15-110 Principles of Computing – F21

Lecture 11:
Lists 1

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Terminology: Scalar vs. Non-Scalar objects

An object type can be:

- **Composite** → made of multiple components,
- Or be **indivisible**

In python this difference is expressed in terms of:

- Scalar type (e.g., `1, 3.5, False`)
- Non-scalar (~vector) type (e.g., `'Toyota', [3, 5, 7]`)

Vs.

- ✓ **Scalar**: the object is indivisible
- ✓ **Non-scalar**: the object is composed by multiple parts that can be individually manipulated (accessed, modified, removed, added)

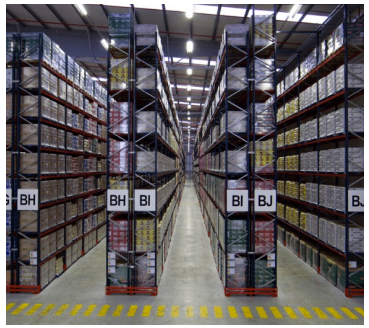
E.g., in the string `'Toyota'` I can access and modify the first and last letter to get `'Coyote'`

Data structures

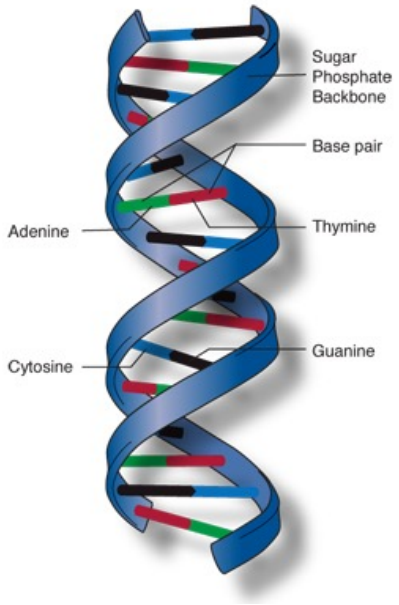
- **Data structure: Container used to to store data (information) in a specific organized form, a *layout***

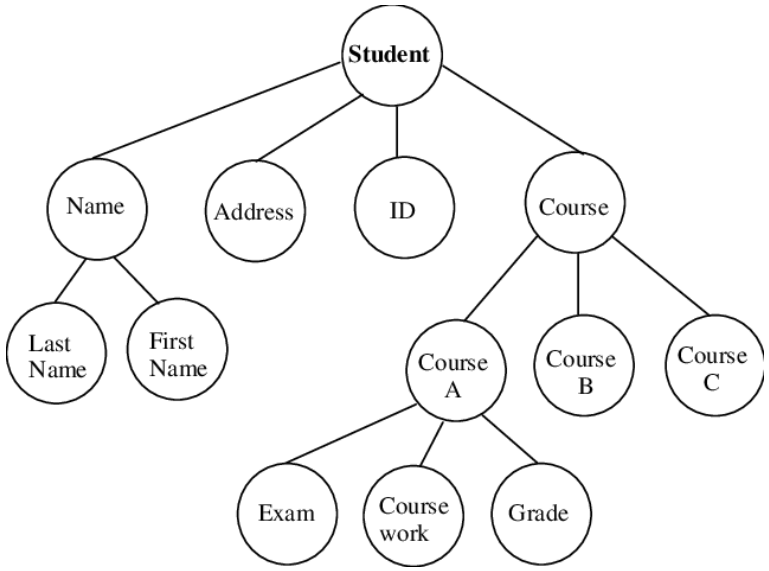
- A given *layout* determines a data structure to be efficient in some operations and/or effective in the representation of parts of information, and maybe inefficient / ineffective in others

