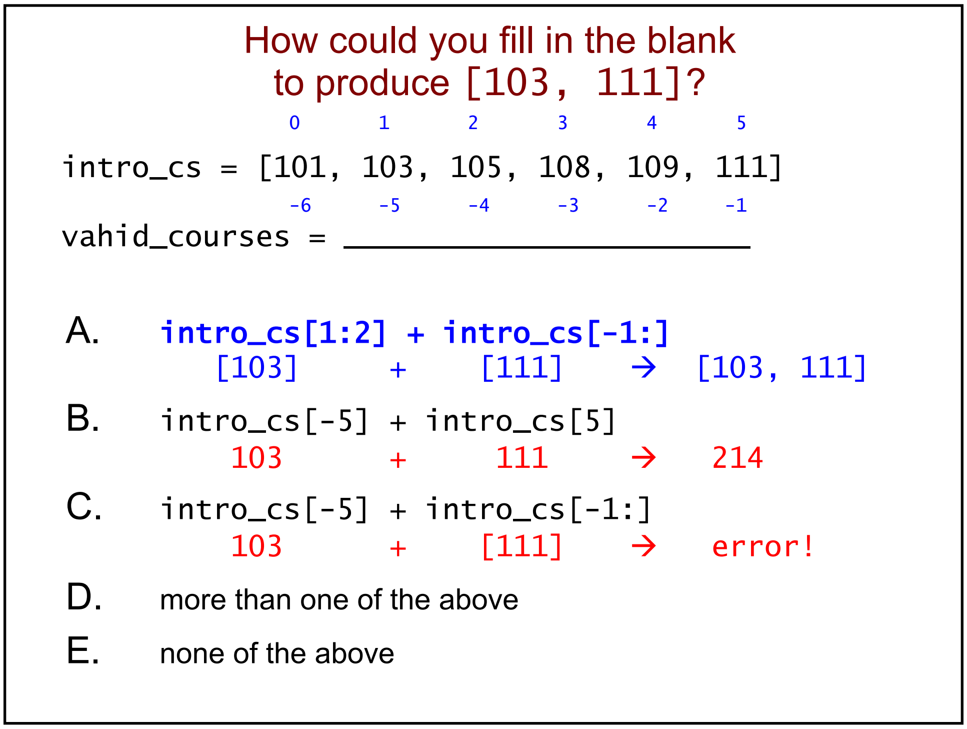
A. `intro_cs[1:2] + intro_cs[-1:]`

B. `intro_cs[-5] + intro_cs[5]`

C. `intro_cs[-5] + intro_cs[-1:]`

D. more than one of the above

E. none of the above



How could you fill in the blank to produce [103, 111]?

```
                0        1        2        3        4        5
intro_cs = [101, 103, 105, 108, 109, 111]
                -6       -5       -4       -3       -2       -1
vahid_courses = ______________________
```

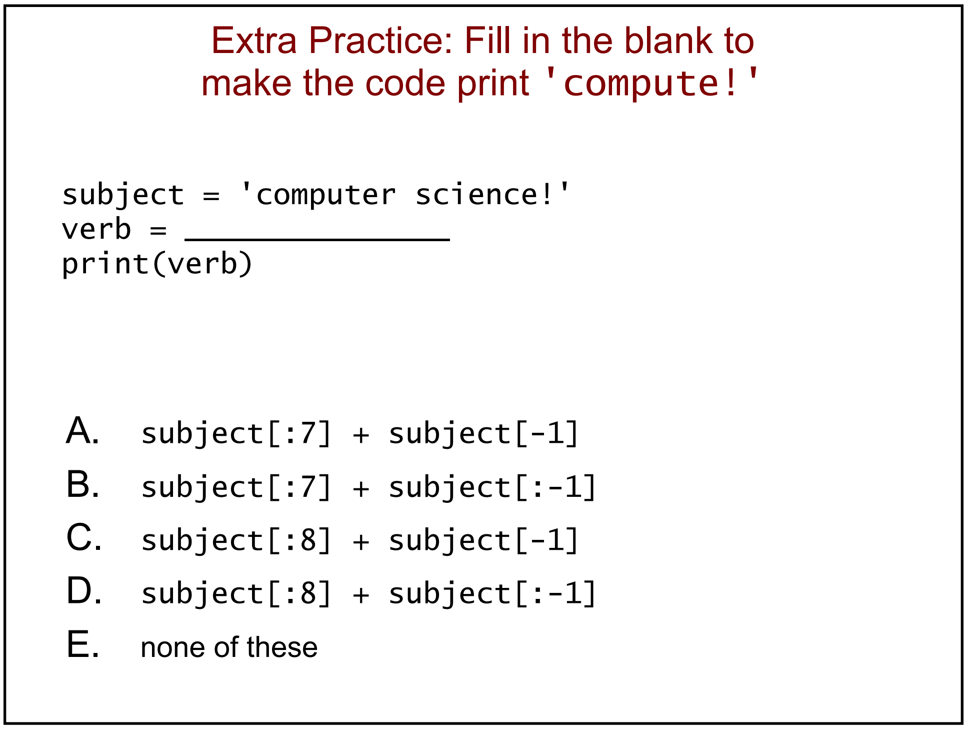
A. **intro_cs[1:2] + intro_cs[-1:]**
```
      [103]      +     [111]     →   [103, 111]
```

