# Python Workshop Series Session 3: *Iteration and Lists*

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## Outline

- Lists
- Tuples & Dictionaries
- Loops

# Memory: ID Know (Really)

- The ***id*** function returns the "identity" of an object in Python.
- As we will soon see, everything in Python is an object…
- In many Python ***implementations***, id returns object memory address.
- Different organizations develop different Python interpreters
- They are free to choose how they ***implement*** those features not strictly required/defined by the Python standard.
- In the meantime, try this:

```
a = 1 ; b = 2
print( id(b) – id(a) )
```

- Semicolons = multiple statements per line
- Anyone not get 32?
- Hmm… we'll come back to this

# Lists in Python

- Multiple objects can be grouped together into lists
- Lists enclosed by brackets [ ]
- Objects can be of different types
- Indexing starts with 0
- Values copied as necessary …
- Try this …

```
a = 1.0
b = [ 1, 2, a, 4 ]
print( b[0] )
print( b[2] )
print( b )
```

```
print ( ‘1’, b[2] is a , id(b[2]), id(a))
a = 2
print ( ‘2’, b[2] is a , id(b[2]), id(a))
c = 1.0
print ( ‘c’, b[2] is c , id(b[2]), id(c))
```

*All in one python script or Jupyter cell!*

# Nested (Multi-dimensional) Lists

- We can have lists of lists:
- Indexing uses two square brackets

```
a = [ 1 , 2]
b = [ 3 , 4]
c = [ a , b , 5 ]
```

```
print( c[ 0 ] )          [1, 2]
print( c[ 1 ] )          [3, 4]
print( c[ 0 ][ 0 ] )     1
print( c[ 0 ][ 1 ] )     2
print( c[ 1 ][ 0 ] )     3
print( c[ 1 ][ 1 ] )     4
print( c[ 2 ] )          5
```

- c[2] is a scalar
- c[0] and c[1] are 2-element lists.

## Nested Lists:  Memory

- Be careful!
- Python **does not** automatically copy a and b…

```
a = [ 1 , 2 ]
b = [ 3 , 4 ]
c = [ a , b ]
```

```
print( a[ 0 ] , c[ 0 ][ 0 ] )
print( id( a[ 0 ] ) , id( c[ 0 ][ 0 ]) )
c[ 0 ][ 0 ] = 4
print( a[ 0 ] , c[ 0 ][ 0 ] )
print( id( a[ 0 ] ) , id( c[ 0 ][ 0 ] ) )
```

# Cloning Lists

- If we want copies, use the “slice” notation → : ←

```
a = [ 1, 2]
b  =  a
b[0] = 5.0
print(a[0], b[0])
```

→

```
a = [ 1, 2]
b = a[ : ]
b[0] = 5.0
print( a[0], b[0] )
```

---

```
a = [ 1, 2]
b = [ 3, 4]
c = [ a[ : ] , b[ : ] ]
```

```
print( a[ 0 ] , c[ 0 ][ 0 ] )
c[ 0 ][ 0 ] = 4
print( a[ 0 ] , c[ 0 ][ 0 ] )
```

# Sublists

- Copy a list portion using the slice notation with bounds

```
a = [ 1 , 2 , 3 , 4 , 5 ]
b = a[ 2 : 4 ]
print( len( b ) )
print( b )
```

len function:
returns number of elements in a list

This grabs a[ 2 ] and a[ 3 ]  --  not a[ 4 ]!

**Slicing Convention:**

- b is essentially a copy of [ a[ 2 ] , a[ 3 ] ]
- b *is not a copy of* [ a[ 2 ], a[ 3 ], a[ 4 ] ]

## Essentially?

```
a = [ 1 , 2 , 3 , 4 , 5 ]
b = a[ 2 : 4 ]

print(  id(a[2]) , id(b[0]) )
b[0] = 85

print(  id(a[2]) , id(b[0]) )
```

**... well, more or less.**

# Lists and functions

- Lists are passed by reference.
- Avoid unwanted side-effects by passing list clones instead

```
def modify( a ):
    a[ 0 ] = 2
```

