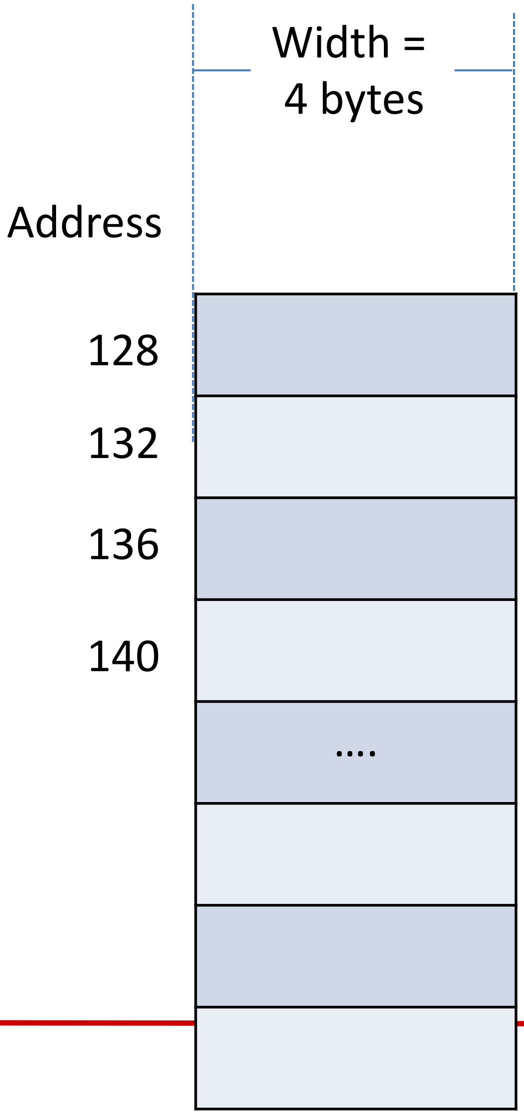
Ceng 111 – Fall 2021
Week 8b

Credit: Some slides are from the “Invitation to Computer Science” book by G. M. Schneider, J. L. Gersting and some from the “Digital Design” book by M. M. Mano and M. D. Ciletti.

Previously on CENG111!

Structured Data

- If you have lots and lots of one type of data (for example, the ages of all the people in Turkey):
  - You can store them into memory consecutively (supported by most PLs)
    - This is called *arrays*.
  - Easy to access an element. Nth element:
    - <Starting-address>+ (N-1)*<Word Width>
    - Ex: 2nd element is at 128 + (2-1) * 4 = 132



Structured Data

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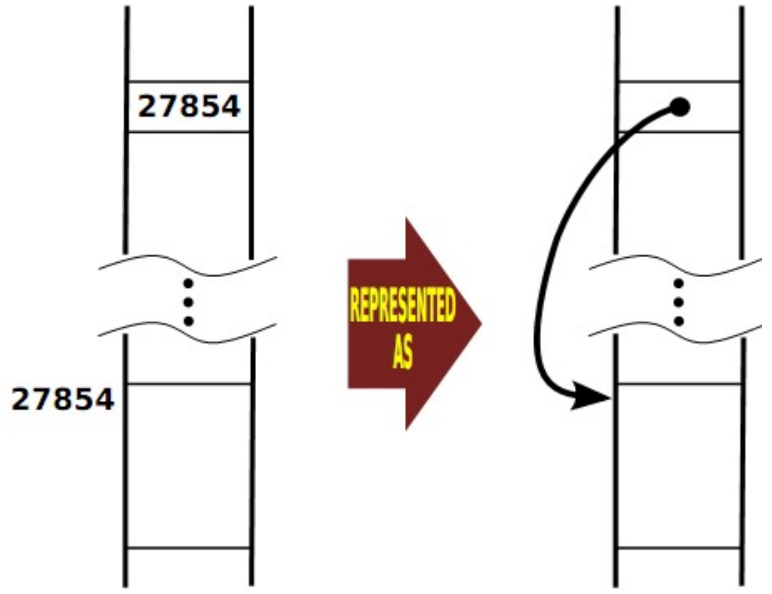
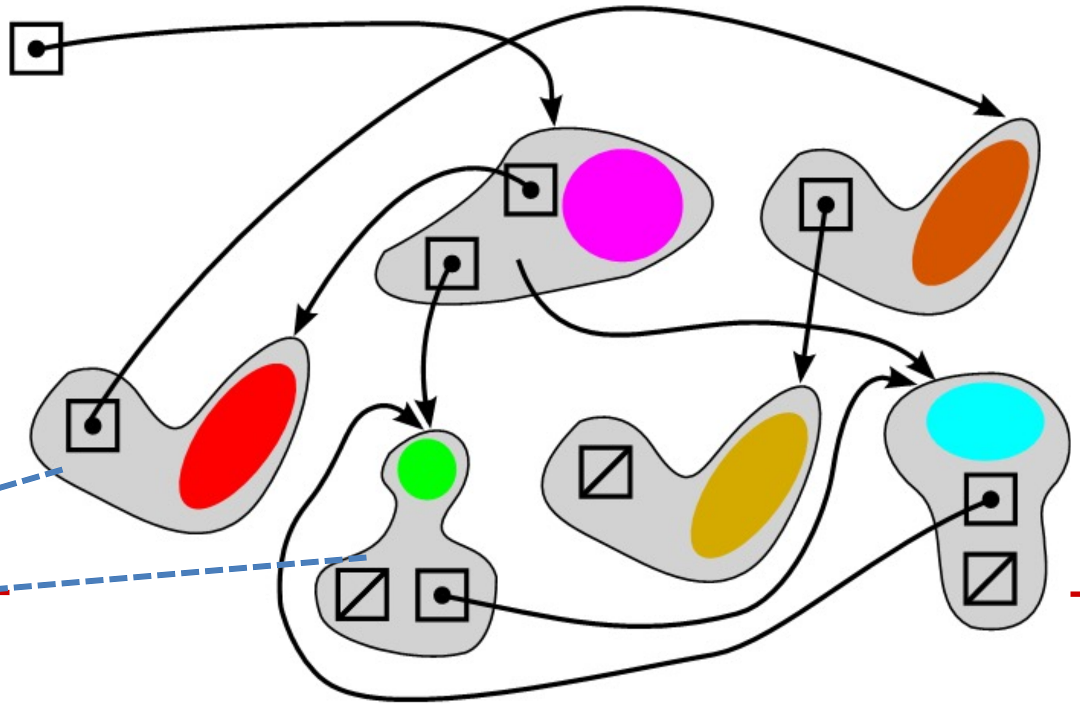
- What if you have to make a lot of deletions and insertions in the middle of an array?
- Then, you have to store your data in blocks/units such that each unit has the starting address of the next unit/block.