B. intro_cs[-5] + intro_cs[5]
```
       103       +      111      →    214
```

C. intro_cs[-5] + intro_cs[-1:]
```
       103       +     [111]     →    error!
```

D. more than one of the above

E. none of the above



Extra Practice: Fill in the blank to make the code print 'compute!'

```
subject = 'computer science!'
verb = _______________
print(verb)
```

A. subject[:7] + subject[-1]

B. subject[:7] + subject[:-1]

C. subject[:8] + subject[-1]

D. subject[:8] + subject[:-1]

E. none of these

Extra Practice: Fill in the blank to make the code print 'compute!'

```
subject = 'computer science!'
verb = _______________
print(verb)
```

A. **subject[:7] + subject[-1]**

B. subject[:7] + subject[:-1]

C. subject[:8] + subject[-1]

D. subject[:8] + subject[:-1]

E. none of these

Extra practice from the textbook authors!

```
pi = [3,1,4,1,5,9]
L = [ 'pi', "isn't", [4,2] ]
M = 'You need parentheses for chemistry !'
     0   4   8   12  16  20  24  28  32
```

Part 1

What is `len(pi)`

What is `len(L)`

What is `len(L[1])`

What is `pi[2:4]`

What slice of `pi` is `[3,1,4]`

What slice of `pi` is `[3,4,5]`

Part 2

What is `L[0]`

These two are different!

What is `L[0:1]`

What is `L[0][1]`

What slice of `M` is `'try'`?

is `'shoe'`?

What is `M[9:15]`

What is `M[::5]`

What is `M[::-5]`

Extra!

What are `pi[0]*(pi[1] + pi[2])` and `pi[0]*(pi[1:2] + pi[2:3])`?

These two are different, too…

Extra practice from the textbook authors!

```
pi = [3,1,4,1,5,9]
L = [ 'pi', "isn't", [4,2] ]
M = 'You need parentheses for chemistry !'
       0   4   8   12  16  20  24  28  32
```

Part 1

What is `len(pi)` 6

What is `len(L)` 3

What is `len(L[1])` 5

What is `pi[2:4]` [4, 1]

What slice of `pi` is `[3,1,4]` pi[:3]

What slice of `pi` is `[3,4,5]` pi[::2]

Part 2

What is `L[0]` 'pi'

What is `L[0:1]` ['pi']

These two are different!

