Python Basics

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Reference: Vanderplas, Jacob T. *A Whirlwind Tour of Python*. O'Reilly Media, 2016.

Reference

- Vanderplas, Jacob T. A Whirlwind Tour of Python. O'Reilly Media, 2016. https://www.oreilly.com/programming/free/files/a-whirlwind-tour-of-python.pdf

- Supplemental material (code examples, IPython notebooks, etc.) is available at https://github.com/jakevdp/WhirlwindTourOfPython/

Outline

- Quick Python Syntax
- Variables and Objects
- Operators
- Built-In Types: Simple Values
- Built-In Data Structures
- Control Flow
- Defining and Using Functions
- Objects and Classes
- Errors and Exceptions
- Iterators
- List Comprehensions
- Generators

Quick Python Syntax

- Comments are marked by **#**.
- Quotation marks (**" '**) can also be used to enter comments.
- Use \ to extend a statement on the next line.
- Semicolon **;** can optionally terminate a statement.

```
x += 2  # shorthand for x = x + 2
```

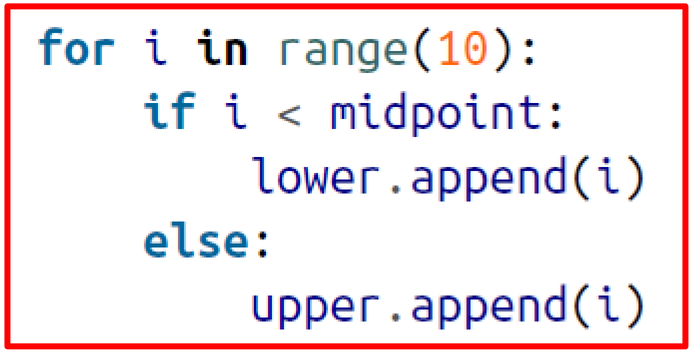
```
# Comments

"""
Multi-line comment often
used in documentation
"""

"Single-line Comment"
```

```
In [2]: x = 1 + 2 + 3 + 4 +\
        5 + 6 + 7 + 8
```

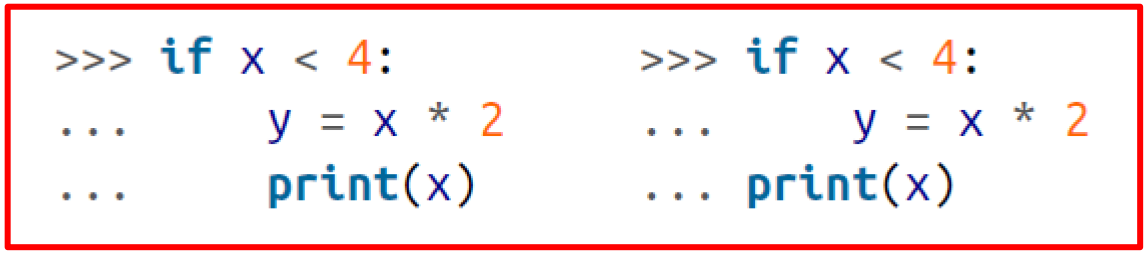
```
lower = []; upper = []
```

Quick Python Syntax

- In Python, code blocks are denoted by indentation .
- Four spaces are usually used.
- Which code snippet always prints **x**?



```python
for i in range(10):
    if i < midpoint:
        lower.append(i)
    else:
        upper.append(i)
```

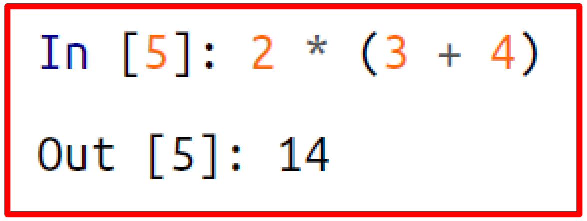


```python
>>> if x < 4:
...     y = x * 2
...     print(x)
```

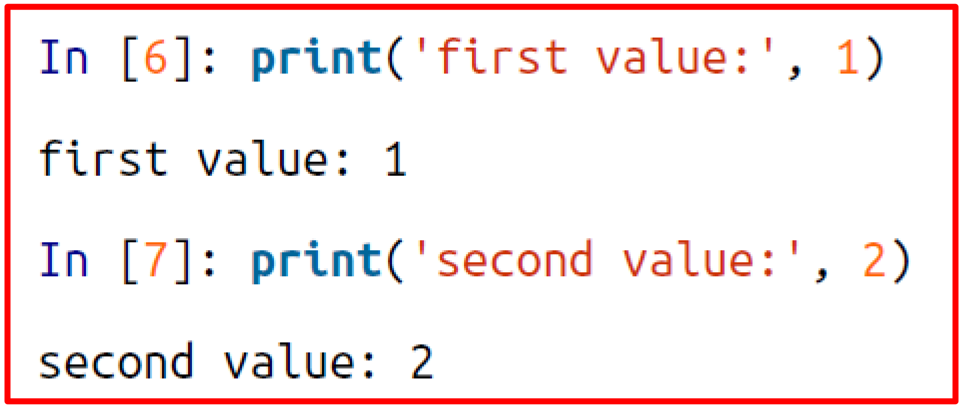
```python
>>> if x < 4:
...     y = x * 2
... print(x)
```

Quick Python Syntax

- Parentheses are for grouping or calling.



```
In [5]: 2 * (3 + 4)

Out [5]: 14
```



```
In [6]: print('first value:', 1)

first value: 1

In [7]: print('second value:', 2)

second value: 2
```

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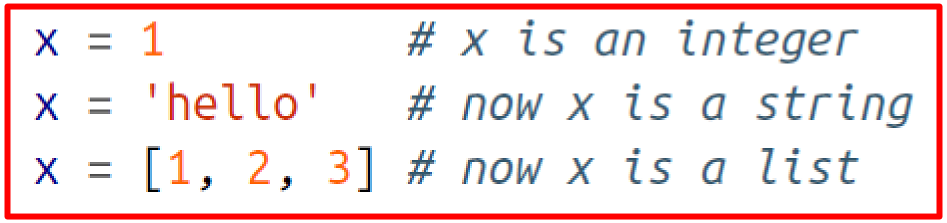
Variables and Objects

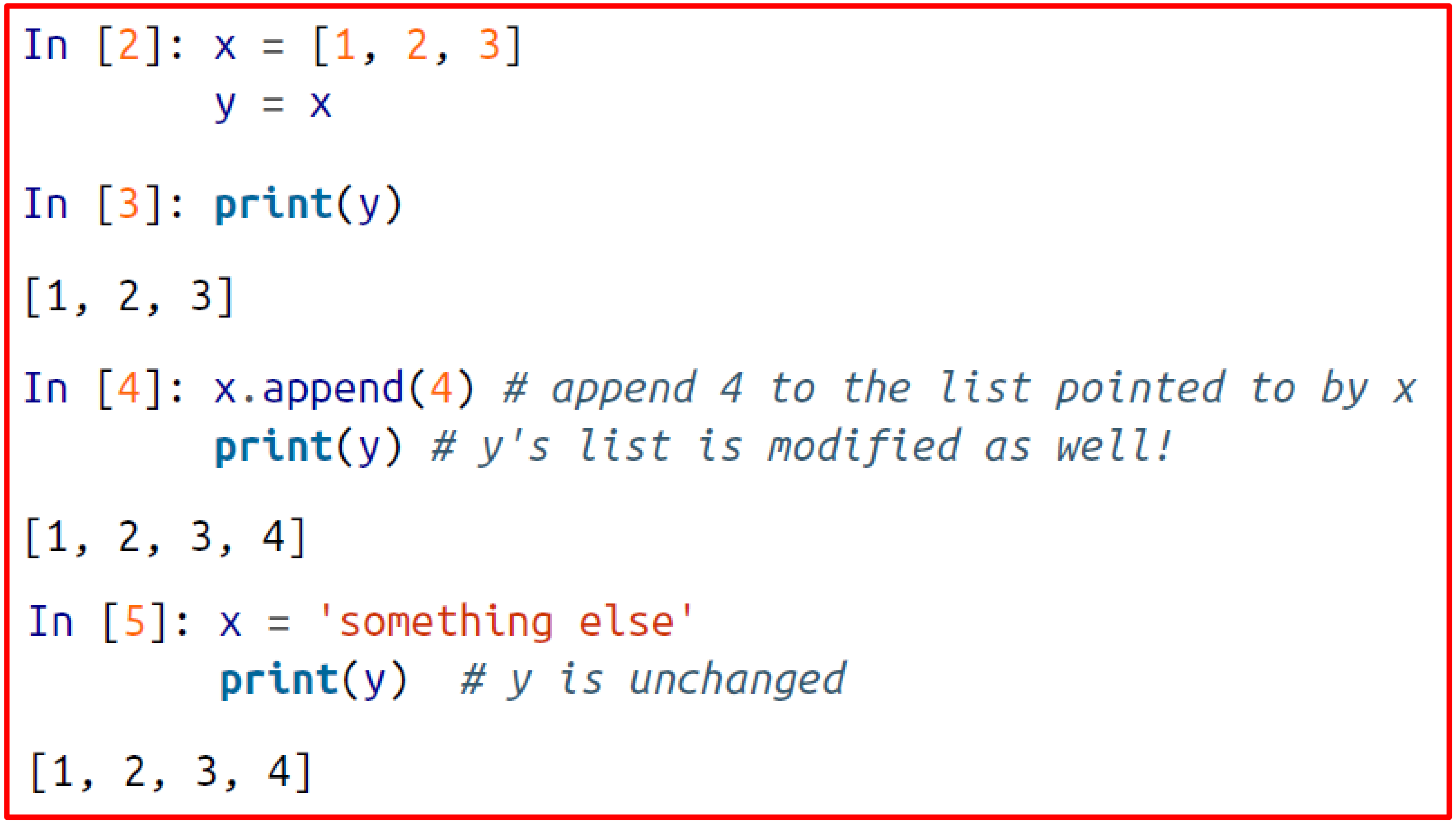
- Python variables are pointers to objects.
- Variable names can point to objects of any type.



```
x = 1          # x is an integer
x = 'hello'    # now x is a string
x = [1, 2, 3]  # now x is a list
```