Blocks of Data

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Strings

- Sequence of characters:
  - Ex: “Book”, “Programming”, “Python”
- How can they be represented?
  1. Put a set of characters one after the other and end them with a non-character value.
  2. At the beginning of the characters, specify how many characters follow.
- Both have advantages and disadvantages.

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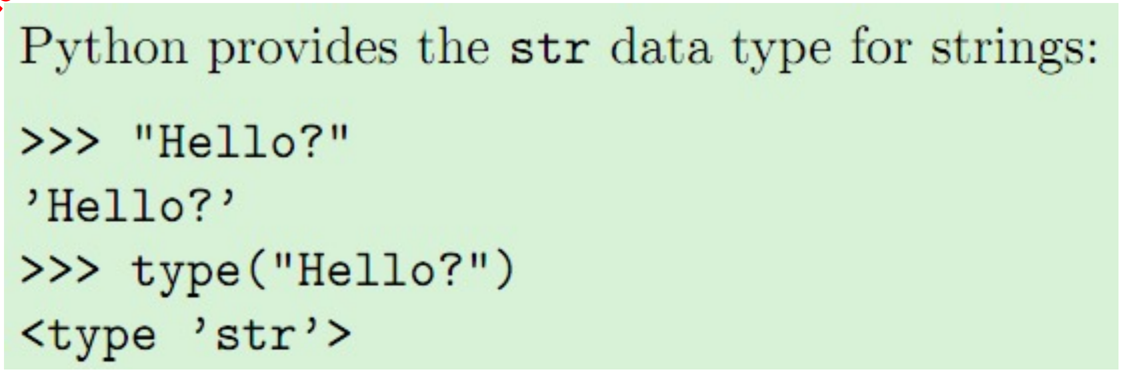
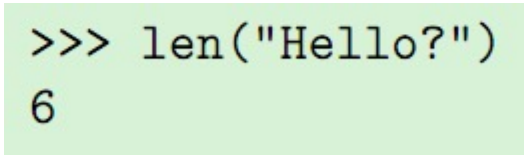
Strings in Python


Python provides the str data type for strings:

```
>>> "Hello?"
'Hello?'
>>> type("Hello?")
<type 'str'>
```

- Simplest operation with a string:


```
>>> len("Hello?")
6
```

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Strings in Python

- Accessing elements of a string
  “Hello?”[0] → 1st character (i.e., “H”)
  “Hello?”[4] → 5th character
- Indexing starts at 0!!!
- What is the last element then?
  - “Hello?”[len(“Hello?”) - 1]
- Negative indexing possible:
  - Last element: “Hello?”[-1] → “?”
- In general:
  - String[start:end:step]
  - Ex: “Hello?”[0:4:2] → “Hl”
  - Ex: “Hello?”[2:4] → “ll”