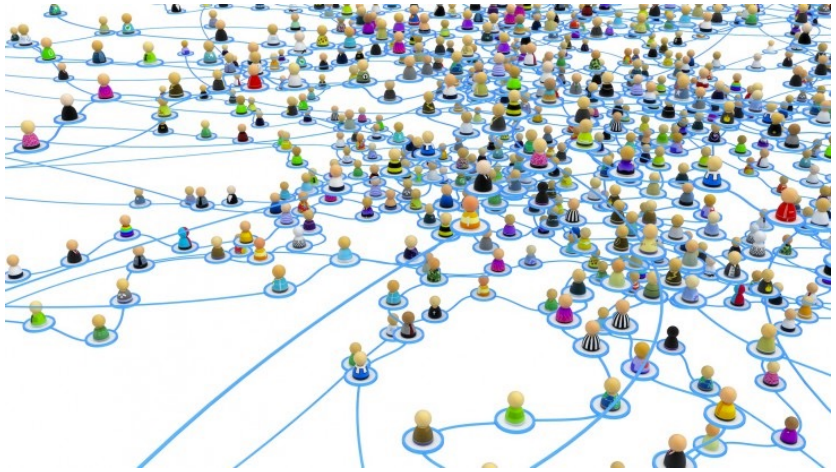
- → The layout affects how we *access / find / change / add / remove / sort/ organize* data



Data structures





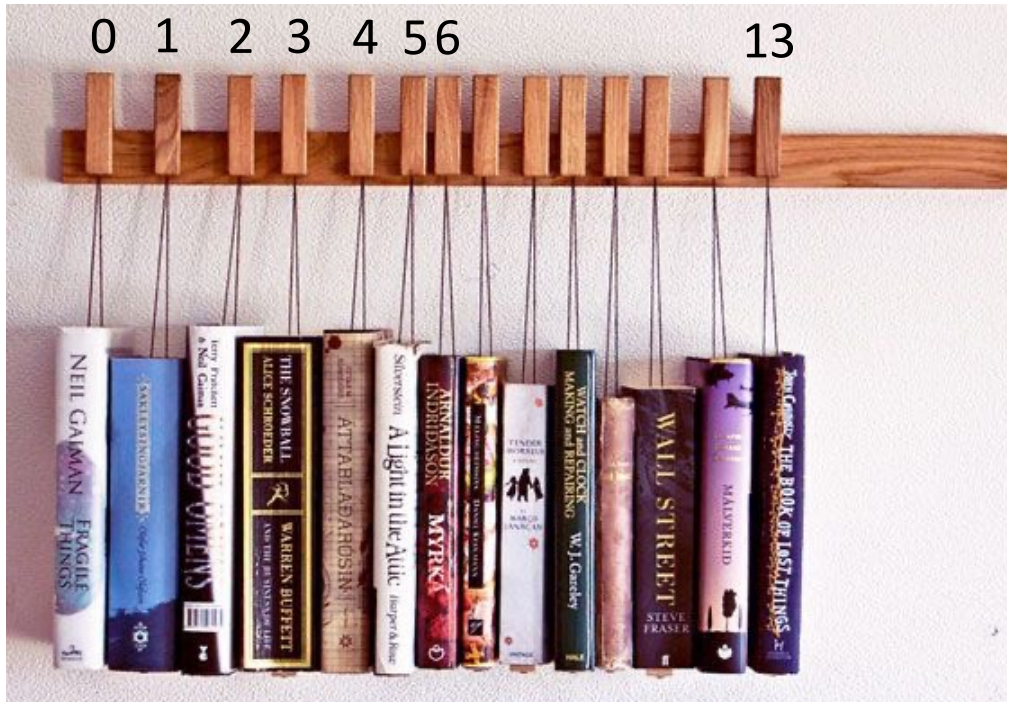


List data structure: basic operations

- List data structure: a container for a **list of *objects*,**
  - ✓ Each object is placed at a defined **position** in the list
    → List elements are **ordered** by their position

A list of books

Each book is at a unique position in the list



I can access my list of books in various ways:

- Retrieve the book at *position 11*
- Retrieve the book *Wall Street*
- Which book is at position 5?
- Is *Harry Potter* in the list?
- How many books are in the list?
- Is there any empty space in the list rack?