Variables and Objects

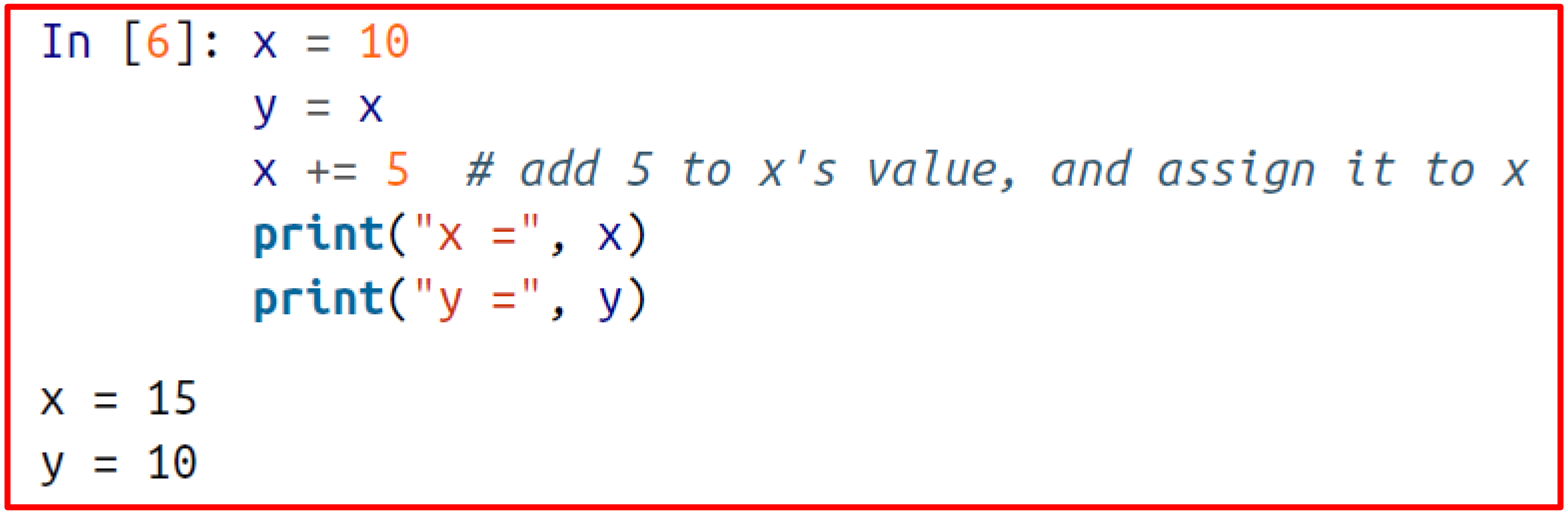
- If we have two variable names pointing to the same mutable object, then changing one will change the other as well!



```
In [2]: x = [1, 2, 3]
        y = x

In [3]: print(y)

[1, 2, 3]

In [4]: x.append(4) # append 4 to the list pointed to by x
        print(y) # y's list is modified as well!

[1, 2, 3, 4]

In [5]: x = 'something else'
        print(y)  # y is unchanged

[1, 2, 3, 4]
```

Variables and Objects

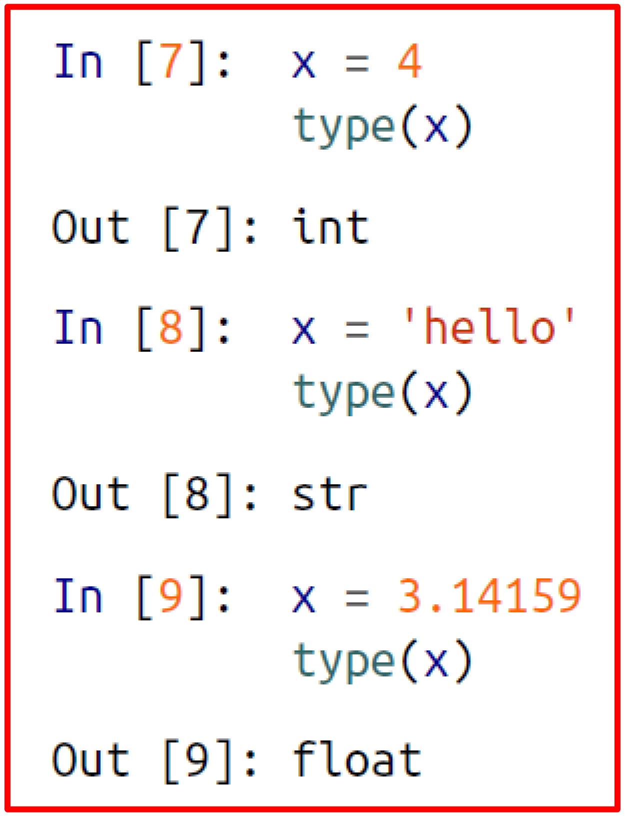
- Numbers, strings, and other simple types are immutable.



```
In [6]: x = 10
        y = x
        x += 5  # add 5 to x's value, and assign it to x
        print("x =", x)
        print("y =", y)

x = 15
y = 10
```

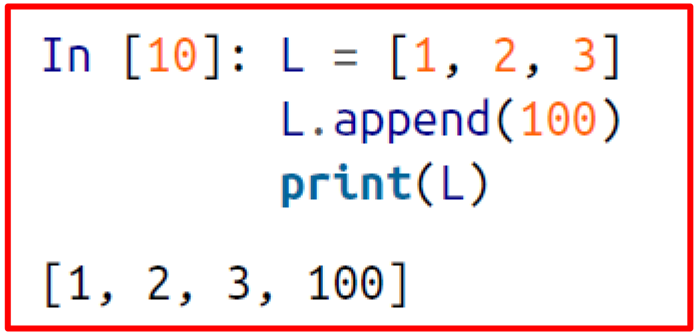
Variables and Objects

- Everything is an object



```
In [7]:  x = 4
          type(x)

Out [7]: int

In [8]:  x = 'hello'
          type(x)

Out [8]: str

In [9]:  x = 3.14159
          type(x)

Out [9]: float
```

- Object have attributes and methods accessible through the dot syntax (.)



```
In [10]: L = [1, 2, 3]
         L.append(100)
         print(L)

[1, 2, 3, 100]
```

Outline

Arithmetic Operators

Operator	Name	Description
`a + b`	Addition	Sum of a and b
`a - b`	Subtraction	Difference of a and b
`a * b`	Multiplication	Product of a and b
`a / b`	True division	Quotient of a and b
`a // b`	Floor division	Quotient of a and b, removing fractional parts
`a % b`	Modulus	Remainder after division of a by b
`a ** b`	Exponentiation	a raised to the power of b
`-a`	Negation	The negative of a
`+a`	Unary plus	a unchanged (rarely used)

```
>>> a = 5
>>> b = 3
>>> a / b
1.6666666666666667
>>> a // b
1
>>> a % b
2
```

Bitwise Operators

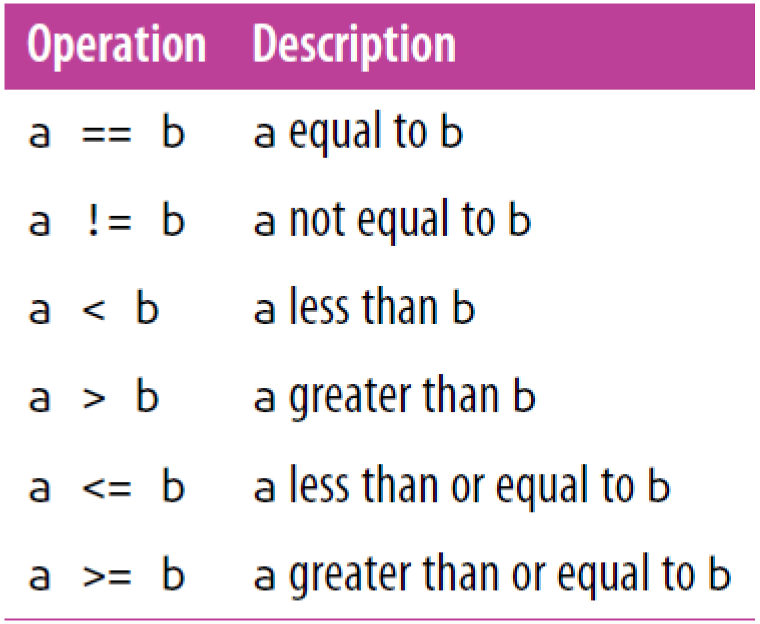
Operator	Name	Description
`a & b`	Bitwise AND	Bits defined in both a and b
`a | b`	Bitwise OR	Bits defined in a or b or both
`a ^ b`	Bitwise XOR	Bits defined in a or b but not both
`a << b`	Bit shift left	Shift bits of a left by b units
`a >> b`	Bit shift right	Shift bits of a right by b units
`~a`	Bitwise NOT	Bitwise negation of a

Weight	8	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

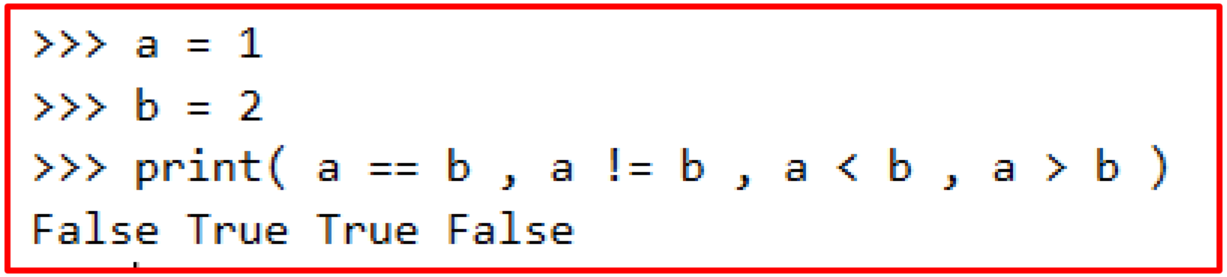
```
>>> a = 1
>>> b = 2
>>> print( a & b , a | b , a ^ b , b << a , b >> a , ~b )
0 3 3 4 1 -3
```

Comparison Operators

- Return Boolean values **True** or **False**



Operation	Description
`a == b`	a equal to b
`a != b`	a not equal to b
`a < b`	a less than b
`a > b`	a greater than b
`a <= b`	a less than or equal to b
`a >= b`	a greater than or equal to b



```
>>> a = 1
>>> b = 2
>>> print( a == b , a != b , a < b , a > b )
False True True False
```

Assignment Operators

- Assignment is evaluated from left to right.
- There is an augmented assignment operator corresponding to each of the binary arithmetic and bitwise operators.