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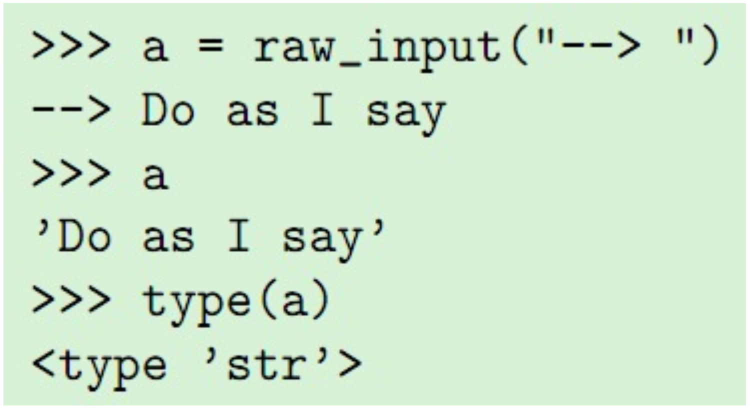
Creating Strings in Python

1. Enclosing a set of characters between quotes:
   - “ali”, “veli”, “deli”, …
2. Using the str() function:
   - str(4.5) → “4.5”
3. Using the raw_input() function:



```
>>> a = raw_input("--> ")
--> Do as I say
>>> a
'Do as I say'
>>> type(a)
<type 'str'>
```

Previously on CENG111!

Internal of Python’s String Implementation

(taken from https://www.laurentluce.com/posts/python-string-objects-implementation/)

- PyStringObject structure
  - “A string object in Python is represented internally by the structure PyStringObject. “ob_shash” is the hash of the string if calculated. “ob_sval” contains the string of size “ob_size”. The string is null terminated. The initial size of “ob_sval” is 1 byte and ob_sval[0] = 0. If you are wondering where “ob_size is defined”, take a look at PyObject_VAR_HEAD in object.h."

```
typedef struct {
    PyObject_VAR_HEAD
    long ob_shash;
    int ob_sstate;
    char ob_sval[1];
} PyStringObject;
```

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Today

- Tuples, Lists

Administrative Notes

- Midterm date:
  - 22 December, Wednesday, 18:00

Tuples

- Tuple: ordered set of data:
  - (1, 2, 3)
  - (“a”, “b”, “c”)
- May be heterogeneous:
  - (“Salary”, 2000, “Age”, 25, “Birth”, “Ankara”)

Tuples in Python

```
>>> (1, 2, 3, 4, "a")
(1, 2, 3, 4, 'a')
>>> type((1, 2, 3, 4, "a"))
<type 'tuple'>
```

- Tuples in Python: collection of data enclosed in parentheses, separated by comma.
- Accessing elements of a tuple (like strings):

- Positive Indexing: `(1, 2, 3, 4, "a")[2]` returns `3`.
- Negative Indexing: `(1, 2, 3, 4, "a")[-1]` returns `'a'`.
- Ranged Indexing, *i.e.*, `[start:end:step]`: `(1, 2, 3, 4, "a")[0:4:2]` leads to `(1, 3)`.

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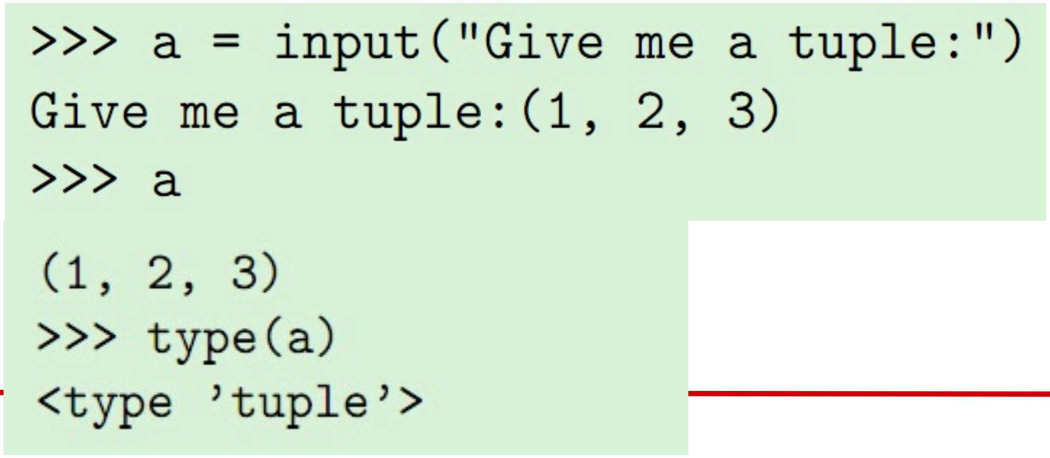
Creating Tuples in Python

1. Enclosing data within parentheses:
   - Ex: (1, “a”, “cde”, 23)
2. Using the tuple() function:
   - Ex: tuple(“ABC”) → (‘A’, ‘B’, ‘C’)
3. Using the input() function:



```
>>> a = input("Give me a tuple:")
Give me a tuple:(1, 2, 3)
>>> a
(1, 2, 3)
>>> type(a)
<type 'tuple'>
```

Lists

- Similar to tuples.
- Difference:
  - Tuples are immutable (i.e., not changeable) whereas lists are mutable.