What is `L[0][1]` 'i'

What slice of `M` is `'try'`? M[31:34]

is `'shoe'`? M[30:17:-4]

What is `M[9:15]` 'parent'

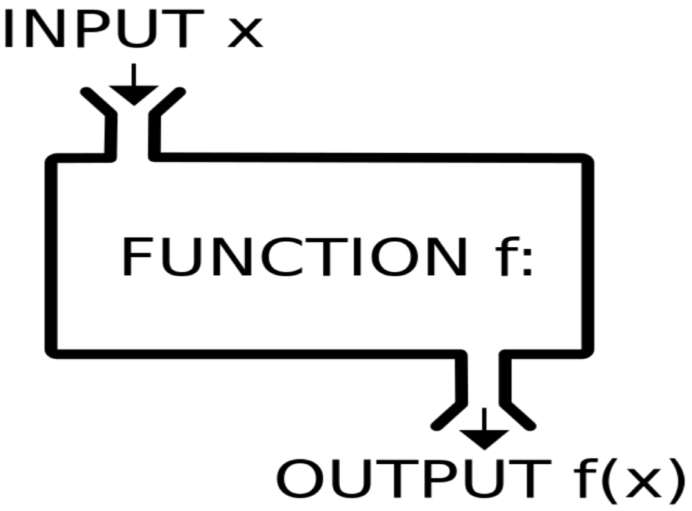
What is `M[::5]` 'Yeah cs!'

What is `M[::-5]` '!sc haeY'

Extra! What are `pi[0]*(pi[1] + pi[2])` and `pi[0]*(pi[1:2] + pi[2:3])`?

These two are different, too… 15 [1, 4, 1, 4, 1, 4]

Functions

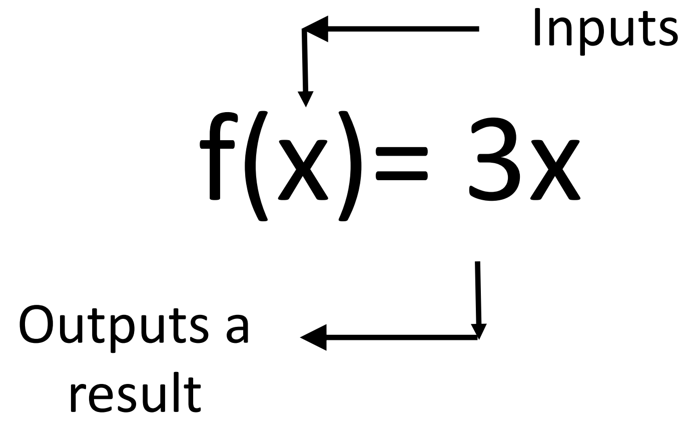


INPUT x

FUNCTION f:

OUTPUT f(x)