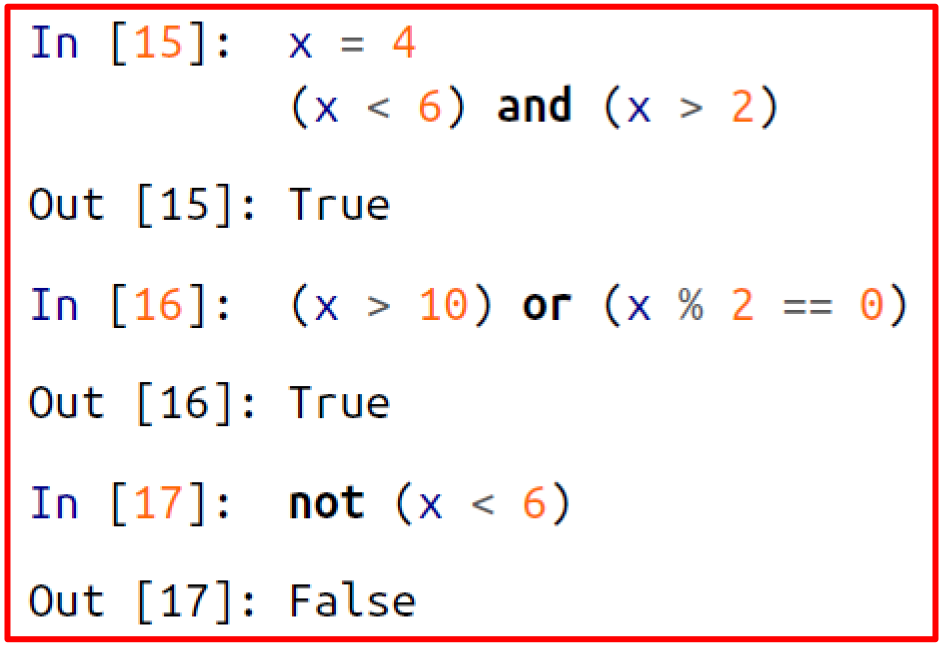
```
>>> i = j = k = 10
>>> print( i , j , k )
10 10 10
```

```
a += b    a -= b   a *= b    a /= b

a //= b   a %= b   a **= b   a &= b

a |= b    a ^= b   a <<= b   a >>= b
```

```
>>> a = 2
>>> b = 10
>>> b += a
>>> print( a , b )
2 12
```

Boolean Operators

- The Boolean operators operate on Boolean values:
  - **and**
  - **or**
  - **not**
- Can be used to construct complex comparisons.



```
In [15]:  x = 4
          (x < 6) and (x > 2)

Out [15]: True

In [16]:  (x > 10) or (x % 2 == 0)

Out [16]: True

In [17]:  not (x < 6)

Out [17]: False
```

Identity and Membership Operators

Operator	Description
`a is b`	True if a and b are identical objects
`a is not b`	True if a and b are not identical objects
`a in b`	True if a is a member of b
`a not in b`	True if a is not a member of b

```
In [19]:  a = [1, 2, 3]
          b = [1, 2, 3]

In [20]:  a == b

Out [20]: True

In [21]:  a is b

Out [21]: False

In [22]:  a is not b

Out [22]: True

In [23]:  a = [1, 2, 3]
          b = a
          a is b

Out [23]: True
```

```
In [24]:  1 in [1, 2, 3]

Out [24]: True

In [25]:  2 not in [1, 2, 3]

Out [25]: False
```

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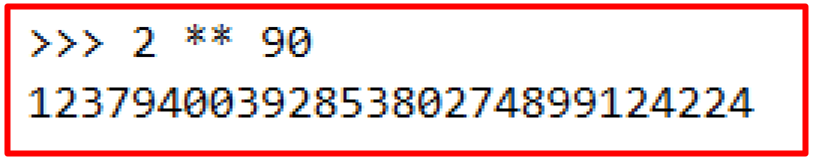
Python Scalar Types

Type	Example	Description
`int`	`x = 1`	Integers (i.e., whole numbers)
`float`	`x = 1.0`	Floating-point numbers (i.e., real numbers)
`complex`	`x = 1 + 2j`	Complex numbers (i.e., numbers with a real and imaginary part)
`bool`	`x = True`	Boolean: True/False values
`str`	`x = 'abc'`	String: characters or text
`NoneType`	`x = None`	Special object indicating nulls

```
>>> print( int('1') , float(1) , len(str(10)) )
1 1.0 2
```

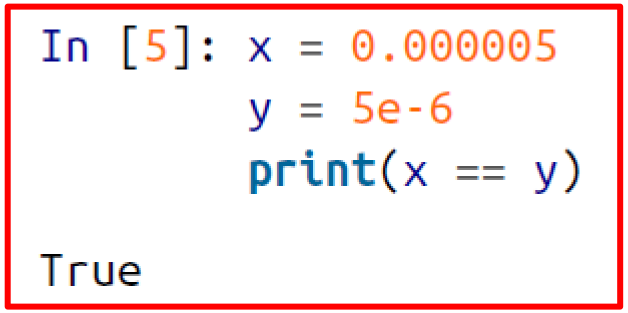
Integers and Floats

- Integers are variable-precision, no overflow is possible.



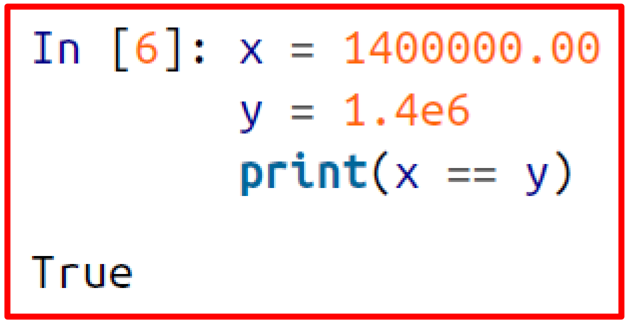
```
>>> 2 ** 90
1237940039285380274899124224
```

- The floating-point type can store fractional numbers. They can be defined either in standard decimal notation or in exponential notation.



```
In [5]: x = 0.000005
        y = 5e-6
        print(x == y)

True
```

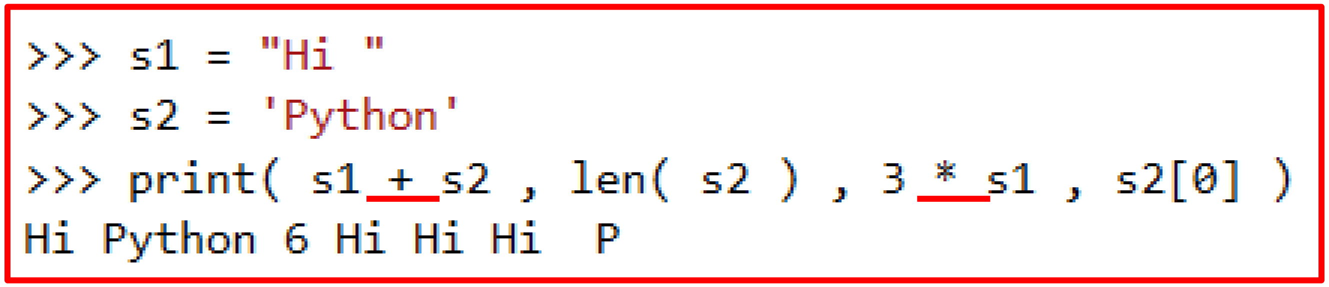


```
In [6]: x = 1400000.00
        y = 1.4e6
        print(x == y)

True
```

Strings

- Strings in Python are created with single or double quotes.
- The built-in function **`len()`** returns the string length.
- Any character in the string can be accessed through its index.

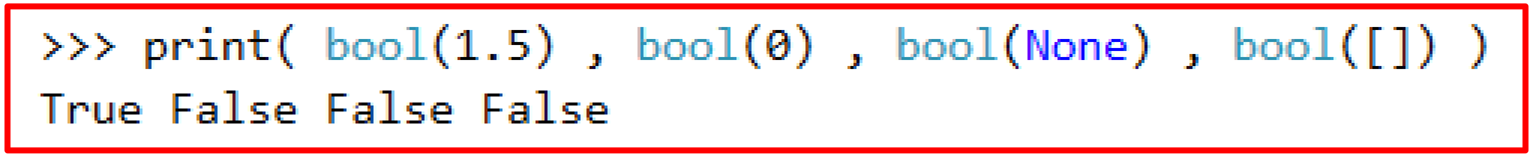


```
>>> s1 = "Hi "
>>> s2 = 'Python'
>>> print( s1 + s2 , len( s2 ) , 3 * s1 , s2[0] )
Hi Python 6 Hi Hi Hi  P
```

None and Boolean

- Functions that do not return value return **None**.
- **None** variables are evaluated to **`False`**.

- The Boolean type is a simple type with two possible values: **`True`** and **`False`**.
- Values are evaluated to True unless they are **None**, zero or empty.



```
>>> print( bool(1.5) , bool(0) , bool(None) , bool([]) )
True False False False
```

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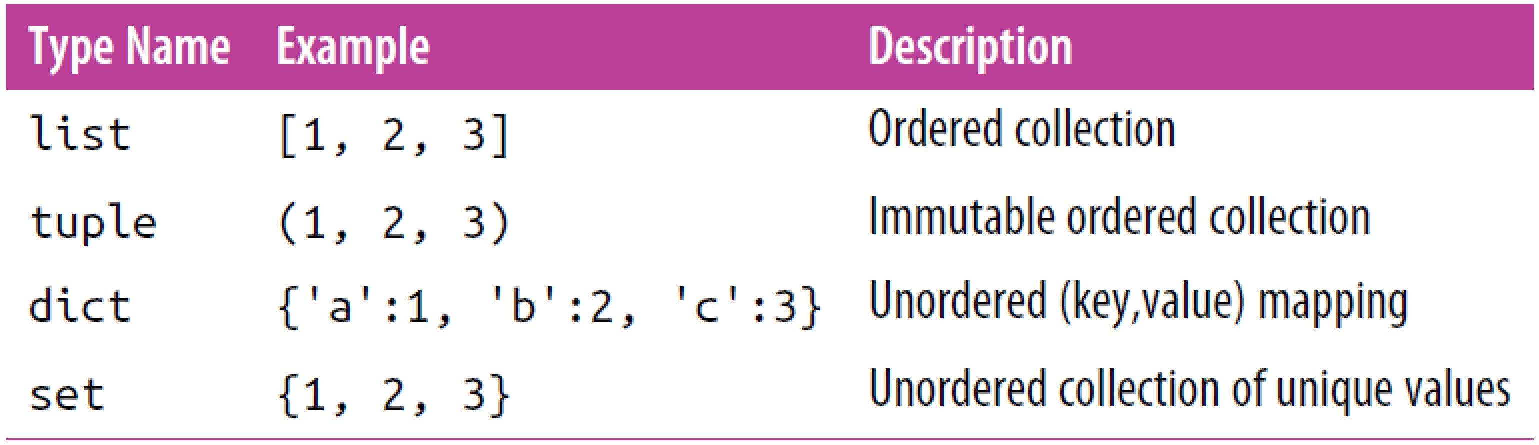
Built-In Data Structures

- There are four built in Python data structures.