Lists in Python

```
>>> [1, 2, 3, 4, "a"]
[1, 2, 3, 4, 'a']
>>> type([1, 2, 3, 4, "a"])
<type 'list'>
```

- Lists in Python: collection of data enclosed in brackets, separated by comma.
- Accessing elements of a list (like strings & tuples):

- Positive Indexing: `[1, 2, 3, 4, "a"][2]` returns 3.
- Negative Indexing: `[1, 2, 3, 4, "a"][-1]` returns 'a'.
- Ranged Indexing, *i.e.*, `[start:end:step]`: `[1, 2, 3, 4, "a"][0:4:2]` leads to `[1, 3]`.

Creating Lists in Python

1. Enclosing data within brackets:
   - Ex: [1, “a”, “cde”, 23]
2. Using the list() function:
   - Ex: list(“ABC”) → [‘A’, ‘B’, ‘C’]
3. Using the range() function:

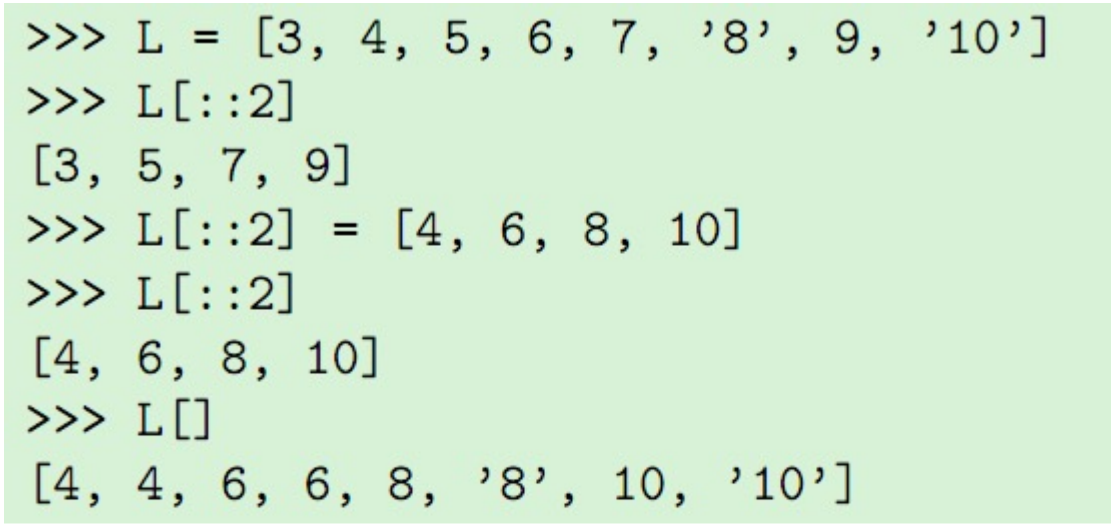
```
range(   [start,] stop[, step])
```

   - Ex: range(1, 10, 2) → [1, 3, 5, 7, 9]
4. Using the input() function:

```
>>> a = input("Give me a list:")
Give me a list:[1, 2, "a"]
>>> a
[1, 2, 'a']
>>> type(a)
<type 'list'>
```

Modifying a List in Python

- List[range] = Data
  - Ex:



```
>>> L = [3, 4, 5, 6, 7, ’8’, 9, ’10’]
>>> L[::2]
[3, 5, 7, 9]
>>> L[::2] = [4, 6, 8, 10]
>>> L[::2]
[4, 6, 8, 10]
>>> L[]
[4, 4, 6, 6, 8, ’8’, 10, ’10’]
```

- Using the append() function:
  - List.append(item)
  - Ex: [1, 2, 3].append(5) → [1, 2, 3, 5]

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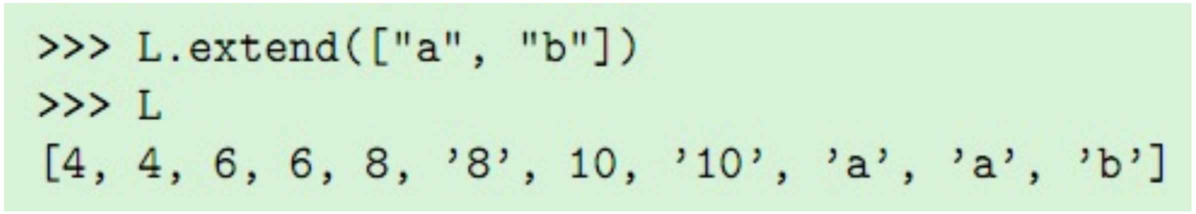
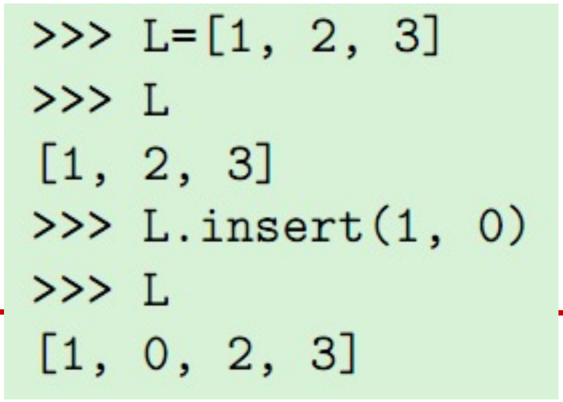
Modifying a List in Python