Side Effect

```
b = [ 0 , 0 ]
modify( b )
print( b )
```

No Side Effect

```
b = [ 0 , 0 ]
modify( b[ : ] )
print( b )
```

# append & del

- The **append** method grows a list
- Syntax: *listname* dot *append( )*
- The **del** statement deletes elements or sublists

```
a = [ ]  init empty list
a.append(  1 )
print( len( a ) ,  a)
a.append(  4 )
print( len( a ) , a)
a.append(  8 )
print( len( a ) , a)
```

```
a = [ 4 , 8 , 12 , 13 ]
print( a  )
del a[ 0 : 2 ]
print( a  )
del a[ 0 ]
print( a )
```

## List Initialization: Replication

- Occasionally useful to initialize a list with known values
- Use the * operator to replicate values from an existing list or list expression

1-dimensional list

```
a = [ 1 , 2 ]
b = 3 * a
print( b )
```

b is [ 1, 2, 1, 2, 1, 2 ]

Nested list

```
a = [ 1 , 2 ]
b = 3*[ a ]
print( b )
```

b is [ [ 1, 2 ], [ 1, 2 ], [ 1, 2 ] ]

# List Initialization:  Replication

- Extends naturally to higher dimensions

```
a = [ [ 1 , 2 ] , [ 3 , 4 ] ]
b = 2 * a
print( b )
```

b is [ [1, 2], [3, 4], [1, 2], [3, 4] ]

```
a = [ [ 1,2], [ 3, 4] ]
c = 2*[a]
print(c)
```

c is [ [ [1, 2], [3, 4] ], [ [1, 2], [ 3, 4] ] ]

c[0][0][1] ↗   c[1][1][0] ↗

# List-like Class:  Tuples

- Similar to Lists, but immutable (can't change values)
- Use ( )  instead of [ ] during creation (only)

```
a = ( 1 , 2 )
print( a[ 0 ] )
a[ 0 ] = 2  not allowed
```

lists of tuples

```
a = ( 1 , 2)
b = ( 3 , 4)
c = [ a , b]
c[ 0 ] = 1          OK – replace tuple with int
c[ 1 ][ 0 ] = 2     not OK – modifying tuple element
```

## Tuples of lists

- A bit non-intuitive

```
a = [ 1 , 2 ]
b = [ 2 , 3 ]
c = ( a , b)
```

Allowed; modifying list element

```
c[0][0] =4
```

Not allowed; modifying tuple element

```
c[0] =2
```

# Tuple Assignment

- Useful Python feature
- Values on right assigned to values on left

Create a,b,c and assign them values

```
( a, b, c ) = (1, 2, 3)
```

Swap values

```
tmp = a
a = b
b = tmp
```

$\longleftrightarrow$

```
( a , b ) = ( b , a )
```

***Question:***
How do the object id’s behave?

## List-like Objects: Dictionaries

- Key-value pairs
- Key (i.e., the index) must be immutable (ints or strings)
- Initialize with { } ( not [ ] or ( ) )

```
var = { }
var['Apple'] = 43
var[8] = [ 'Orange', 2, 14.0]
```

```
print ( var[ 'Apple' ] )
```

```
43
```

```
print( var[ 8 ] )
```

```
[ 'Orange', 2, 14.0]
```

```
print( var[ 8 ][ 2 ] )
```

```
14.0
```

# Lists: odds and ends

- Concatenation:

```
a = [ 1 , 2 ]
b = [ 2 , 3 ]
c = a + b
print(c)
```

- Membership:

```
mylist = [ ‘Mario’ , ‘Luigi’ ]
b = ‘Mario’ in mylist
c = ‘Zelda’ in mylist
print( b , c )
```