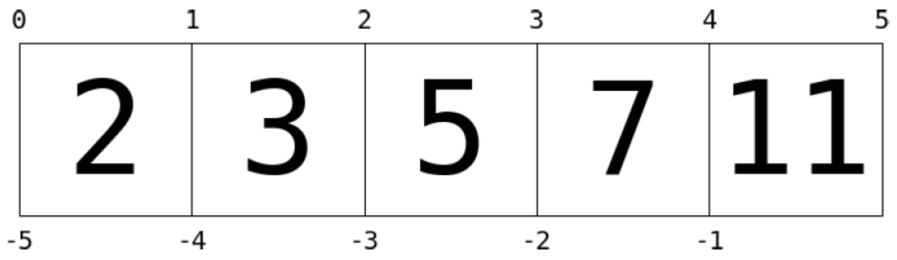


Type Name	Example	Description
`list`	`[1, 2, 3]`	Ordered collection
`tuple`	`(1, 2, 3)`	Immutable ordered collection
`dict`	`{'a':1, 'b':2, 'c':3}`	Unordered (key,value) mapping
`set`	`{1, 2, 3}`	Unordered collection of unique values

Lists

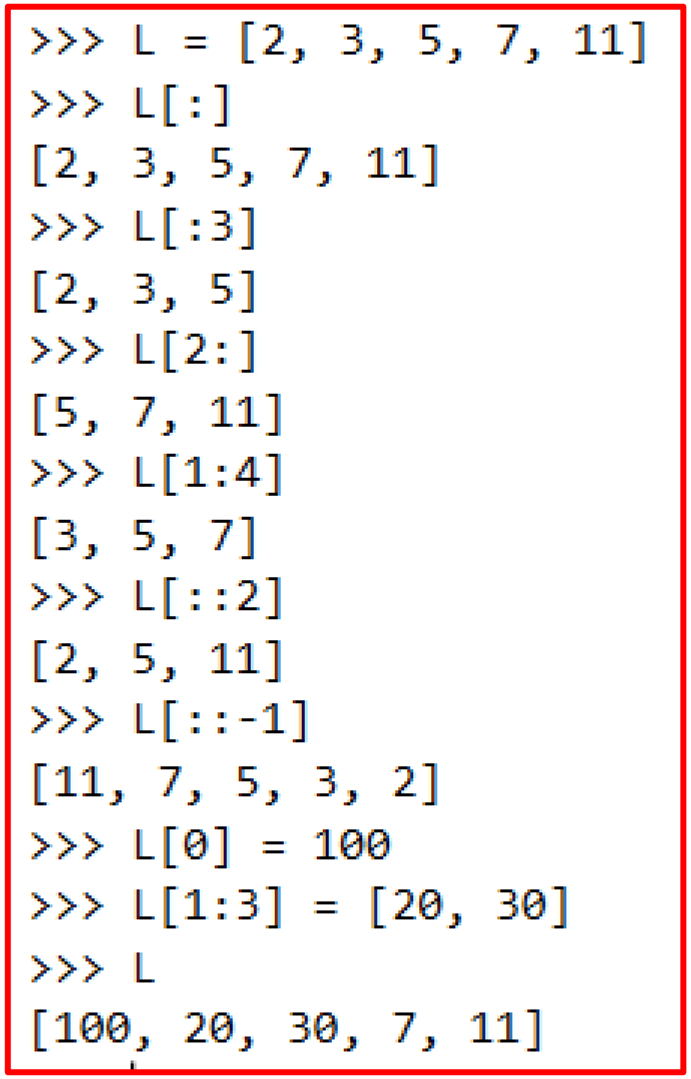
- List are ordered and mutable.
- A list can hold objects of any type.
- Python uses zero-based indexing.
- Elements at the end of the list can be accessed with negative numbers, starting from -1.

```
>>> L = [2, 3, 5, 7]
>>> L.append(11)
>>> print( len(L) , L[0] , L[4] )
5 2 11
>>> L = [15, 16] + L
>>> print( L )
[15, 16, 2, 3, 5, 7, 11]
>>> L.sort()
>>> print( L )
[2, 3, 5, 7, 11, 15, 16]
>>> L = [1, 'two', 3.14, [0, 3, 5]]
>>> L[3]
[0, 3, 5]
>>> L[-2]
3.14
```



Lists

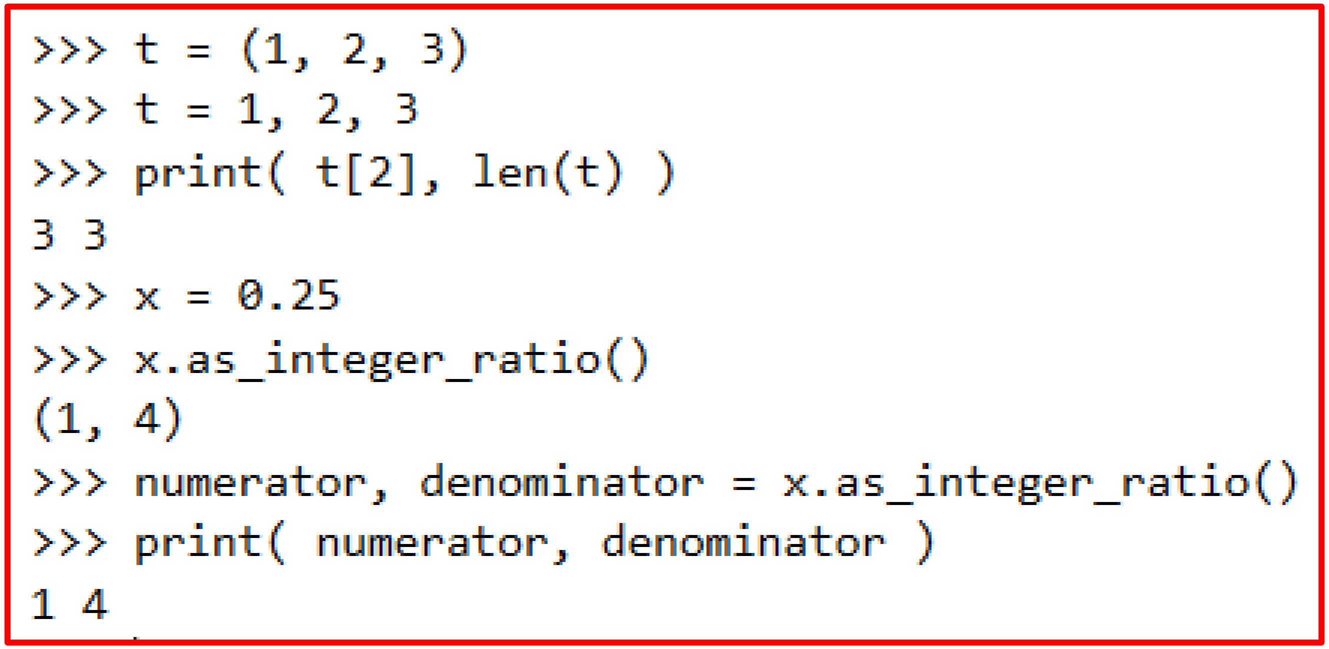
- Slicing is a means of accessing multiple values in sub-lists.
- **`[start : end+1 : inc]`**
- Negative step reverses the list.
- Both indexing and slicing can be used to set elements as well as access them.



```
>>> L = [2, 3, 5, 7, 11]
>>> L[:]
[2, 3, 5, 7, 11]
>>> L[:3]
[2, 3, 5]
>>> L[2:]
[5, 7, 11]
>>> L[1:4]
[3, 5, 7]
>>> L[::2]
[2, 5, 11]
>>> L[::-1]
[11, 7, 5, 3, 2]
>>> L[0] = 100
>>> L[1:3] = [20, 30]
>>> L
[100, 20, 30, 7, 11]
```

Tuples

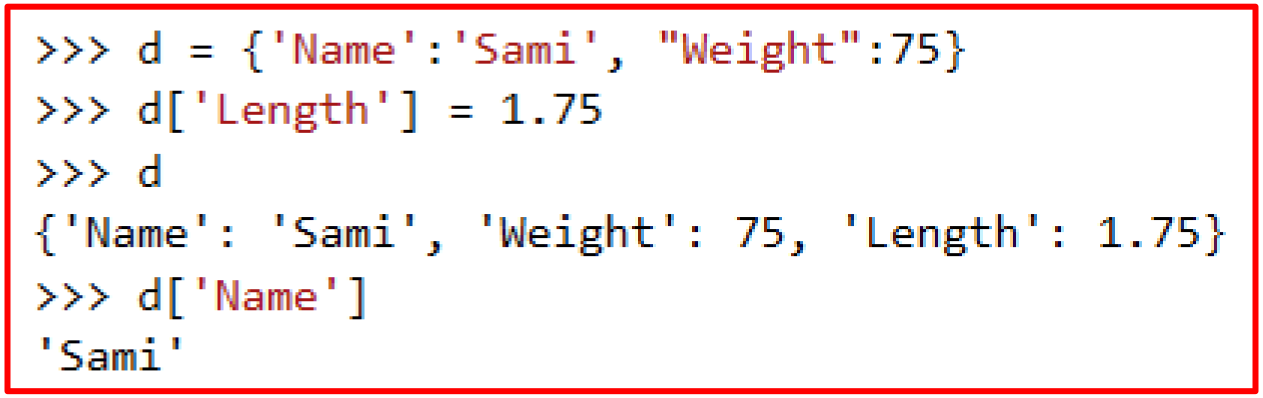
- Tuples are similar to lists, but are immutable.
- Can be defined with or without parentheses ( ).
- Functions return multiple values as tuples.



```
>>> t = (1, 2, 3)
>>> t = 1, 2, 3
>>> print( t[2], len(t) )
3 3
>>> x = 0.25
>>> x.as_integer_ratio()
(1, 4)
>>> numerator, denominator = x.as_integer_ratio()
>>> print( numerator, denominator )
1 4
```

Dictionaries

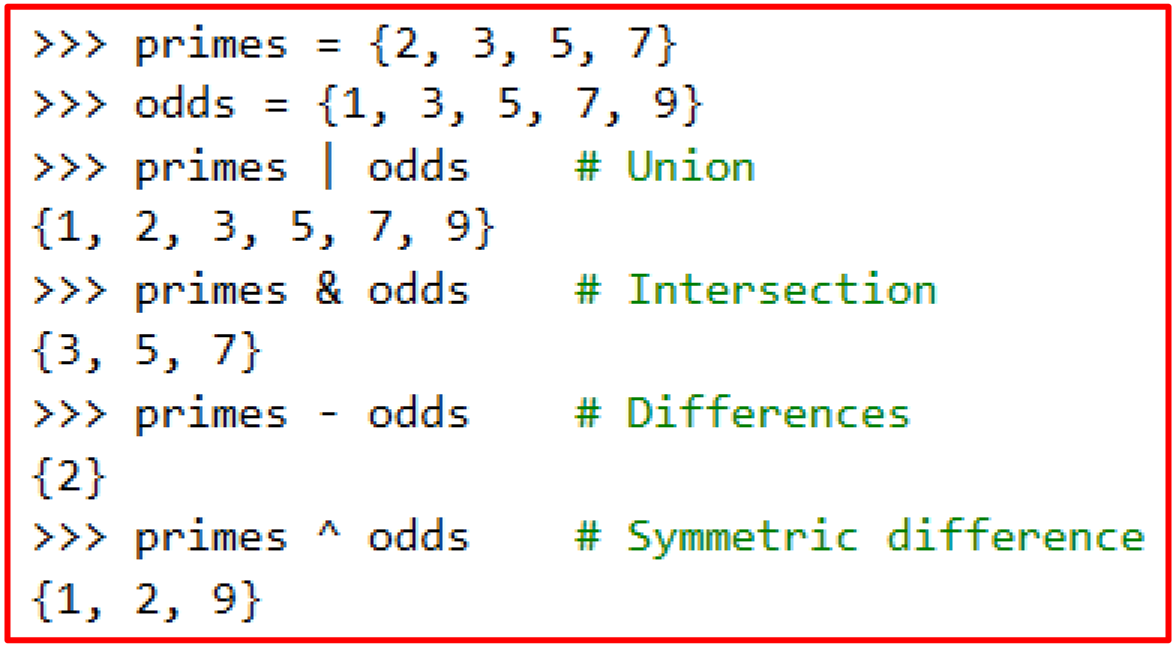
- Dictionaries are flexible mappings of keys to values.
- They can be created via a comma-separated list of **`key:value`** pairs within curly braces.



```
>>> d = {'Name':'Sami', "Weight":75}
>>> d['Length'] = 1.75
>>> d
{'Name': 'Sami', 'Weight': 75, 'Length': 1.75}
>>> d['Name']
'Sami'
```