- Using the extend() function:
  - List.extend(Another_list)
  - Ex: [1, 2, 3].extend([“a”, “b”]) → [1, 2, 3, “a”, “b”]



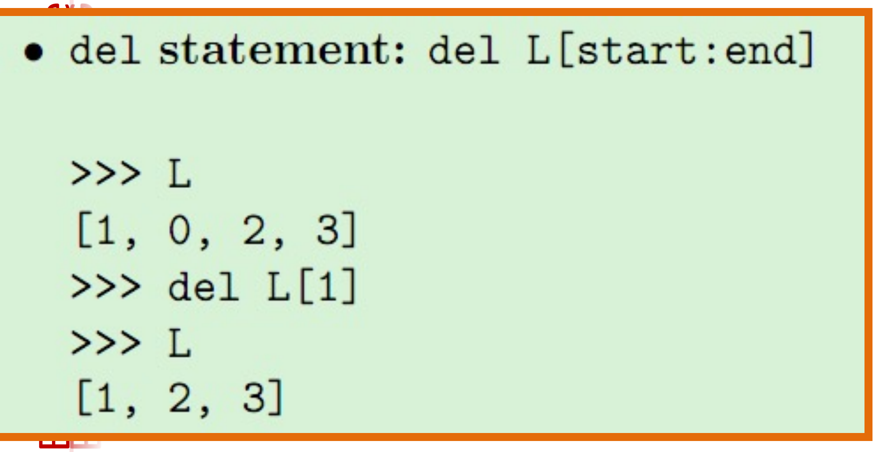
```
>>> L.extend(["a", "b"])
>>> L
[4, 4, 6, 6, 8, '8', 10, '10', 'a', 'a', 'b']
```

- Using the insert() function:
  - List.insert(index, item)



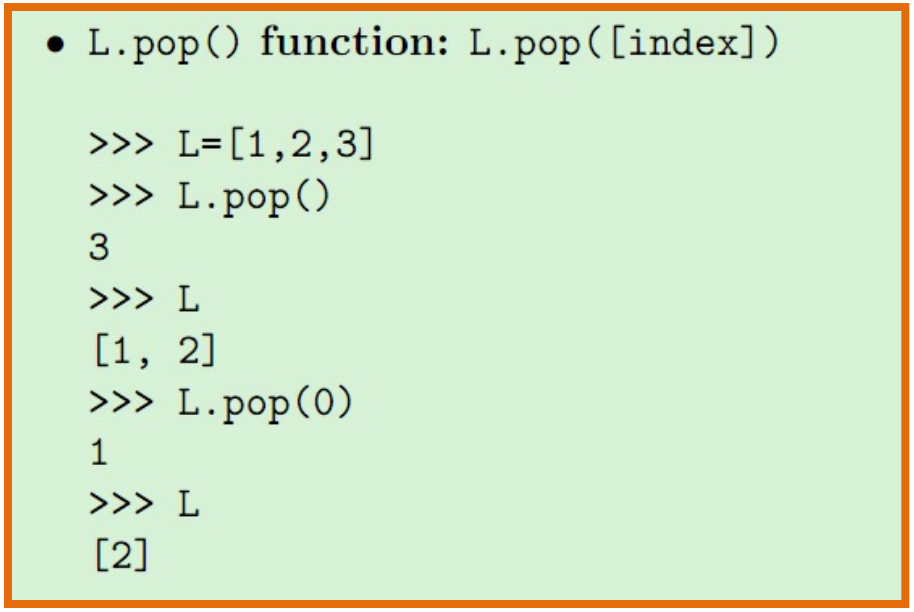
```
>>> L=[1, 2, 3]
>>> L
[1, 2, 3]
>>> L.insert(1, 0)
>>> L
[1, 0, 2, 3]
```