List data type in python

- **List:** (non-scalar type) ordered **sequence** of *objects* (any type, not need same type)
  - Purpose: *group* items together in the same object
  - **Syntax:** `[a, b, c, …, ]`

➢ Examples of list variables assigned with list literals

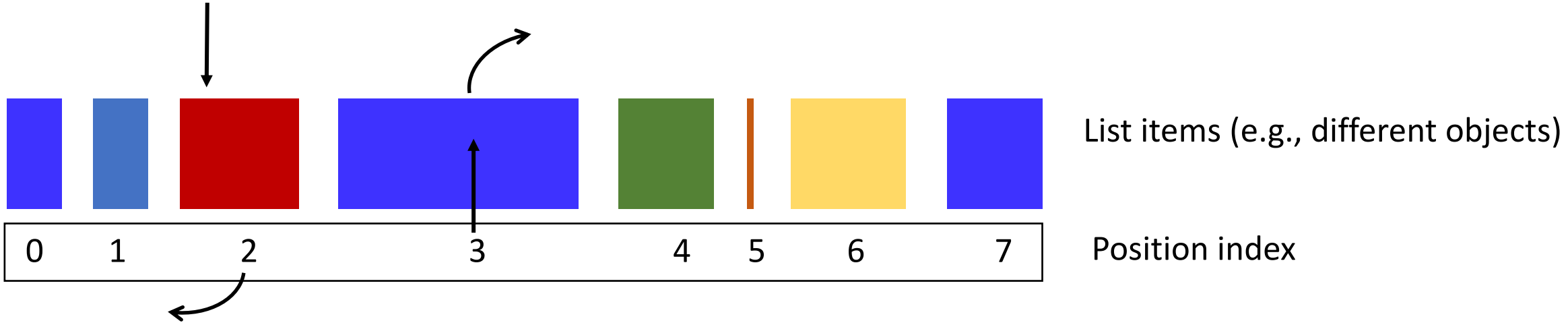
```
prime_numbers = [3, 5, 7, 11]

irrational_numbers = [2.71828, 3.14159, 1.41421]

fruits = ['apple', 'pear', 'banana', 'orange']

person_info = ['Donald', 'Trump', 14, 'June', 1946, 'President']

fruit_info = ['melon', 3.6, 'yellow', 12.5]

logical_values = [True, False, True, 255]
```

List data type in python

- Examples of list variables assigned with list literals

```
empty_list = []

one_element_list = [5]
one_element_list = [5,]

list_of_lists = [1, 'sedan', ['Toyota', 'Corolla', 1.8, 2012], 52000]
```