Sets

- Sets are unordered collections of unique items.
- They are defined using curly brackets { }.
- Set operations include union, intersection, difference and symmetric difference.



```
>>> primes = {2, 3, 5, 7}
>>> odds = {1, 3, 5, 7, 9}
>>> primes | odds     # Union
{1, 2, 3, 5, 7, 9}
>>> primes & odds     # Intersection
{3, 5, 7}
>>> primes - odds     # Differences
{2}
>>> primes ^ odds     # Symmetric difference
{1, 2, 9}
```

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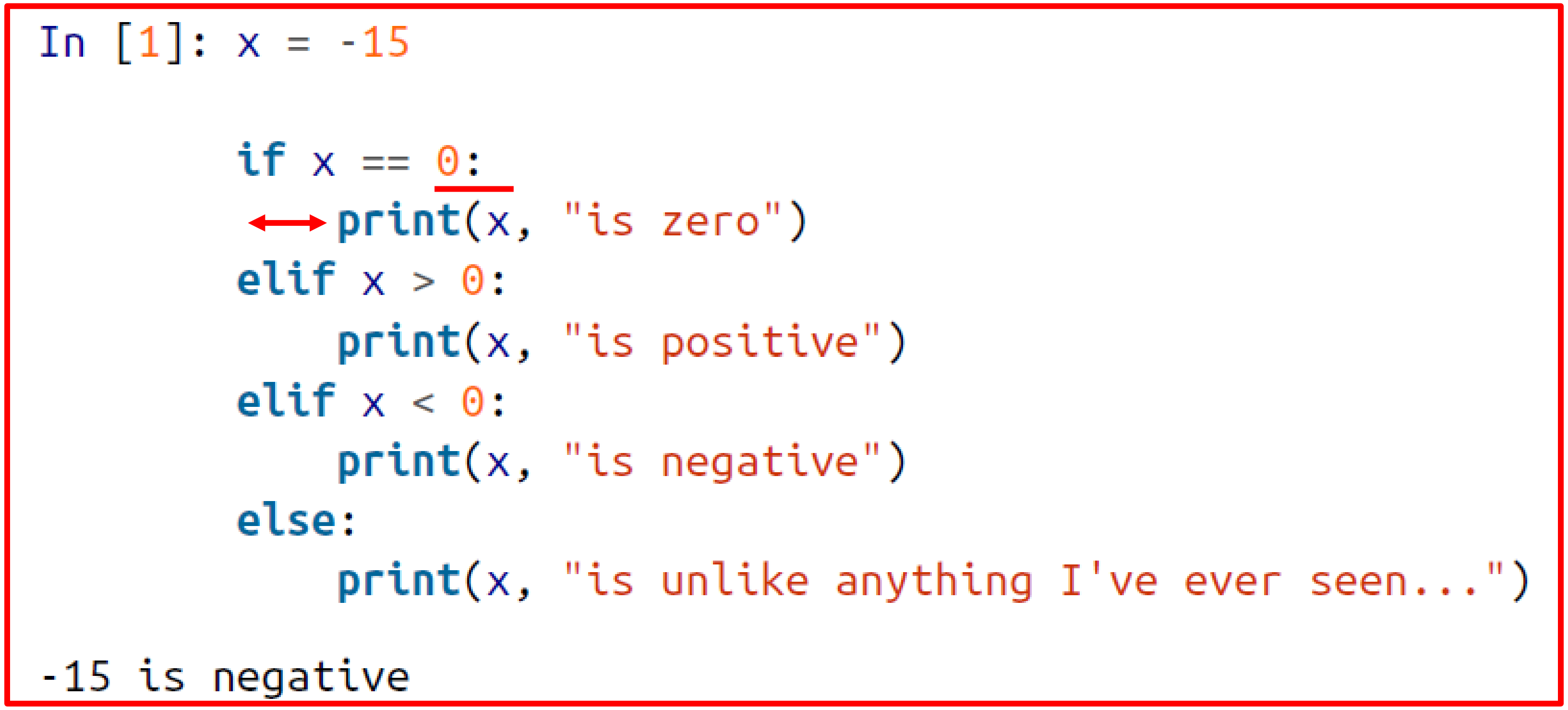
Conditional Statements: `if`, `elif`, and `else`

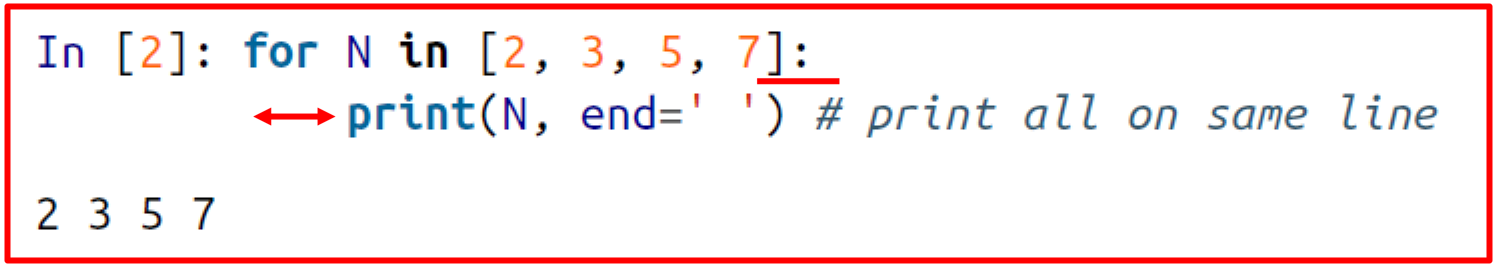
- **`if`** statements in Python have optional **`elif`** and **`else`** parts.



```
In [1]: x = -15

        if x == 0:
            print(x, "is zero")
        elif x > 0:
            print(x, "is positive")
        elif x < 0:
            print(x, "is negative")
        else:
            print(x, "is unlike anything I've ever seen...")

-15 is negative
```

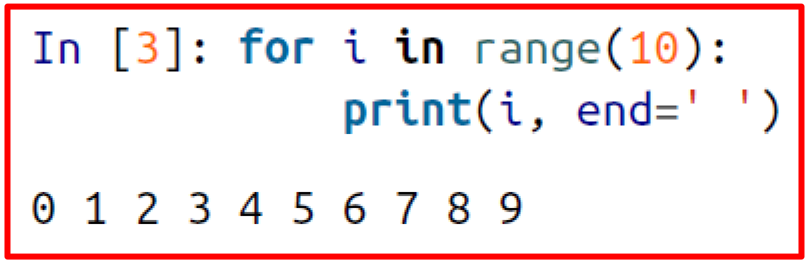
for Loops

- The **for** loop is repeated for each index returned by the iterator after **in**.



```
In [2]: for N in [2, 3, 5, 7]:
            print(N, end=' ') # print all on same line

2 3 5 7
```

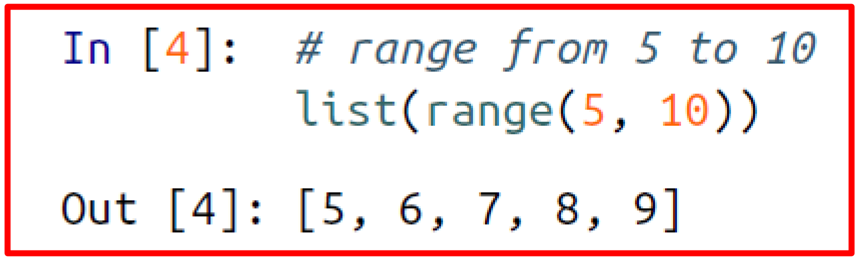
- The **range()** object is very useful in for loops.



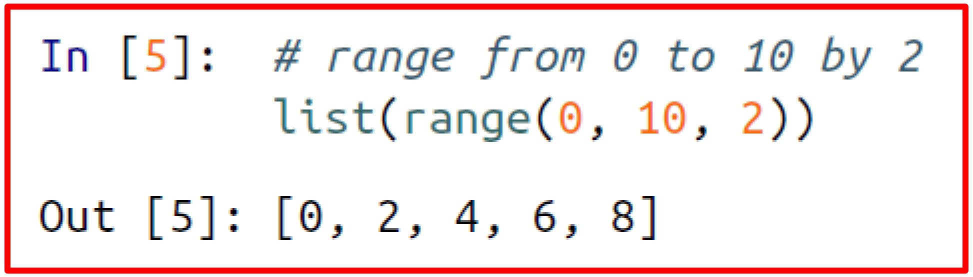
```
In [3]: for i in range(10):
            print(i, end=' ')

0 1 2 3 4 5 6 7 8 9
```

for Loops

- The **range(start, end+1, inc)** has default zero start and unit increment.



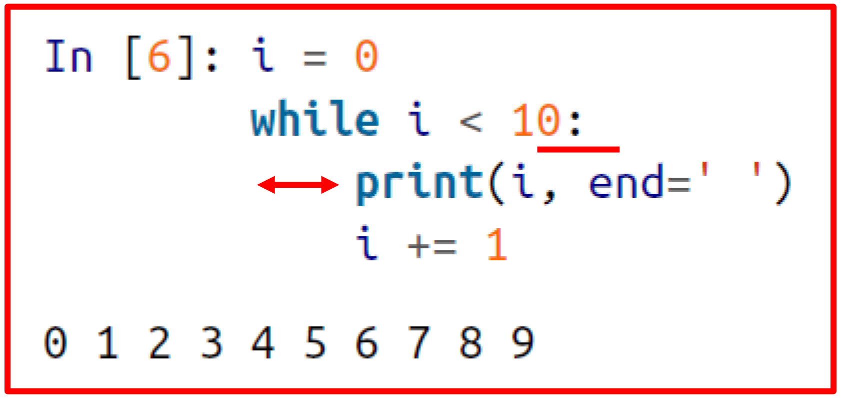
```
In [4]:  # range from 5 to 10
         list(range(5, 10))

Out [4]: [5, 6, 7, 8, 9]
```



```
In [5]:  # range from 0 to 10 by 2
         list(range(0, 10, 2))

Out [5]: [0, 2, 4, 6, 8]
```

while Loops

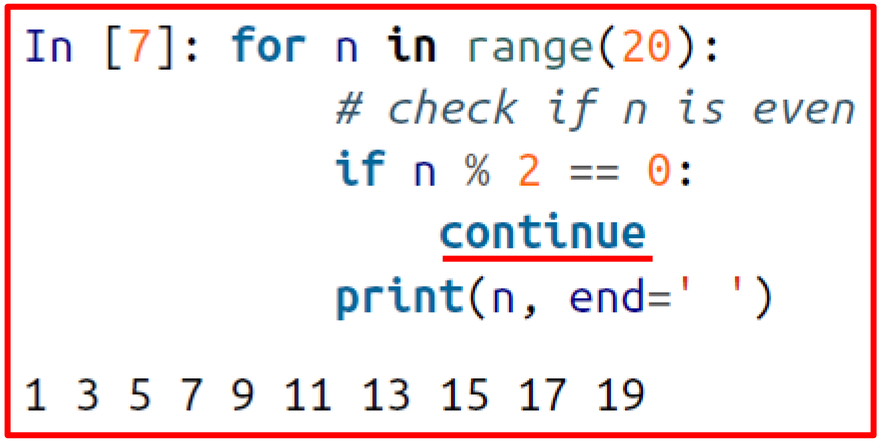
- The **while** loop iterates as long as the condition is met.



```
In [6]: i = 0
        while i < 10:
            print(i, end=' ')
            i += 1

0 1 2 3 4 5 6 7 8 9
```

`break` and `continue`: Fine-Tuning Your Loops

- The **`continue`** statement skips the remainder of the current loop, and goes to the next iteration.