Removing Elements from a List in Python



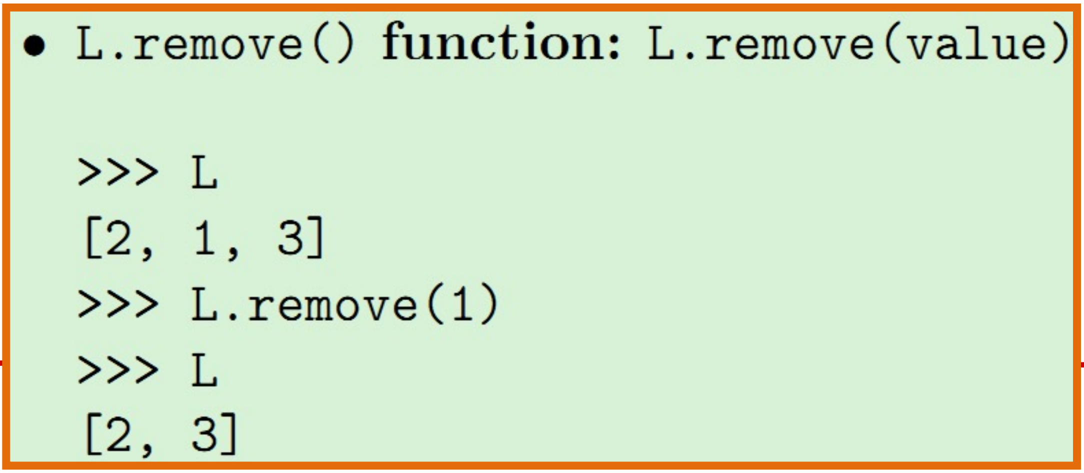
- **del statement:** `del L[start:end]`

```
>>> L
[1, 0, 2, 3]
>>> del L[1]
>>> L
[1, 2, 3]
```



- `L.pop()` **function:** `L.pop([index])`

```
>>> L=[1,2,3]
>>> L.pop()
3
>>> L
[1, 2]
>>> L.pop(0)
1
>>> L
[2]
```



- `L.remove()` **function:** `L.remove(value)`

```
>>> L
[2, 1, 3]
>>> L.remove(1)
>>> L
[2, 3]
```

A frequent operation with containers

- Membership
  - in
  - not in
- “en” in “deneme”
  - True
- “an” in “deneme”
  - False
- “dem” in “deneme”
  - False

Accessing Data/Containers by Names: Variables

- Naming:
  - Usually: A combination of letters and numbers
  - Ex: a123, 123a, …
- Scope & Extent:
  - Scope: Where a variable can be accessed.
  - Extent: The lifetime of a variable.
- Typing:
  - Statically typed: The type of a variable is fixed.
  - Dynamically typed: The type of a variable is variable ☺

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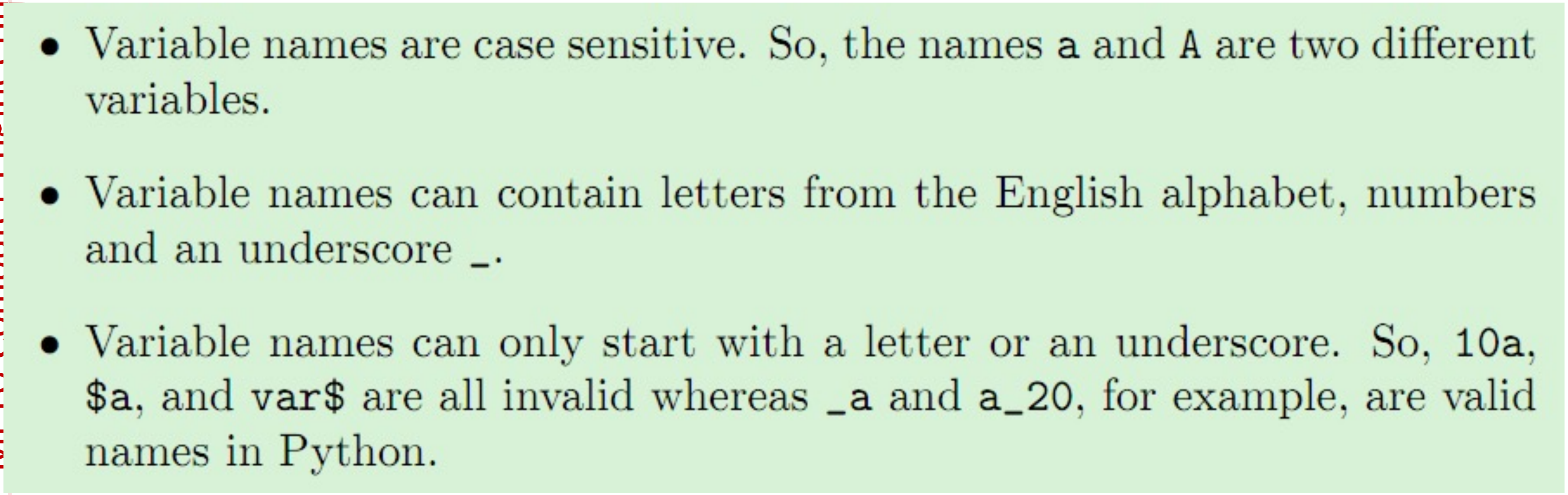
Variables in Python

```
>>> a = 4
>>> b = 3
>>> c = a + b
>>> a
4
>>> b
3
>>> c
7
```

- We don’t need to define a variable before using it.
- We don’t need to specify the type of a variable.