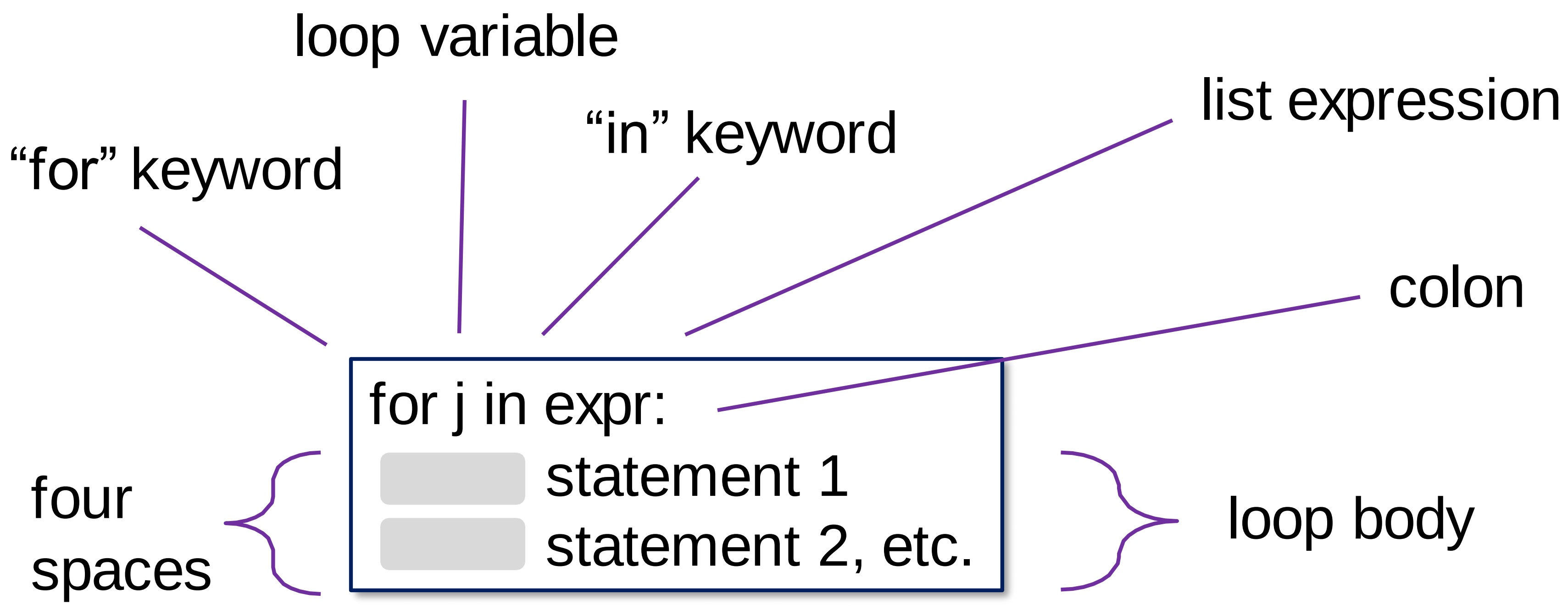
## Lists: Final Remarks

- See online text, chapter 11 for more on lists.
- Strings act like lists
  - Immutable
  - For useful string methods see online text, ch. 8

## Iteration in Python

- Three commonly used loop constructs:
  - for
  - while
  - enumerate

# For Loop Syntax



```
for j in expr:
    statement 1
    statement 2, etc.
```

For each element in expr:

- Assign its value to j
- Execute statements in loop body

# For Loop Examples

- Try these:

```
a = [1,2,3]
for j in a:
        print(j)
```

```
a = (1,2,3)
for j in a:
        print(j)
```

```
a = [ [1,2] , [3,4] ]
for j in a:
        print(j)
```

```
a = [‘Peter’, ‘Paul’, ‘Mary’]
for j in range(3):
        print( j )
        print( a[ j ] )
```

*range* function

- range(n)
  - Integer sequence 0 through n-1
- range(m,n)
  - Integer sequence m through n-1

# Nesting Loops

- Indent again to start a nested loop
- Try this

```
a = [ [ 1 , 2 , 0 ] , [ 3 , 4 , 7 ] ]
alen = len(a)
for j in range(alen):
        jlen = len(a[ j ])
        for k in range(jlen):
                print( j , k ,  ‘ : ‘, a[ j ][ k ] )
```

# Exercise 1:  For Loops

- Write a function that:
  - Accepts a list of numbers
  - Returns the sum of those numbers
- Be sure to use a for loop

```
def myfunc(a):
        n = len(a)
        …
        return my sum
```

```
for j in range(n):
        statement 1
        statement 2, etc.
```