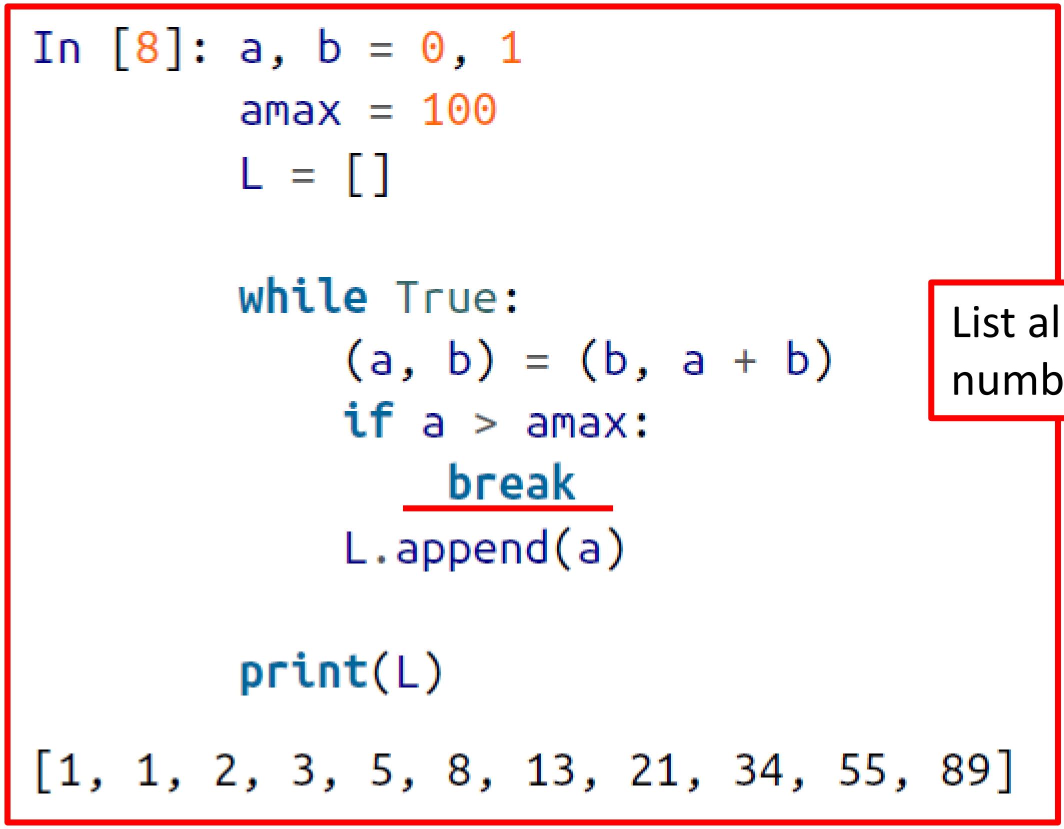


```
In [7]: for n in range(20):
            # check if n is even
            if n % 2 == 0:
                continue
            print(n, end=' ')

1 3 5 7 9 11 13 15 17 19
```

Prints odd numbers

break and continue: Fine-Tuning Your Loops

- The **break** statement breaks out of the loop entirely.



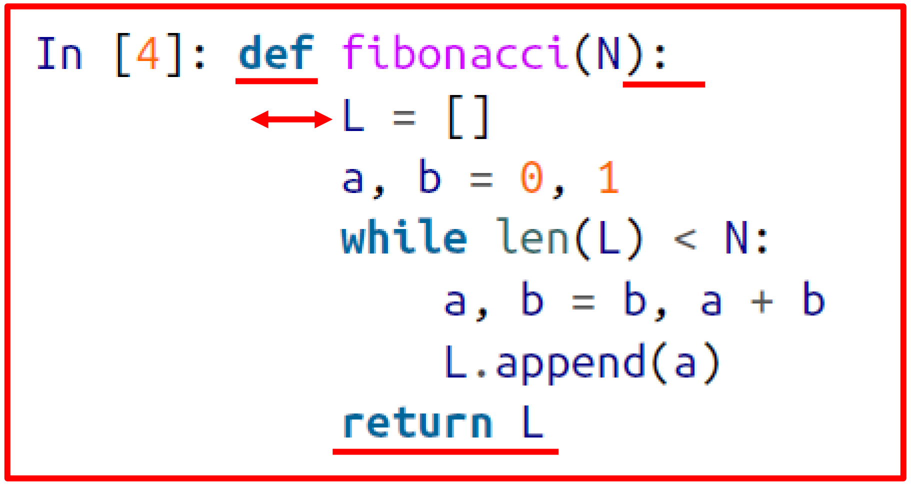
```
In [8]: a, b = 0, 1
        amax = 100
        L = []

        while True:
            (a, b) = (b, a + b)
            if a > amax:
                break
            L.append(a)

        print(L)

[1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89]
```

List all Fibonacci numbers up to 100.

Outline

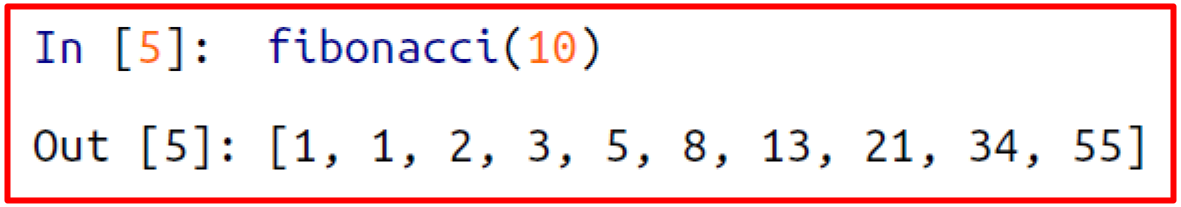
Defining Functions

- Functions are defined with the **def** statement.
- The following function returns a list of the first N Fibonacci numbers.



```
In [4]: def fibonacci(N):
            L = []
            a, b = 0, 1
            while len(L) < N:
                a, b = b, a + b
                L.append(a)
            return L
```

- Calling it:



```
In [5]:  fibonacci(10)

Out [5]: [1, 1, 2, 3, 5, 8, 13, 21, 34, 55]
```

Default Argument Values

- You can have default values for arguments.

```
def fibonacci(N, a=0, b=1):
    L = []
    while len(L) < N:
        a, b = b, a + b
        L.append(a)
    return L
```

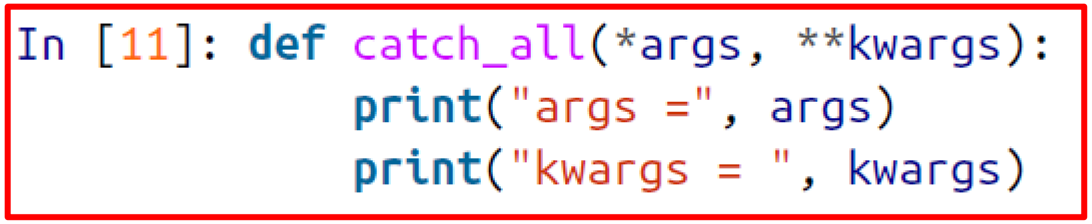
- It can be called with our without the optional args.

```
fibonacci(10)

[1, 1, 2, 3, 5, 8, 13, 21, 34, 55]
```

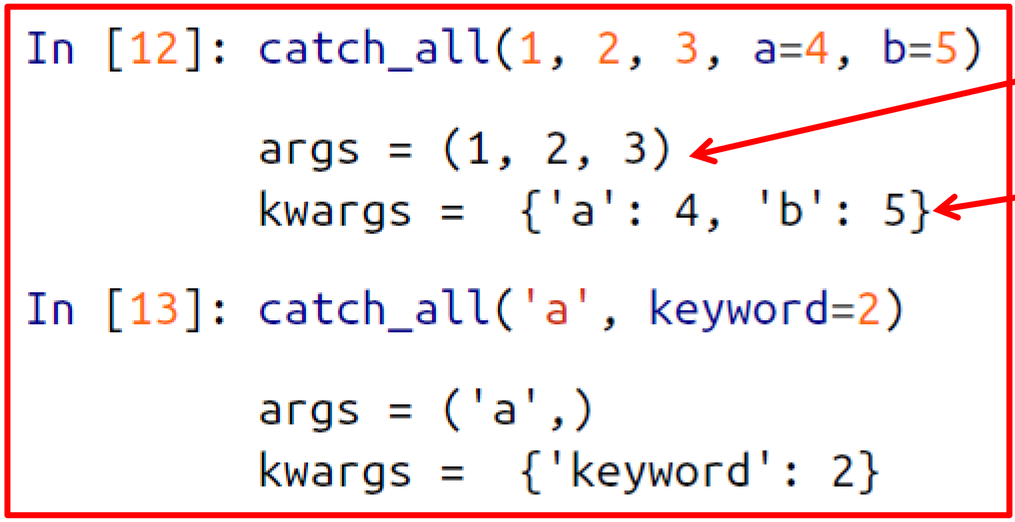
```
fibonacci(10, 0, 2)

[2, 2, 4, 6, 10, 16, 26, 42, 68, 110]
```

*args and **kwargs: Flexible Arguments

- Functions can be defined using ***args** and ****kwargs** to capture variable numbers of arguments and keyword arguments.



```
In [11]: def catch_all(*args, **kwargs):
             print("args =", args)
             print("kwargs = ", kwargs)
```



```
In [12]: catch_all(1, 2, 3, a=4, b=5)

         args = (1, 2, 3)
         kwargs =  {'a': 4, 'b': 5}

In [13]: catch_all('a', keyword=2)

         args = ('a',)
         kwargs =  {'keyword': 2}
```

Tuple

Dictionary

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- Defining and Using Functions
- Objects and Classes
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- Generators

Objects and Classes

- Python is object-oriented programming language.
- Objects bundle together data and functions.
- Each Python object has a type, or class.
- An object is an instance of a class.
- Accessing instance data:

```
object.attribute_name
```

- Accessing instance methods:

```
object.method_name(parameters)
```

String Objects

- String objects are instances of class `str`.

```
name = input("Please enter your name: ")
print("Hello " + name.upper() + ", how are you?")
```

```
Please enter your name: Sami
Hello SAMI, how are you?
```

- String objects have many useful methods

  https://docs.python.org/3/library/stdtypes.html#text-sequence-type-str

String Methods

```
>>> s = "   Hi   "
>>> s.strip()
'Hi'
>>> 'Age: {0}, Weight: {1}'.format(20, 70)
'Age: 20, Weight: 70'
>>> s = 'This is a string'
>>> s.find('is')
2
>>> s.replace('a', 'the')
'This is the string'
```

File Objects

- Files can be opened for read, write or append.

```python
f = open('myfile.txt', 'w')
f.write('Line 1\n')
f.write('Line 2\n')
f.close()

f = open('myfile.txt', 'r')
for line in f:
    print(line.strip())
f.close()
```

```
Line 1
Line 2
```