Basic operations in a list: access / read data

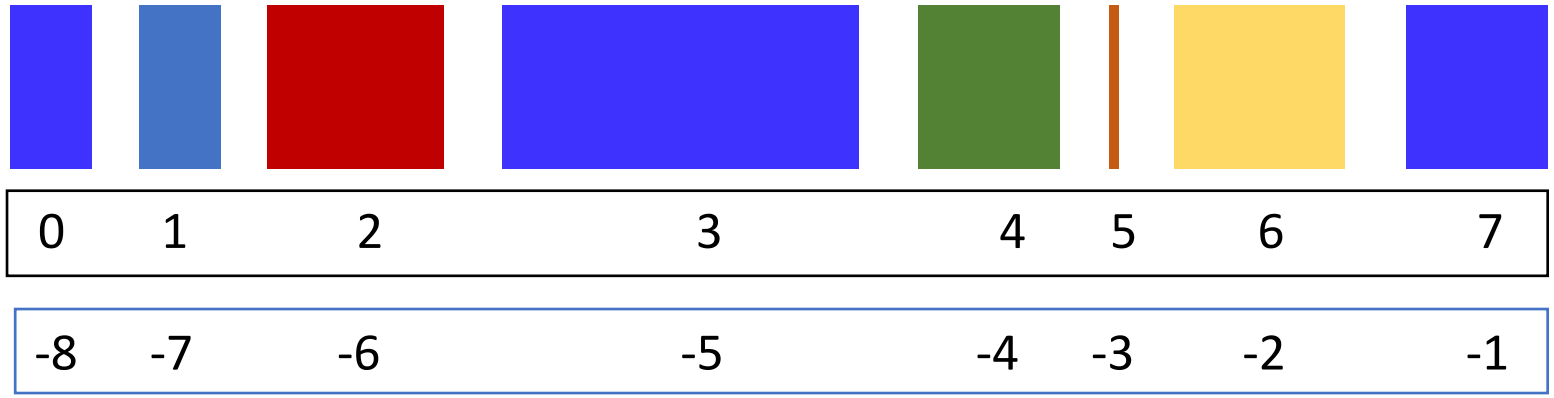


- **Access (read) operations**, at any position:
  - get data by index (in 2 steps time)
  - find data / index by content (linear number steps for scanning the list)

Basic operations in a list: access / read data with [], [:], [::]

- **Syntax**, for a list variable `L`
  - *Single* list element: `L[index]`
  - *Subsequence* of list elements: `L[from : to]`
  - *Subsequence with a stride*: `L[from : to : step]`

Like `range()`!



List items (e.g., different objects)

+ve Position index: $0 \rightarrow n-1$

-ve Position index: $-1 \rightarrow -n$

Basic operations in a list: access single elements with []

- **Syntax**, for a list variable `L`
  - *Single* list element: `L[index]`
  - Index can be positive or negative, or 0

```
prime_numbers = [3, 5, 7, 11, 13]
even_numbers = [2, 4, 6, 8, 10]
mix = [-1, 'Hello!', True, 10, 9, 'another string', False]
```

```
x = prime_numbers[0]      → x is of type int and has value 3
x = even_numbers[2]       → x is of type int and has value 6
x = prime_numbers[-3]     → x is of type int and has value 7
x = mix[1]                → x is of type str and has value 'Hello!'
x = mix[2]                → x is of type bool and has value True
```

Basic operations in a list: access subsequences (*slicing*) [:]

- **Syntax**, for a list variable `L`
  - *Subsequence* of list elements: `L[from : to]`

```
prime_numbers = [3, 5, 7, 11, 13]
even_numbers = [2, 4, 6, 8, 10]
mix = [-1, 'Hello!', True, 10, 9, 'another string', False]
```

```
x = prime_numbers[0:3]    → x is of type list and has value [3,5,7]
x = even_numbers[2:4]     → x is of type list and has value [6,8]
x = prime_numbers[-3:-4]  → x is of type list and has value [ ]
x = mix[1:4]              → x is of type list and has value ['Hello! ', True, 10]
x = mix[2:10]             → x is of type list and has value [True, 10, 9, 'another string', False]
```

Basic operations in a list: slicing with a stride [: :]

- **Syntax**, for a list variable `L`
  - *Subsequence with a stride*: `L[from : to : step]`

```
prime_numbers = [3, 5, 7, 11, 13]
even_numbers = [2, 4, 6, 8, 10]
mix = [-1, 'Hello!', True, 10, 9, 'another string', False]
```