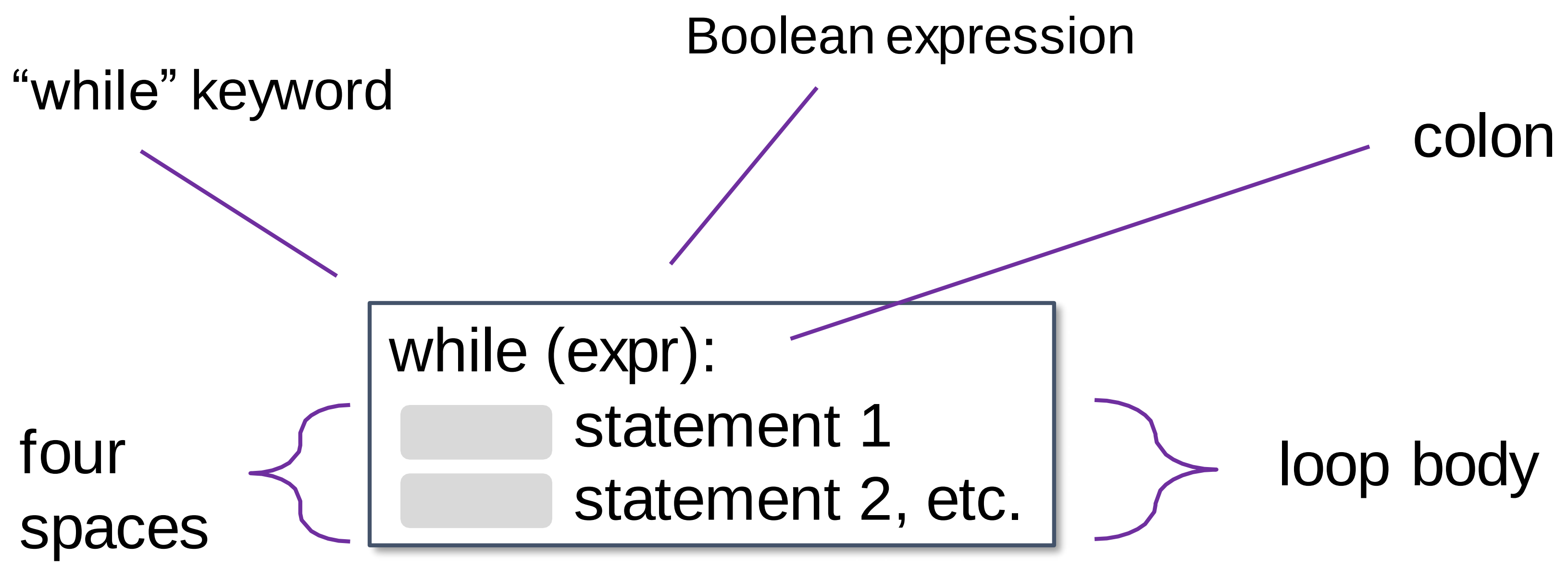
# Exercise 2: For Loops

- Write a function that:
  - Accepts a single integer N
  - Returns a list of all odd numbers 1 through N
- Recall that the % operator is used to check for remainders (mod division)

```
def myfunc(n):
        odds = [ ]
        …
        odds.append(things)
        return my sum
```

```
for j in range(n):
        statement 1
        statement 2, etc.
```

# While Loop Syntax



```
while (expr):
    statement 1
    statement 2, etc.
```

As long as expr is True:

- Execute statements in loop body

# While Loop Examples

- Try these:

```
a = [ 1 , 2 , 3 ]
j = 0
n = len( a )
while( j < n ):
        print( a[ j ] )
        j += 1
```