Algebraic Function

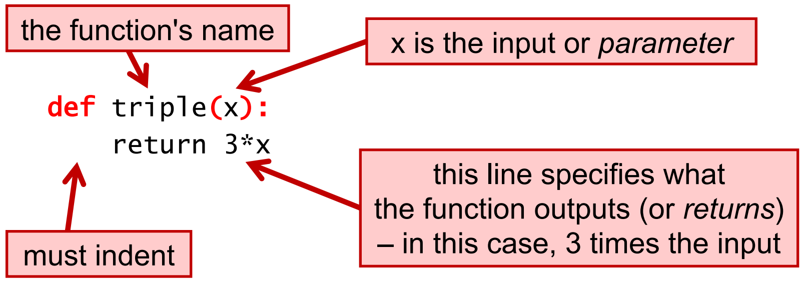


Inputs

$$f(x)= 3x$$

Outputs a result

Defining a Function



the function's name

x is the input or *parameter*

```
def triple(x):
    return 3*x
```

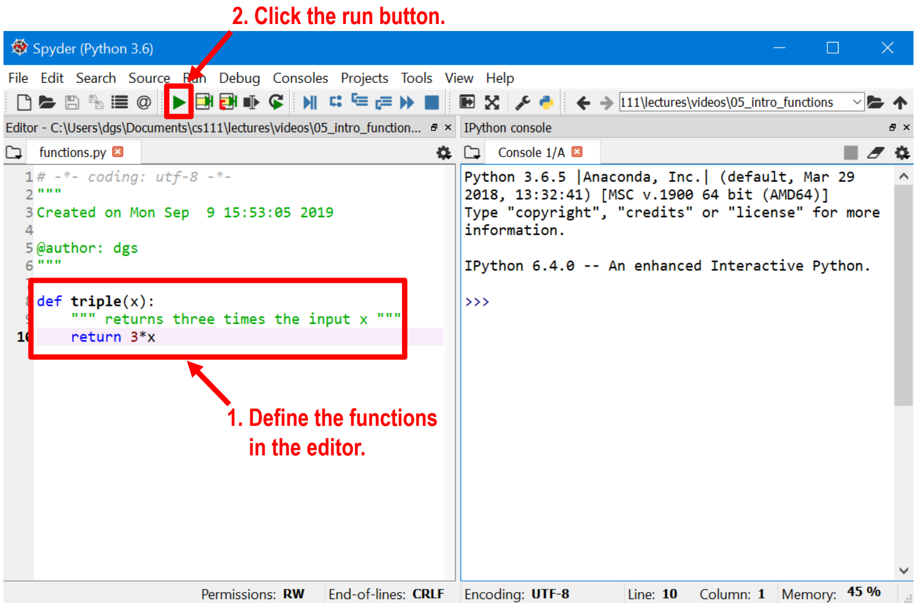
must indent

this line specifies what the function outputs (or *returns*) – in this case, 3 times the input

- Once we define a function, we can call it:

```
>>> triple(3)
9
>>> triple(10)
30
>>> triple(0.5)
1.5
```

Working with Functions in Spyder


Spyder (Python 3.6)
File Edit Search Source Run Debug Consoles Projects Tools View Help
111\lectures\videos\05_intro_functions
Editor - C:\Users\dgs\Documents\cs111\lectures\videos\05_intro_function...
functions.py
IPython console
Console 1/A
Permissions: RW End-of-lines: CRLF Encoding: UTF-8 Line: 10 Column: 1 Memory: 45 %

2. Click the run button.

```
# -*- coding: utf-8 -*-
"""
Created on Mon Sep  9 15:53:05 2019

@author: dgs
"""

def triple(x):
    """ returns three times the input x """
    return 3*x
```

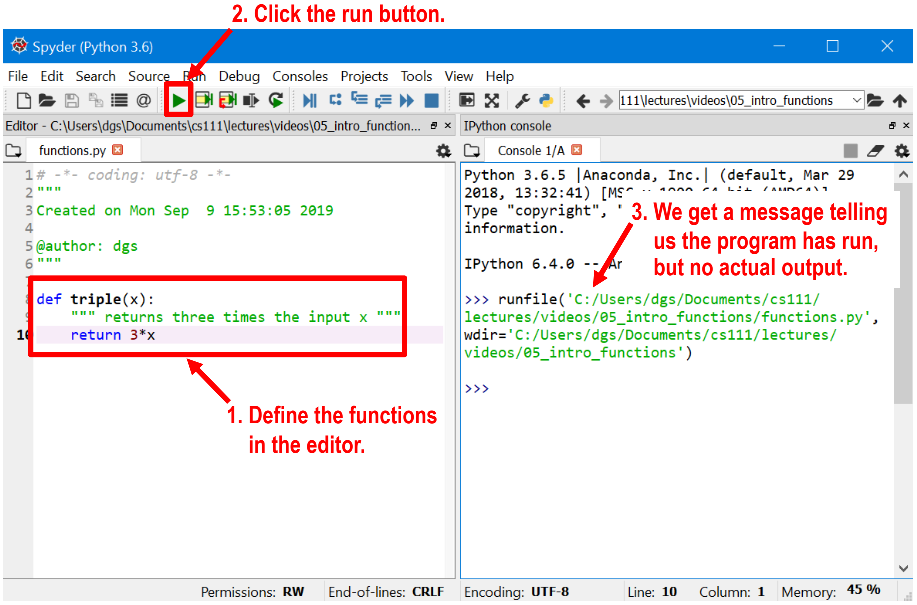
```
Python 3.6.5 |Anaconda, Inc.| (default, Mar 29
2018, 13:32:41) [MSC v.1900 64 bit (AMD64)]
Type "copyright", "credits" or "license" for more
information.

IPython 6.4.0 -- An enhanced Interactive Python.

>>>
```

1. Define the functions in the editor.

Working with Functions in Spyder


Spyder (Python 3.6)
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Python 3.6.5 |Anaconda, Inc.| (default, Mar 29
2018, 13:32:41) [MS
Type "copyright", '
information.