Classes

- New class types can be defined using `class` keyword.

```python
class Animal(object):
    def __init__(self, name='Animal'):  # Constructor
        print('Constructing an animal!')
        self.name = name
        if name == 'Cat':
            self.meows = True  # Attribute
        else:
            self.meows = False
        super(Animal, self).__init__()

    def does_meow(self):   # Method
        return self.meows

cat = Animal('Cat')
print('It meows ', cat.does_meow())
```

```
Constructing an animal!
It meows  True
```

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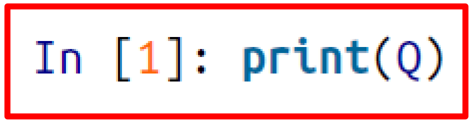
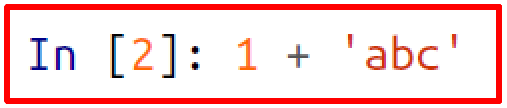
Runtime Errors

- Referencing an undefined variable



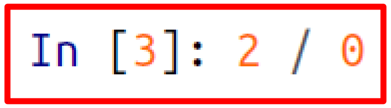
```
In [1]: print(Q)
```

- Unsupported operation



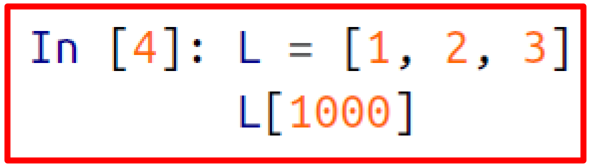
```
In [2]: 1 + 'abc'
```

- Division by zero



```
In [3]: 2 / 0
```

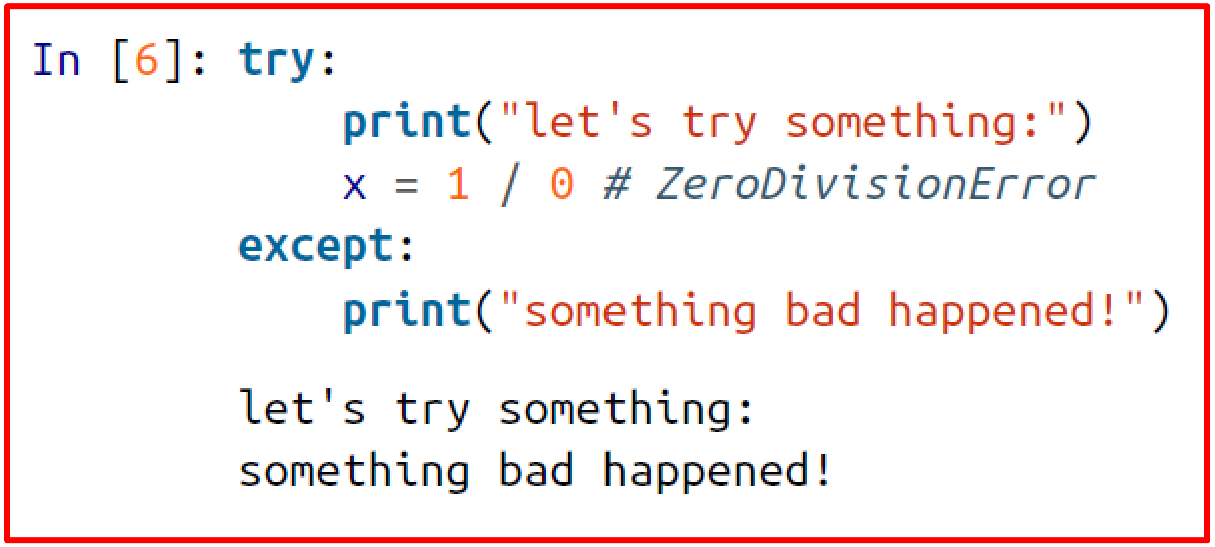
- Accessing a sequence element that doesn't exist



```
In [4]: L = [1, 2, 3]
        L[1000]
```

Catching Exceptions: `try` and `except`

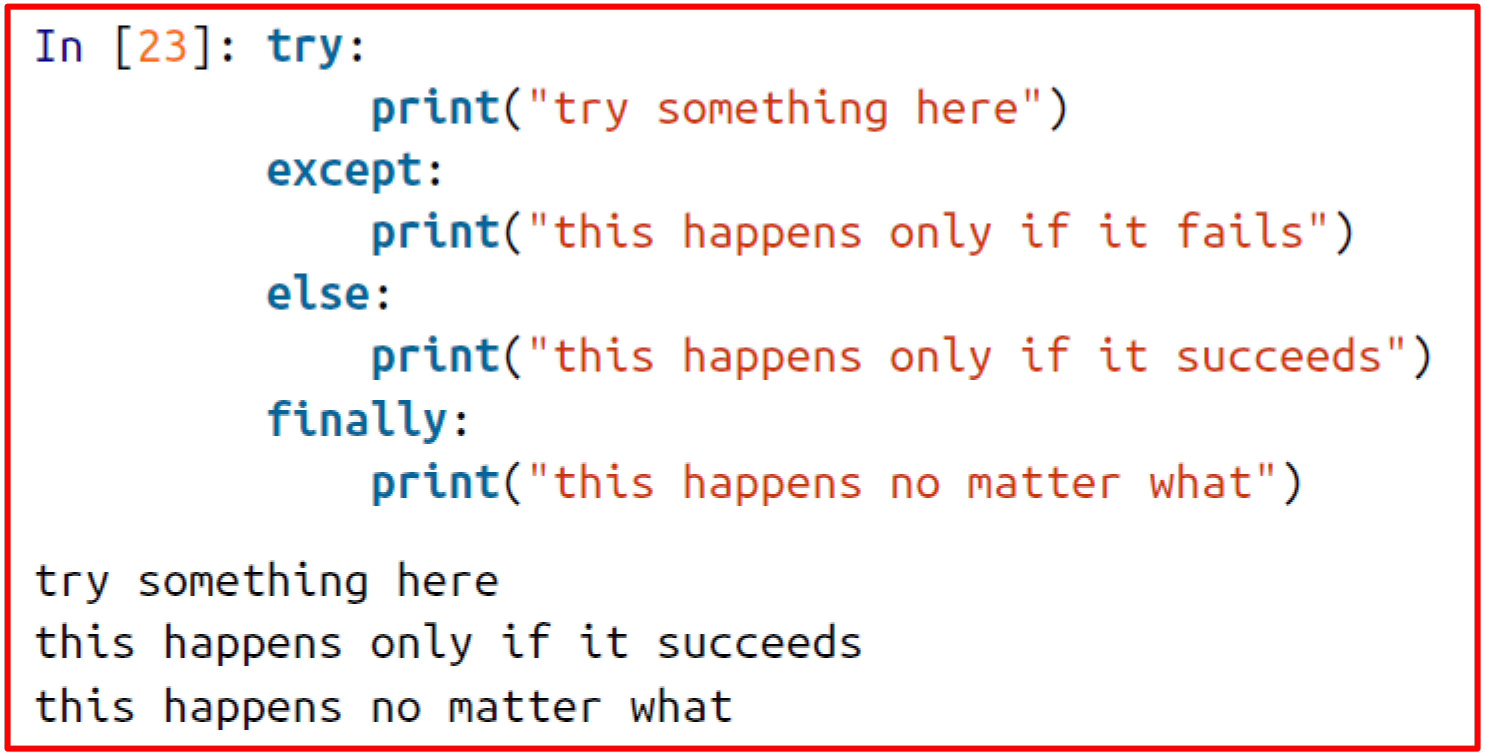
- Runtime exceptions can be handled using the **try…except** clause.



```
In [6]: try:
            print("let's try something:")
            x = 1 / 0 # ZeroDivisionError
        except:
            print("something bad happened!")

        let's try something:
        something bad happened!
```

try…except…else…finally

- Python also support **else** and **finally**

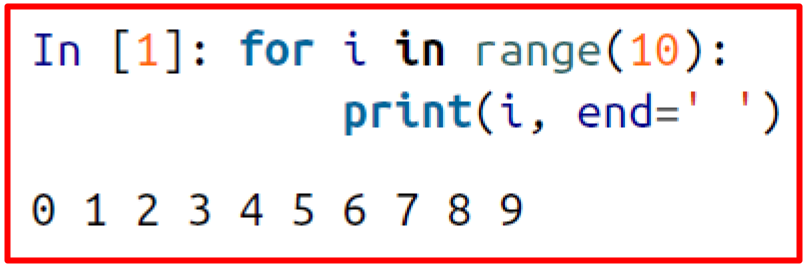


```
In [23]: try:
             print("try something here")
         except:
             print("this happens only if it fails")
         else:
             print("this happens only if it succeeds")
         finally:
             print("this happens no matter what")

try something here
this happens only if it succeeds
this happens no matter what
```

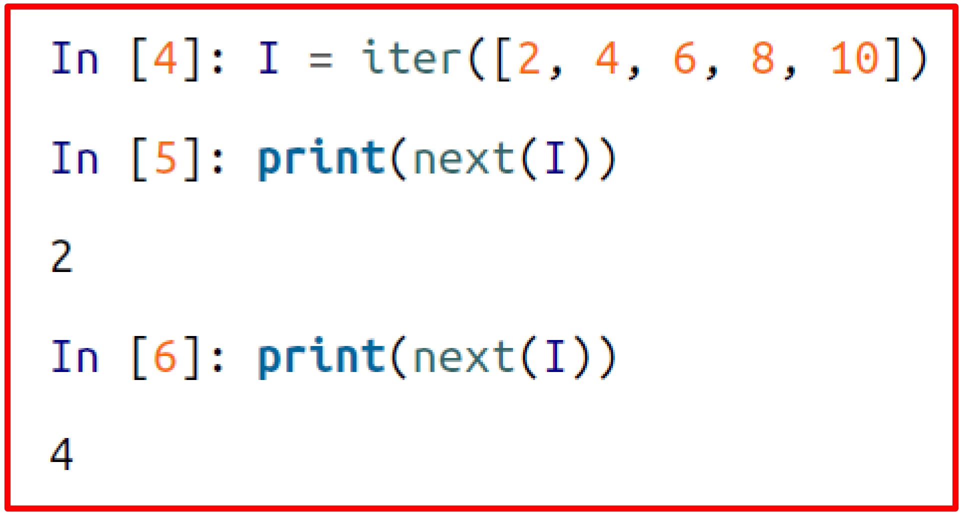
Outline

Iterators

- Iterators are used in **for** loops and can be used using **next()**



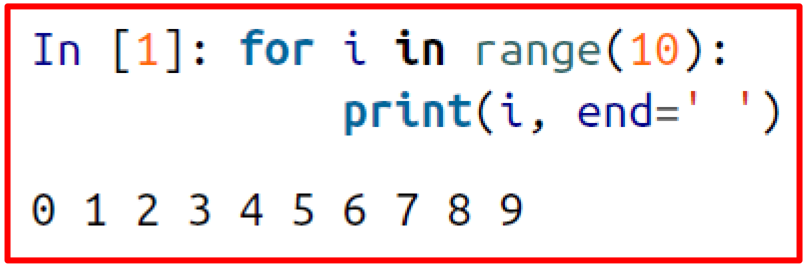
```
In [1]: for i in range(10):
            print(i, end=' ')

0 1 2 3 4 5 6 7 8 9
```



```
In [4]: I = iter([2, 4, 6, 8, 10])

In [5]: print(next(I))

2

In [6]: print(next(I))

4
```