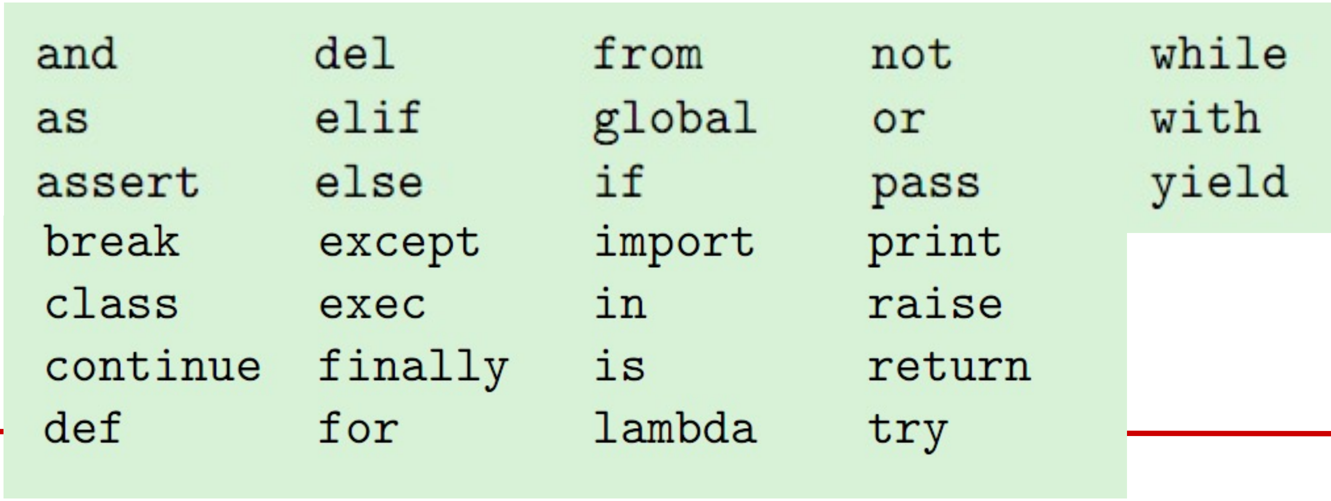
- ‘=‘ means “Change the content of the variable with the value at the right-hand side”.
  - Assignment!
- The left-side of the assignment should be a valid variable name:
  - Ex: a+2 = 5 → NOT VALID!

Variable Naming in Python



- Variable names are case sensitive. So, the names `a` and `A` are two different variables.
- Variable names can contain letters from the English alphabet, numbers and an underscore `_`.
- Variable names can only start with a letter or an underscore. So, `10a`, `$a`, and `var$` are all invalid whereas `_a` and `a_20`, for example, are valid names in Python.

- Variable names cannot be one of the keywords in Python:



and	del	from	not	while
as	elif	global	or	with
assert	else	if	pass	yield
break	except	import	print	
class	exec	in	raise	
continue	finally	is	return	
def	for	lambda	try	

More on Variables in Python

- Typing of variables:
  - Python is dynamically typed:

```
>>> a = 3
>>> type(a)
<type 'int'>
>>> a = 3.4
>>> type(a)
<type 'float'>
```

- Using variables:

```
>>> a = (1, 2, 3, 'a')
>>> type(a)
<type 'tuple'>
>>> a[1]
2
>>> a[-1]
'a'
```

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Variables, Values and Aliasing in Python

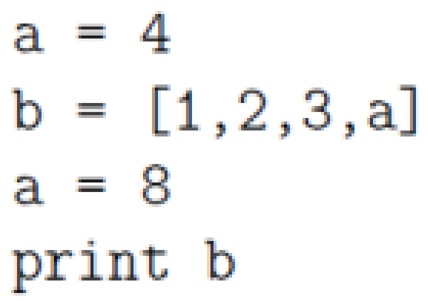
- Every data (whether constant or not) has an identifier (an integer) in Python:

```
>>> a = 1
>>> b = 1
>>> id(1)
135720760
>>> id(a)
135720760
>>> id(b)
135720760
```

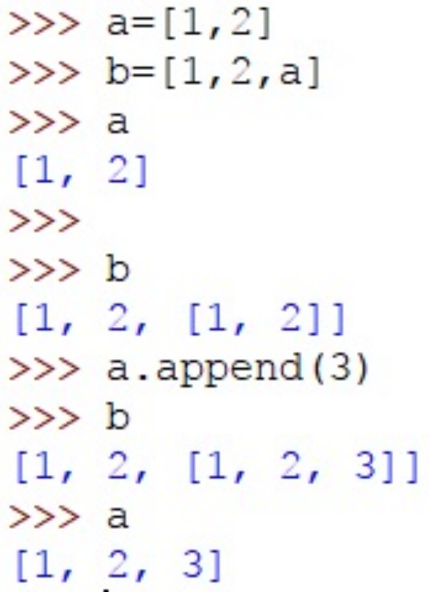
- If the type of the data is mutable, there is a problem!!!

```
>>> a = ['a', 'b']
>>> b = a
>>> id(a)
3083374316L
>>> id(b)
3083374316L
>>> b[0] = 0
>>> a
[0, 'b']
```

This is called Aliasing.



```
a = 4
b = [1,2,3,a]
a = 8
print b
```



```
>>> a=[1,2]
>>> b=[1,2,a]
>>> a
[1, 2]
>>>
>>> b
[1, 2, [1, 2]]
>>> a.append(3)
>>> b
[1, 2, [1, 2, 3]]
>>> a
[1, 2, 3]
```

- Check id(a) and id(b[3])

How to make copy of the list?