IPython 6.4.0 -- Ar

>>> runfile('C:/Users/dgs/Documents/cs111/
lectures/videos/05_intro_functions/functions.py',
wdir='C:/Users/dgs/Documents/cs111/lectures/
videos/05_intro_functions')

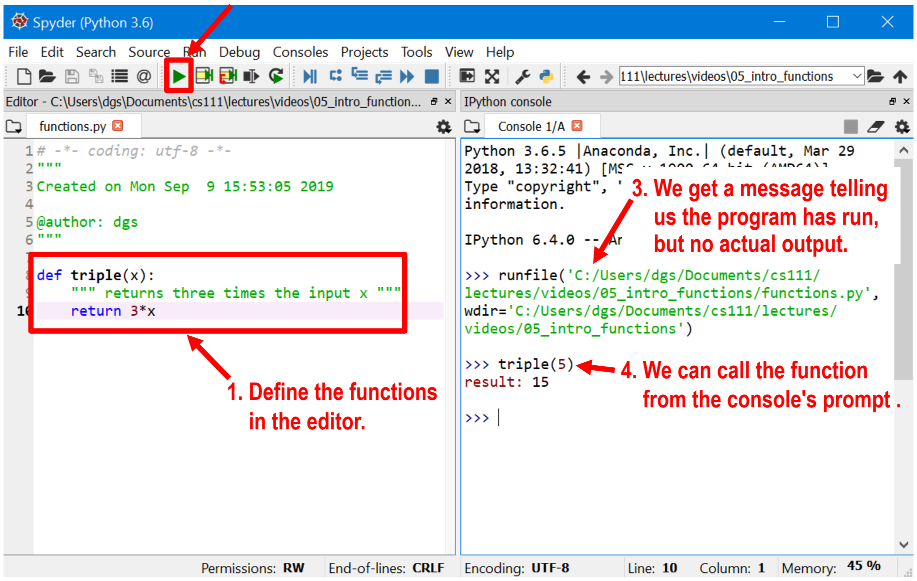
>>>
```

3. We get a message telling us the program has run, but no actual output.

1. Define the functions in the editor.

Working with Functions in Spyder

2. Click the run button.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"""
Created on Mon Sep  9 15:53:05 2019

@author: dgs
"""

def triple(x):
    """ returns three times the input x """
    return 3*x
```

```
Python 3.6.5 |Anaconda, Inc.| (default, Mar 29
2018, 13:32:41) [MSC v.1900 64 bit (AMD64)]
Type "copyright", '
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IPython 6.4.0 -- Ar

>>> runfile('C:/Users/dgs/Documents/cs111/
lectures/videos/05_intro_functions/functions.py',
wdir='C:/Users/dgs/Documents/cs111/lectures/
videos/05_intro_functions')

>>> triple(5)
result: 15

>>> |
```

Permissions: RW End-of-lines: CRLF Encoding: UTF-8 Line: 10 Column: 1 Memory: 45 %

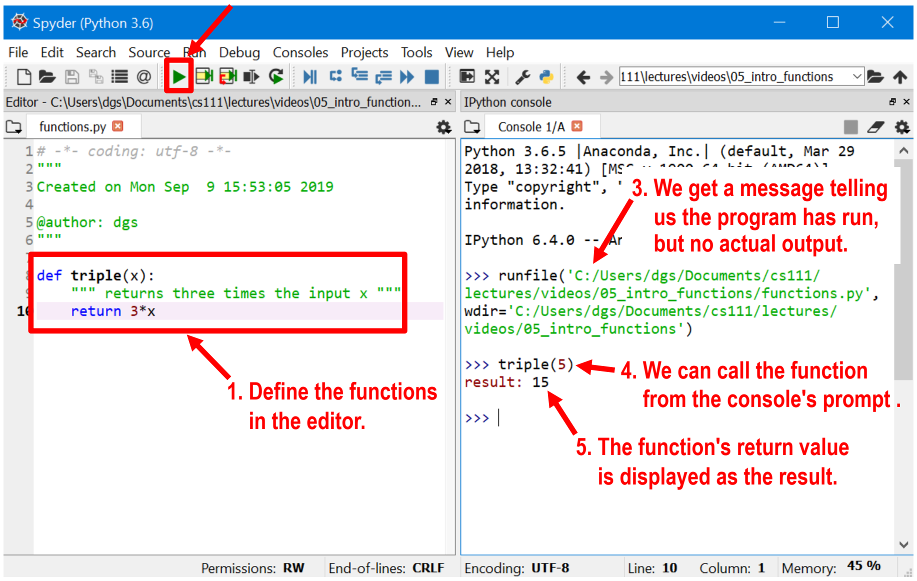
3. We get a message telling us the program has run, but no actual output.