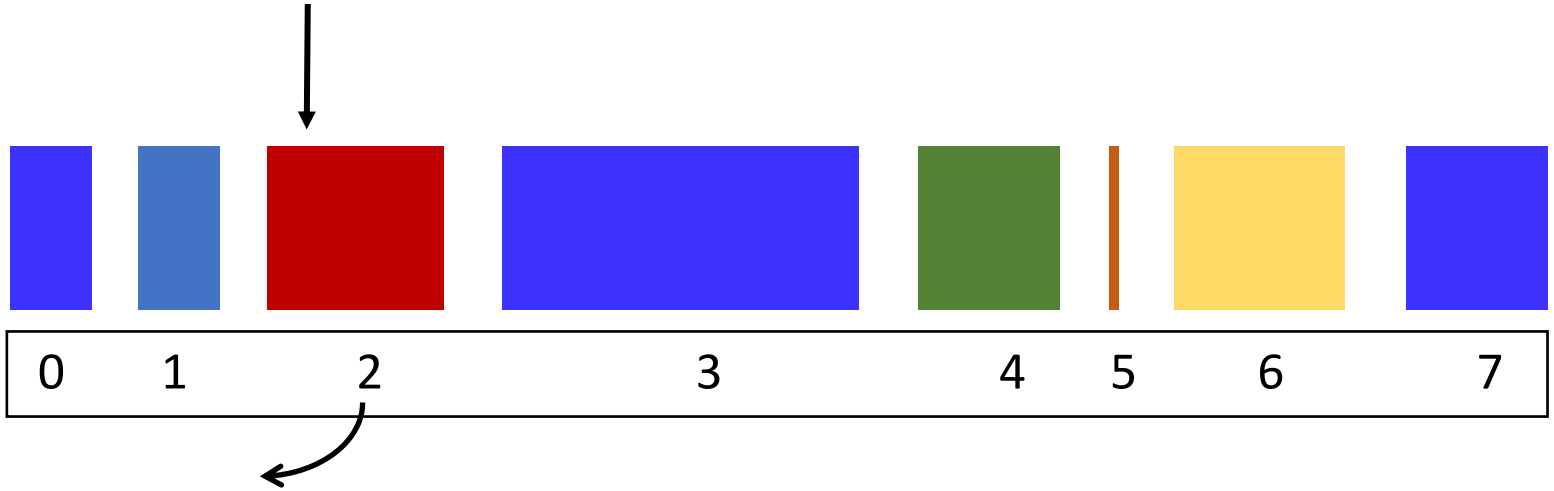
```
x = prime_numbers[0:3:2]        → x is of type list and has value [3,7]
x = even_numbers[2:4:5]         → x is of type list and has value [6]
x = prime_numbers[-1:-3:-1]     → x is of type list and has value [13, 11]
x = mix[1:4:1]                  → x is of type list and has value ['Hello!', True, 10]
x = mix[2:10:3]                 → x is of type list and has value [True, 'another string',]
```

Length of a list

- `len(L)` function, that returns an integer value equal to the number of elements in the list

```
x = len([3, 5, 7, 11, 13])

even_numbers = [2, 4, 6, 8, 10, 12, 14]
x = len(even_numbers)

mix = [-1, 'Hello!', True, 10, 9, 'another string', False]
x = len(mix)

x = len([])

x = len([mix[0]])

x = len(mix[0])

mix = [2, 3, [5, 7, 9], 11 ]
x = len(mix)
```

Finding data by content



List items (e.g., different objects)

Position index

- **Access (read) operations**, at any position:
  - get data by index (in 2 steps time)
  - find data / index by content (linear number steps for scanning the list)

Is that content in the list? If it does, where is it?

Checking presence with membership operators: `in`, `not in`

- Operator `in`: **Membership**, returns `True` if item belongs to the list, `False` otherwise

```
prime_numbers = [3, 5, 7, 11]
is_prime = 5 in prime_numbers
```

→ new `bool` variable with value `True`

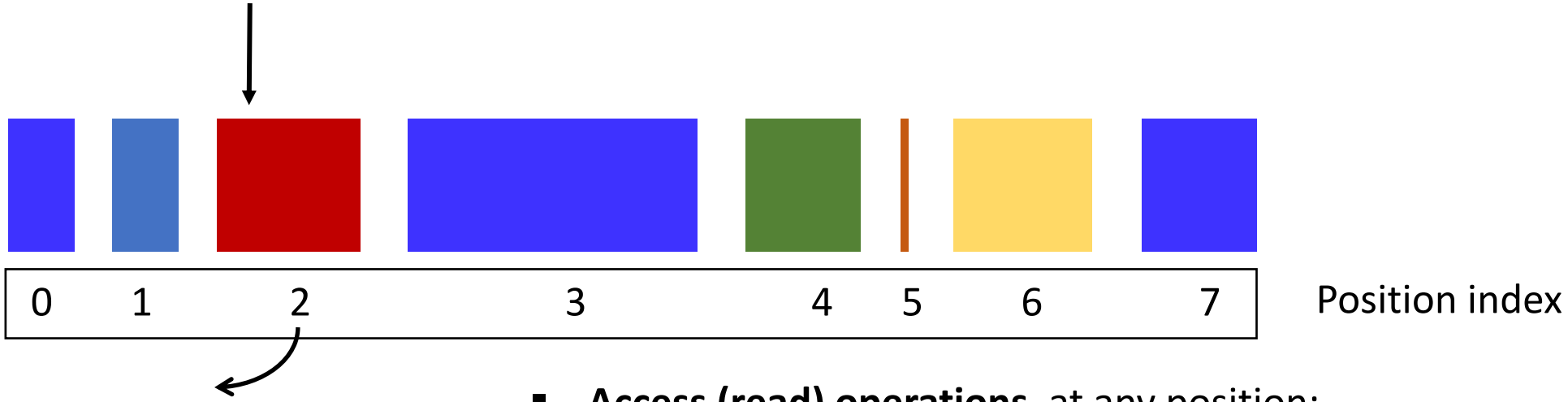
```
n = 15
if (n in prime_numbers):
     print(n, 'is a prime number!')
else:
    print(n, 'is not a prime number')
```