- list(List-to-be-copied)
- L[:]
- Shallow copy

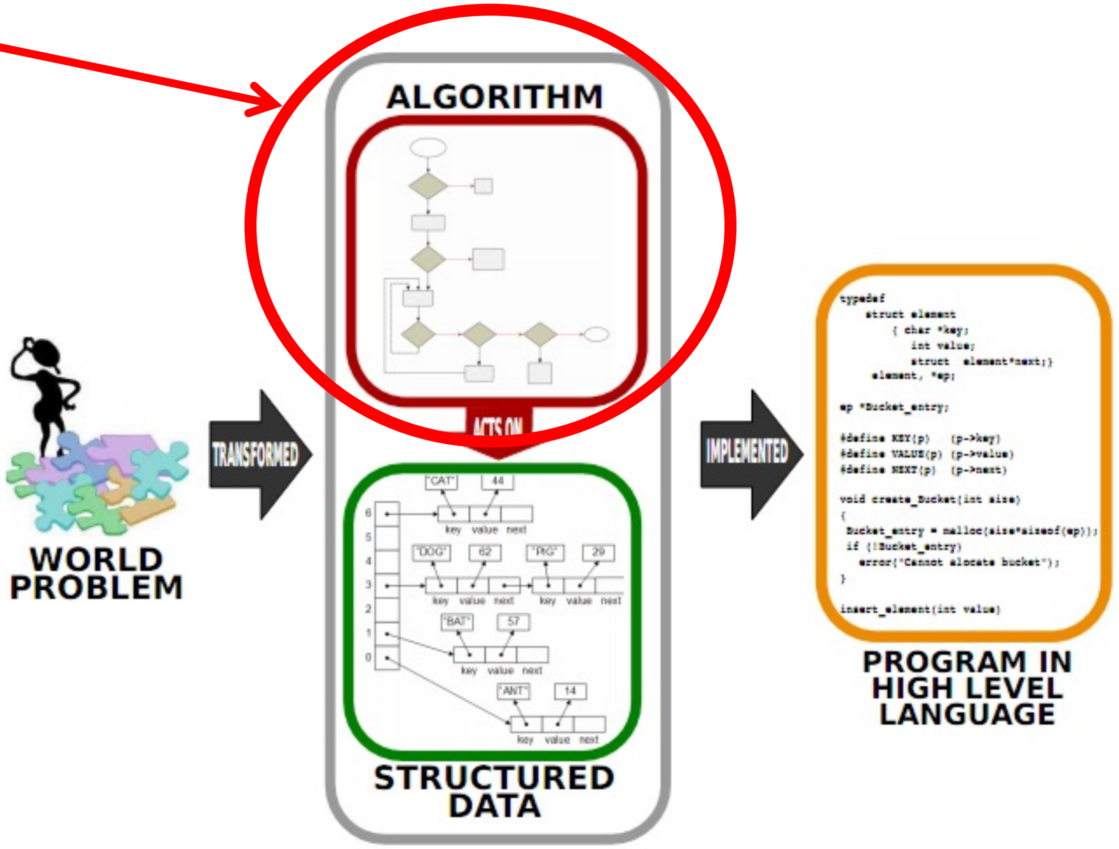
```
import copy
copy.copy(list)
```

- Deep copy

```
import copy
copy.deepcopy(list)
```

Now

- We start another ingredient of a program:
  - Actions!



```
typedef
    struct element
        { char *key;
          int value;
          struct  element*next;}
     element, *ep;

ep *Bucket_entry;

#define KEY(p)   (p->key)
#define VALUE(p) (p->value)
#define NEXT(p)  (p->next)

void create_Bucket(int size)
{
 Bucket_entry = malloc(size*sizeof(ep));
 if (!Bucket_entry)
   error("Cannot alocate bucket");
}

insert_element(int value)
```

What are actions?

- Actions in a PL are the *things* that we can do with the data. What could they be?
  - Create data or modify data
  - Interact with the external environment

Actions for creating/modifying data

- Evaluating a mathematical expression
  - But there are differences to the expressions in Mathematics
- Working with structured data
- Storing results of computations (in another data)
- Making a decision about how to proceed with the computation

  – `if x*y < 3.1415 then` ⟨*do some action*⟩
  – `if "ali" in class_111_list then` ⟨*do some action*⟩
  – `if tall("ali") then` ⟨*do some action*⟩

Interaction-type actions

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- "Interaction" means Input/Output.
- Why interact with the environment? Why do we have Input/Output actions?
  - To react on a change in the external environment
  - To produce an effect in the external environment

Action Types in High-Level Languages

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- Expression evaluation
  - 3 + 4 * 5 / 2

vs.

- Statement execution
  - del L[2:4]