4. We can call the function from the console's prompt .

1. Define the functions in the editor.

Working with Functions in Spyder

2. Click the run button.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111\lectures\videos\05_intro_functions
IPython console
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Editor - C:\Users\dgs\Documents\cs111\lectures\videos\05_intro_function...

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Created on Mon Sep  9 15:53:05 2019

@author: dgs
"""

def triple(x):
    """ returns three times the input x """
    return 3*x
```

```
Python 3.6.5 |Anaconda, Inc.| (default, Mar 29
2018, 13:32:41) [MSC v.1900 64 bit (AMD64)]
Type "copyright", '
information.

IPython 6.4.0 -- Ar

>>> runfile('C:/Users/dgs/Documents/cs111/
lectures/videos/05_intro_functions/functions.py',
wdir='C:/Users/dgs/Documents/cs111/lectures/
videos/05_intro_functions')

>>> triple(5)
result: 15

>>> |
```

Permissions: RW End-of-lines: CRLF Encoding: UTF-8 Line: 10 Column: 1 Memory: 45 %

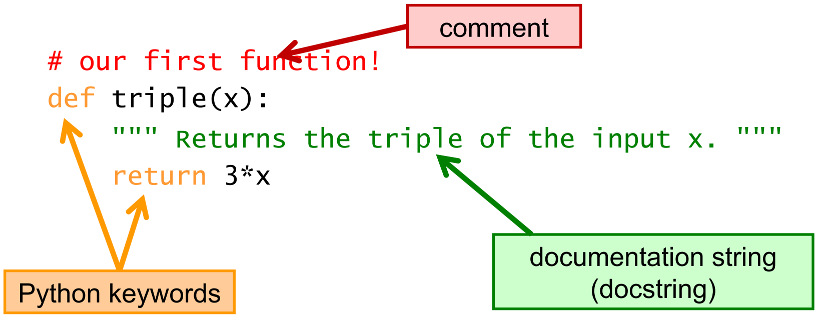
3. We get a message telling us the program has run, but no actual output.

4. We can call the function from the console's prompt .

1. Define the functions in the editor.

5. The function's return value is displayed as the result.

Other Details



```
# our first function!
def triple(x):
    """ Returns the triple of the input x. """
    return 3*x
```

comment

Python keywords

documentation string
(docstring)

- Python uses color-coding to distinguish program components.
- Always use a *docstring* to explain what the function does.
  - surrounded by triple quotes, beginning on the second line
  - `help(`*function name*`)` retrieves it
- Other (non-docstring) comments can be included as needed.

Functions With String Inputs

```
def undo(s):
    """ Adds the prefix "un" to the input s. """
    return 'un' + s

def redo(s):
    """ Adds the prefix "re" to the input s. """
    return 're' + s
```

The evil "un" people!
(from the PBS kids show *Between the Lions*)

- Examples:

```
>>> undo('plugged')
'unplugged'
>>> undo('zipped')
'unzipped'
>>> redo('submit')
'resubmit'
>>> redo(undo('zipped'))      # redo('unzipped')
'reunzipped'
```

Multiple Lines, Multiple Parameters

```
def circle_area(diam):
    """ Computes the area of a circle
        with a diameter diam.
    """
    radius = diam / 2
    area = 3.14159 * (radius**2)
    return area

def rect_perim(l, w):
    """ Computes the perimeter of a rectangle
        with length l and width w.
    """
    return 2*l + 2*w
```

- Examples:

```
>>> rect_perim(5, 7)
24
>>> circle_area(20)
314.159
```

Function and Function Call in the Same File