- Operator `not in`: **Membership**, returns `False` if item belongs to the list, `True` otherwise

```
prime_numbers = [3, 5, 7, 11]
is_prime = 5 not in prime_numbers
```

→ new `bool` variable with value `False`

Finding where an element is: `.index()`



- **Access (read) operations**, at any position:
  - get data by index (in 2 steps time)
  - find data / index by content

❖ `L.index(item)` method: return the position index of `item` in list `L`

```
L = [1, 4, 7, 0, 9]
x = L.index(7)
```

→ x has value 2

```
L = [1, 4, 7, 0, 9]
x = L.index(10)
```

→ Value Error!

Finding where an element is: `.index()` + `in`

```
L = [1, 4, 7, 0, 9]
x = L.index(10)
```

To avoid to crash the program with an error check first with `in`:

```
n = 15
if (n in L):
      pos = L.index(n)
      print(n, 'is at position:', pos)
else:
    print(n, 'is not a value in the list')
```

Modify an existing list

- Address the elements to modify using the [ ] operator and change / reassign their value

```
L = [1, 4, 7, 0, 9]
L[2] = -1
```

→ L is `[1, 4, -1, 0, 9]`

```
L = [1, 4, 7, 0, 9]
L[1] = 'Doha'
```

→ L is `[1, 'Doha', -1, 0, 9]`

```
L = [1, 4, 7, 0, 9]
L[10] = 'Doha'
```

→ Index Error!

Lists of lists

- A list can include elements that are lists (or tuples) → List of lists/tuples

```
L = [ [11,12,13], [21,22,23], [31,32,33], 99, (1,2,3) ]
```

What is the **length** of the list `L`? → `len(L)` → 5

`L[1]` ? → `[21, 22, 23]`

How do we access the third element of of the list `L[1]`?

Using the indexing operator, `[ ]` ! → `L[1][2]`

How do we access the second element of of the tuple `L[2]`? → `L[2][1]` → 32

Looping over a list: directly looping over the elements of the list

✓ A list is a … Sequence!

```
L = [2, 3, 6, -1, 6, 8]
pos_index = 0
for v in L:
    print('List element at position', pos_index, 'has value', v)
    pos_index += 1
```

→ List element at position 0 has value 2
List element at position 1 has value 3
List element at position 2 has value 6
List element at position 3 has value -1
List element at position 4 has value 6
List element at position 5 has value 8

Looping over a list: looping over the indices the list

✓ A list is a ... Sequence!

```
L = [2, 3, 6, -1, 6, 8]
for i in range( len(L) ):
    print('List element at position', i,
          'has value', L[i])
```

→
```
List element at position 0 has value 2
List element at position 1 has value 3
List element at position 2 has value 6
List element at position 3 has value -1
List element at position 4 has value 6
List element at position 5 has value 8
```

`range( len(L) )` generates the list with all the indices for the elements of L

`len(L)` is 6

`range(6)` is `[0,1,2,3,4,5]`