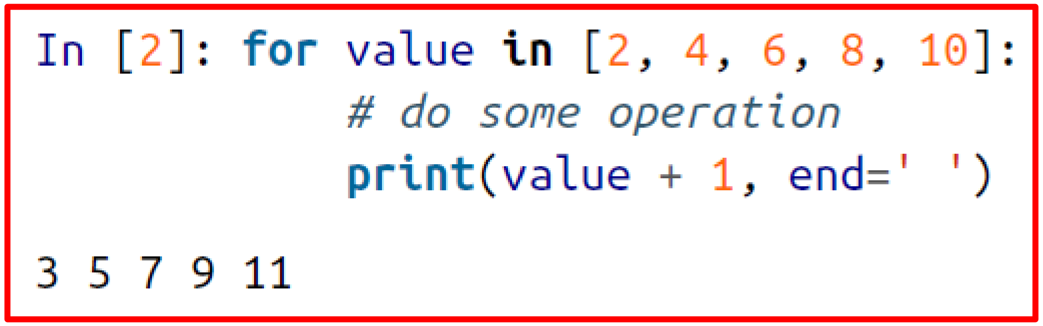
Iterators

- The range iterator



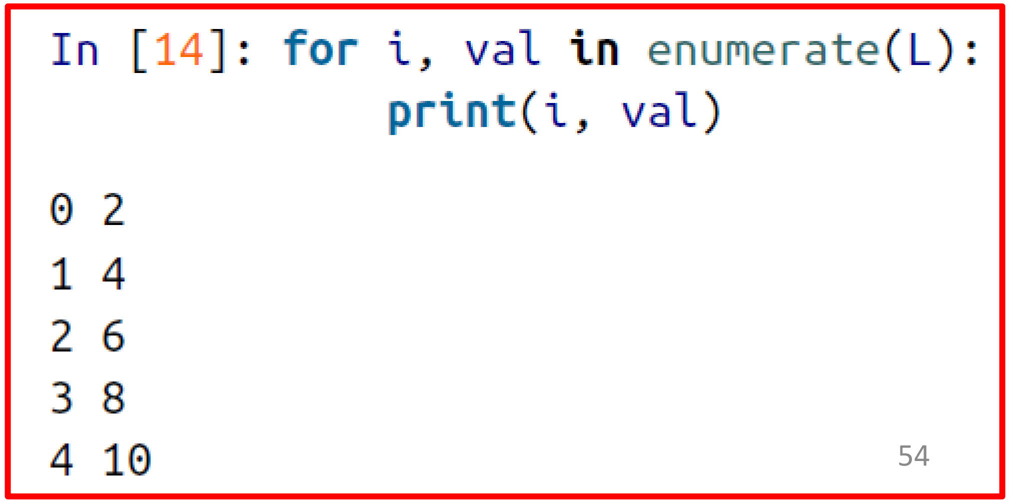
```
In [1]: for i in range(10):
            print(i, end=' ')

0 1 2 3 4 5 6 7 8 9
```

- Iterating over lists



```
In [2]: for value in [2, 4, 6, 8, 10]:
            # do some operation
            print(value + 1, end=' ')

3 5 7 9 11
```

- **enumerate** iterator



```
In [14]: for i, val in enumerate(L):
             print(i, val)

0 2
1 4
2 6
3 8
4 10
```

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List Comprehensions

- A way to compress a list-building for loop into a single short, readable line.
- Syntax: ***[expr for var in iterable]***

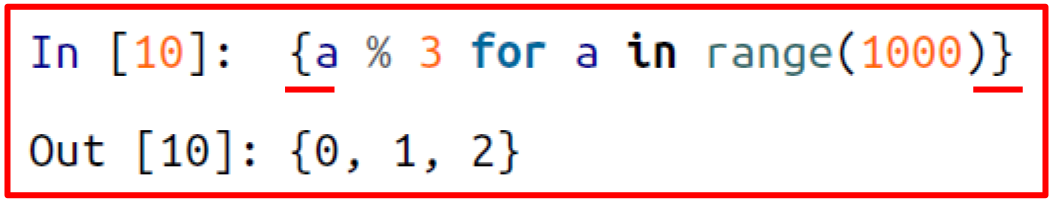
```
In [3]:  [n ** 2 for n in range(12)]

Out [3]: [0, 1, 4, 9, 16, 25, 36, 49, 64, 81, 100, 121]
```

```
In [1]:  [i for i in range(20) if i % 3 > 0]

Out [1]: [1, 2, 4, 5, 7, 8, 10, 11, 13, 14, 16, 17, 19]
```

```
In [4]:  [(i, j) for i in range(2) for j in range(3)]

Out [4]: [(0, 0), (0, 1), (0, 2), (1, 0), (1, 1), (1, 2)]
```

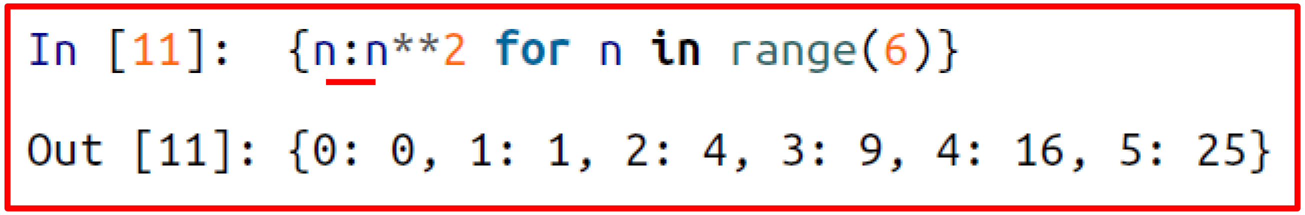
List Comprehensions

- Lists comprehensions can be used to construct sets with no duplicates.



```
In [10]:  {a % 3 for a in range(1000)}

Out [10]: {0, 1, 2}
```

- Or dictionaries

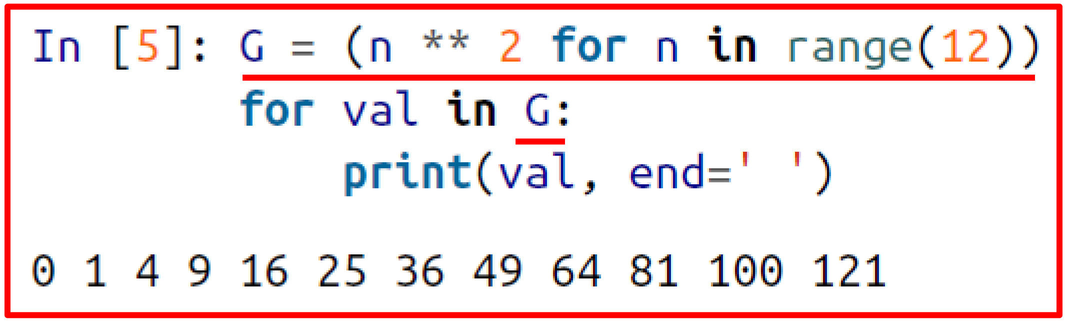


```
In [11]:  {n:n**2 for n in range(6)}

Out [11]: {0: 0, 1: 1, 2: 4, 3: 9, 4: 16, 5: 25}
```

Outline

Generators

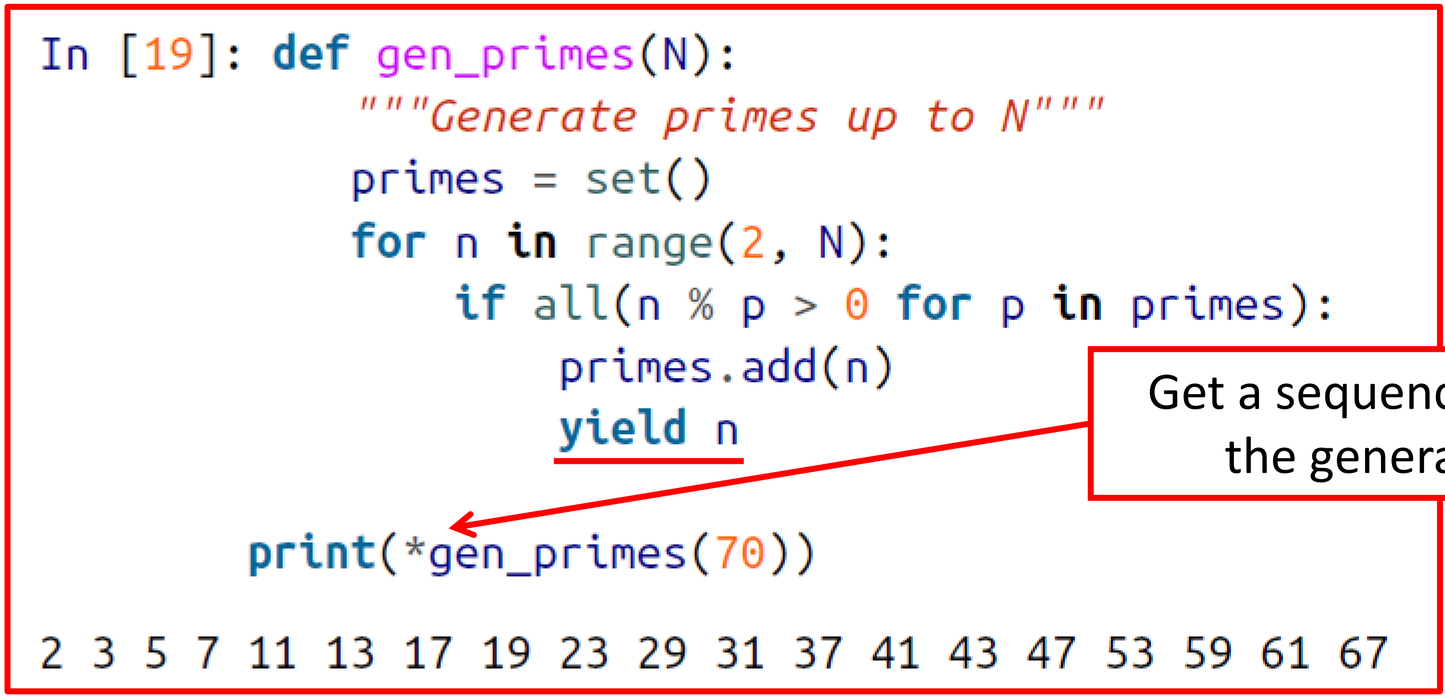
- A list is a collection of values, while a generator expression is a recipe for producing values.



```
In [5]: G = (n ** 2 for n in range(12))
        for val in G:
            print(val, end=' ')

0 1 4 9 16 25 36 49 64 81 100 121
```

Generators

- A generator function uses **`yield`** to yield a sequence of values.



```
In [19]: def gen_primes(N):
             """Generate primes up to N"""
             primes = set()
             for n in range(2, N):
                 if all(n % p > 0 for p in primes):
                     primes.add(n)
                     yield n

         print(*gen_primes(70))

2 3 5 7 11 13 17 19 23 29 31 37 41 43 47 53 59 61 67
```

Get a sequence from the generator

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