```
def circle_area(diam):
    """ Computes the area of a circle
        with a diameter diam.
    """
    radius = diam / 2
    area = 3.14159 * (radius**2)
    return area

def rect_perim(l, w):
    """ Computes the perimeter of a rectangle
        with length l and width w.
    """
    return 2*l + 2*w

print(rect_perim(20, 8))     # Why is print needed?
```

- Defines two functions, but only one gets called when we run the program.
- We can still call either of them from the Console after running the program.

Multiple Lines, Multiple Parameters

```
def calculate(x, y):
    a = y
    b = x + 1
    return a * b - 3


print(calculate(3, 2))
```

What is the output of this code?

```
def calculate(x, y):
    a = y
    b = x + 1
    return a * b - 3


print(calculate(3, 2))
```

x	y	a	b

On paper, make a table for the values of your variables!

A. 5

B. 9

C. 4

D. 3

E. 8

What is the output of this code?

```
def calculate(x, y):
    a = y
    b = x + 1
    return a * b - 3


print(calculate(3, 2))
```

x	y	a	b

A. 5

B. 9

C. 4

D. 3

E. 8

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def calculate(x, y):
    a = y
    b = x + 1
    return a * b - 3


print(calculate(3, 2))
```

x	y	a	b

A. 5

B. 9

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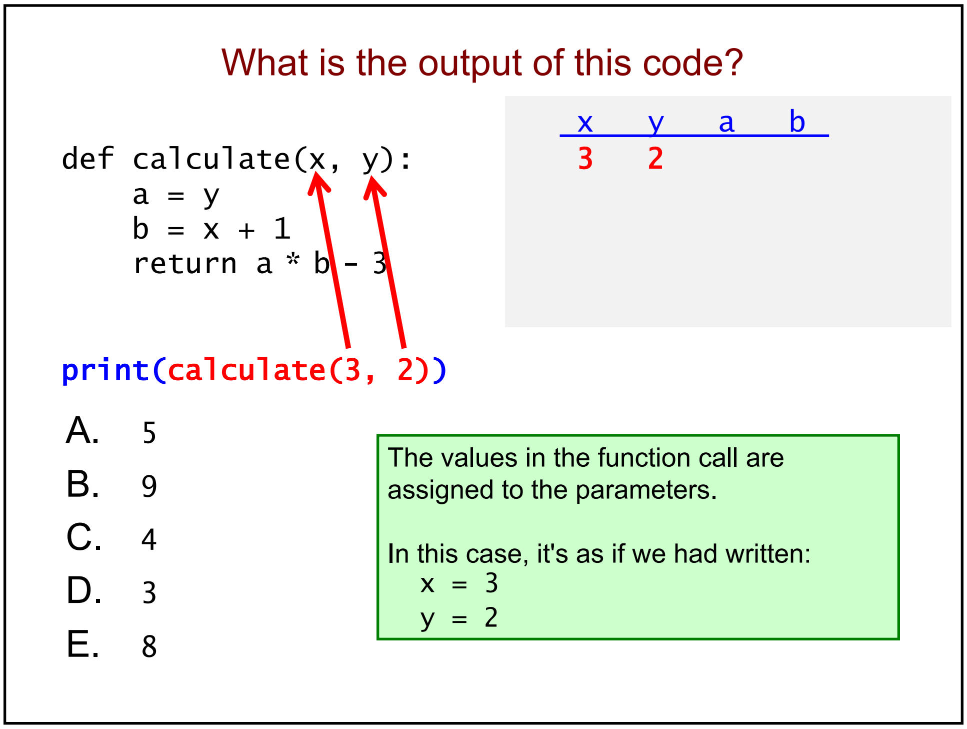