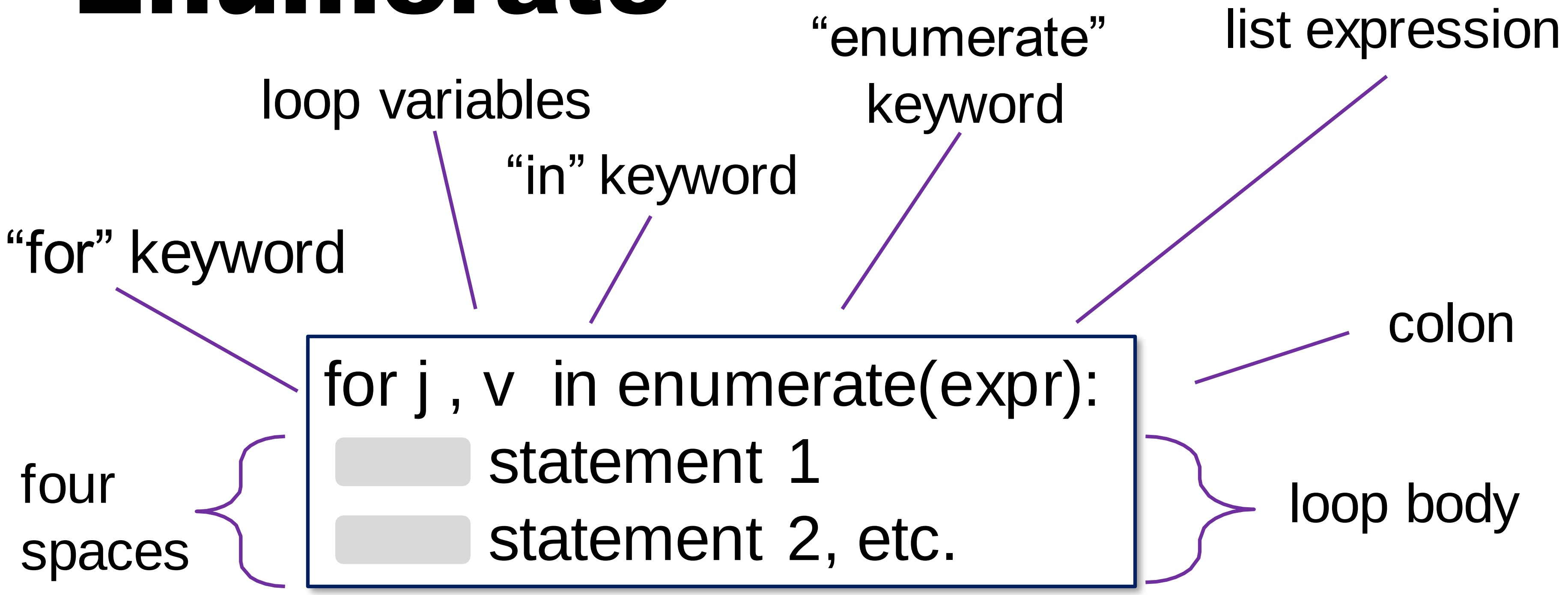
```
a = [ [ 1 , 2 ] , [ 3 , 4 ] ]
n = len( a )
j = 0
while ( j <  n ):
        print( a[ j ] )
        for b in a[ j ]:
                print( b )
        j += 1
```

## Exercise 3: While Loops

- Write a function that:
  - Accepts two lists *a* and *b*
  - Returns the sum of a[ j ]*b[ j ] for all elements j in a and b.
  - Replaces b[ j ] with b[ j ]*a[ j ] as a *side effect*
  - a and b should have the same length – if not, return a NoneType
- Be sure to use while loops

```
while (expr):
        statement 1
        statement 2, etc.
```

# Enumerate



```
for j , v  in enumerate(expr):
    statement 1
    statement 2, etc.
```

For each element in expr:

- Assign its value to v
- Assign a value of 0 through len(expr)-1 to j
- Execute statements in loop body

## Enumeration Example

- Try this:

```
a = [ ‘John’ , 45.0 , 85 ]
for j, v in enumerate(a):
        print( j, v )
```

# Exercise 4: Enumerate

- Write a function that:
  - Accepts a single parameter, assumed to be a list of string values
  - Returns a list of string values with their element index appended.
  - For example:
    - Input = [ ‘Hello’ , ‘There’]
    - Return value = [‘Hello 0’, ‘There 1’]
- Be sure to use enumerate

```
for j , v  in enumerate(expr):
             statement 1
             statement 2, etc.
```

## Exercise 5

- Use a loop and the id function to print the difference in memory addresses between each consecutive pair integers 0 through 260.

- E.g., id(1) – id(0);  id(2) – id(1), etc.
- What do you notice?
- Try doing it backwards.  Does it make a difference?

## Next Time

- Defining Classes/OO Programming in Python
- Modules