What is the output of this code?

```
def calculate(x, y):
    a = y
    b = x + 1
    return a * b - 3


print(calculate(3, 2))
```

x	y	a	b
3	2		

A. 5

B. 9

C. 4

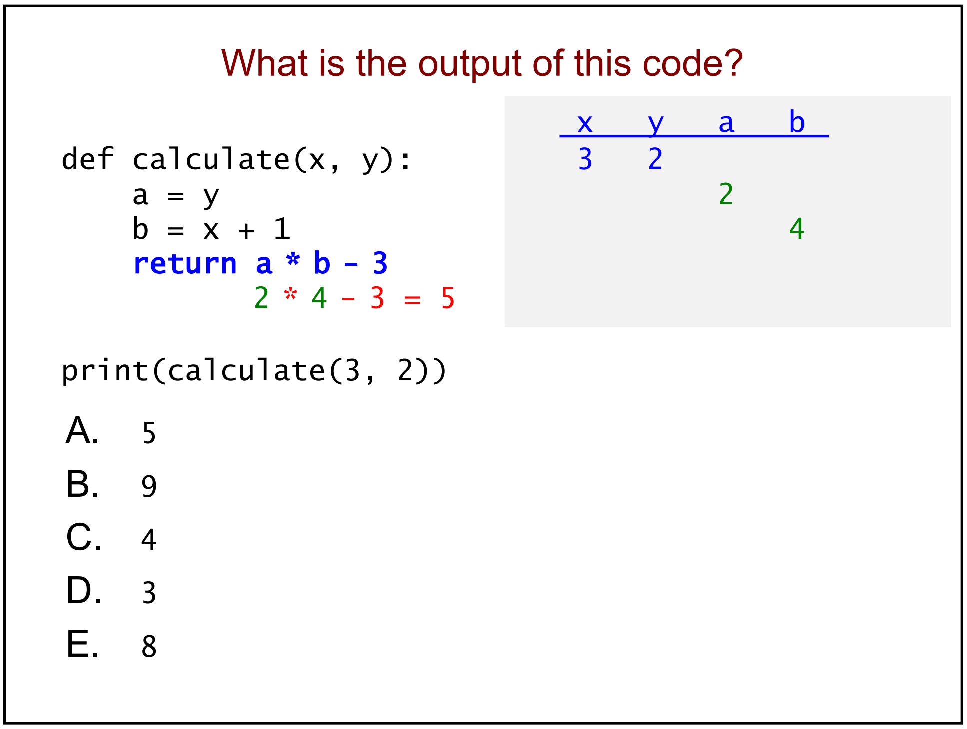
D. 3

E. 8

The values in the function call are assigned to the parameters.

In this case, it's as if we had written:

```
   x = 3
   y = 2
```



What is the output of this code?

```
def calculate(x, y):
    a = y
    b = x + 1
    return a * b - 3
           2 * 4 - 3 = 5

print(calculate(3, 2))
```

x	y	a	b
3	2		
		2	
			4

A. 5

B. 9

C. 4

D. 3

E. 8

What is the output of this code?

```
def calculate(x, y):
    a = y
    b = x + 1
    return a * b - 3
           2 * 4 - 3 = 5

print(calculate(3, 2))    # print(5)
```

x	y	a	b
3	2		
		2	
			4

A. 5

B. 9

C. 4

D. 3

E. 8

Practice Writing a Function

- Write a function `middle_elem(values)` that:
  - takes a list `values` that has at least one element
  - returns the element in the middle of the list
    - when there are two middle elements,
      return the one closer to the end
  - examples:

```
>>> middle_elem([2, 6, 3])
6
>>> middle_elem([7, 3, 1, 2, 4, 9])
2
```

Practice Writing a Function

- Write a function `middle_elem(values)` that:
  - takes a list `values` that has at least one element
  - returns the element in the middle of the list
    - when there are two middle elements, return the one closer to the end
  - examples:

```
>>> middle_elem([2, 6, 3])
6
>>> middle_elem([7, 3, 1, 2, 4, 9])
2
```

```
def middle_elem(values):
    middle_index = _____________
    return _______________
```

Practice Writing a Function

- Write a function `middle_elem(values)` that:
  - takes a list `values` that has at least one element
  - returns the element in the middle of the list
    - when there are two middle elements,
      return the one closer to the end
  - examples:

```
>>> middle_elem([2, 6, 3])
6
>>> middle_elem([7, 3, 1, 2, 4, 9])
2
```

```
def middle_elem(values):
    middle_index = len(values) // 2
    return values[middle_index]
```