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Loops and lists

Foundation of programming (CK0030)

Francesco Corona

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FdP

- ☻ Intro to variables, objects, modules, and text formatting
- ☹ **Programming with WHILE- and FOR-loops, and lists**
- ☹ Functions and IF-ELSE tests

- ☹ Data reading and writing
- ☹ Error handling
- ☹ Making modules

- ☹ Arrays and array computing
- ☹ Plotting curves and surfaces

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Alternative implementations

Usually, there are alternative ways to write code that solves a problem

- We explore alternative constructs and programs
- Store numbers in lists and print out tables

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WHILE loops as FOR loops

Alternative implementations

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WHILE loops as FOR loops

Definition

Any `FOR-loop` can be implemented as a `WHILE-loop`

Consider the general piece of code

```
for element in somelist:
 <process element>
```

It can be re-written

```
index = 0

while index < len(somelist):
 element = somelist[index]
 <process element>
 index += 1
```

■

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Example

Printout of the Celsius-Fahrenheit table of temperatures

```
Cdegrees = [-20,-15,-10,-5,0,5,10,15,20,25,30,35,40]

print '    C      F'

index = 0
while index < len(Cdegrees):
 C = Cdegrees[index]
 F = (9.0/5)*C + 32
 print '%5d %5.1f' % (C, F)
 index += 1
```

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```
Cdegrees = [-20,-15,-10,-5,0,5,10,15,20,25,30,35,40]

print '    C      F'

for C in Cdegrees:
 F = (9.0/5)*C + 32
 print '%5d %5.1f' % (C, F)
```

```
C = -20
dC = 5

while C <= 40:
 F = (9.0/5)*C + 32
 print C, F
 C = C + dC
```

■

Range construction

Alternative implementations

Range construction

It is often tedious to manually type the many elements in `Cdegrees`

- We should use a loop to automate the list construction

```
C_value = -50
C_max = 200
Cdegrees = []

while C_value <= C_max:
 Cdegrees.append(C_value)
 C_value += 2.5                          # C_value = C_value + 2.5
```

The **range construction** is a particularly useful tool for the task

Range construction (cont.)

Definition

range(n)

range(n) generates a `list` of sequential integers in $[0, n-1]$

- *(Integer n is not included)*

$\leadsto$ *0, 1, 2, . . . , n-1*

range(start, stop, step) generates a list of integers in a sequence

$\leadsto$ *start, start + (1*step), start + (2*step) up to stop*

- *(stop is not included)*

range(start, stop) is the same as range(start, stop, 1)

$\leadsto$ *start, start + (1*1), start + (2*1) up to stop*

- *(That is, step = 1)*

Range construction (cont.)

Things to remember

In Python 2.x, function `range(n)` returns a `list object`

In Python 3.x, function `range(n)` returns a `range object`

- A `range object` can be converted to a `list object`

$\leadsto$ `list(range(n))`

This exists in Python 2.x as function `xrange(n)`

Range construction (cont.)

Example

Consider the following examples

`range(2, 8, 3)`

- The output

⤳ `2`

⤳ `2 + (1*3) = 5` (but not `8 = 2 + (2*3)`)

`range(1, 11, 2)`

- The output

⤳ `1`

⤳ `3 = 1 + (1*2)`

⤳ `5 = 1 + (2*2)`

⤳ `7 = 1 + (3*2)`

⤳ `9 = 1 + (4*2)`

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Range construction (cont.)

A `FOR-loop` over the `list` (object) of integers (type `int` objects) from `range`

```
for i in range(start, stop, step):
 ...                                          # Some operation on element
                                              # <Process element>
```

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Range construction (cont.)

Example

We use `range` to create a list `Cdegrees` with values `[-20,-15,...,35,40]`

- Two ways (with and without a loop)

```
Cdegrees = []                              # Create empty list to be filled

for C in range(-20, 45, 5):                #     Pick element C from a list
 Cdegrees.append(C)                        #         of sequential integers

                                           # Element C, inside the FOR loop
                                           # 1st element: -20
                                           # 2nd element: -20 + (1*5) = -15
                                           # 3rd element: -20 + (2*5) = -10
                                           # ...
```

```
Cdegrees = range(-20, 45, 5)
```

To include integer 40, the upper limit must be greater than 40

⤳ This is important

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Range construction (cont.)

Example

Suppose that now we want to create a slightly different `Cdegrees` list

- `[-10, -7.5, -5, ..., 35, 37.5 ,40]`
- The spacing between entries is 2.5
- The entries are real numbers

We cannot use `range` directly, we must adapt its use

⤳ `range(-10, 45, 2.5)` would give an error

⤳ `range` can only create integers

⤳ We have decimal degrees

Range construction (cont.)

We must introduce an **integer counter** `i` generate by function `range`

- We generate `C` values by $C = -10 + \underbrace{i}_{\uparrow} \cdot 2.5$, $i = 0, 1, 2, \ldots, 20$

```python
Cdegrees = []

for i in range(0, 21):                # Generate a range of integers
 C = -10 + i*2.5                      #       Element i is used here
 Cdegrees.append(C)
```

■

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FOR loops with list indexes

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FOR-loops with list indexes

Consider an alternative to iterating over (the elements of) a list directly

```python
for element in somelist:
 ...                                   # Some operation on element
 ...                                   #          <Process element>
```

We can iterate over list indices and then index the list inside the loop

```python
for i in range(len(somelist)):
 element = somelist[i]
 ...                                   # Some operation on element
 ...                                   #          <Process element>
```

`len(somelist)` returns the length of `somelist`

⇝ Indices start at `0`, the largest valid index is `len(somelist)-1`

⇝ `range(len(somelist))` is `[0, 1, ..., len(somelist)-1]`

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FOR loops with list indexes (cont.)

Iterating over loop indices is often a useful programming practice

- An example is when we need to process two lists
- (At the same time)

FOR loops with list indexes (cont.)

Example

Suppose that we want to create two lists, `Cdegrees` and `Fdegrees`

Then, suppose that we want to use the two lists to write a table

- The table must have `Cdegrees` and `Fdegrees` as columns

```
n = 21
C_min = -10; C_max = 40                              # Min and max value of C
dC = (C_max - C_min)/float(n-1)                      #          Increment in C


Cdegrees = []                                        #        Build the C list
for i in range(0, n):                                #         Initially empty
 C = -10 + i*dC
 Cdegrees.append(C)


Fdegrees = []                                        #        Build the F list
for C in Cdegrees:                                   #         Initially empty
 F = (9.0/5)*C + 32
 Fdegrees.append(F)


for i in range(len(Cdegrees)):                       #  Print the joint table
 C = Cdegrees[i]                                     #      Loop over indexes
 F = Fdegrees[i]                                     #      Loop over indexes
 print '%5.1f %5.1f' % (C, F)
```

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FOR loops with list indexes (cont.)

In the example, we started with empty lists then appended new elements

We can start with lists of correct size, containing, say, zeros

- Then, we index the lists to fill in actual values

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FOR loops with list indexes (cont.)

Definition

A list of zeros

How to create a list of length n consisting of zeros

```
somelist = [0]*n
```

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FOR loops with list indexes (cont.)

Example

```
n = 21
C_min = -10                                #                  Min value of C
C_max = +40                                #                  Max value of C
dC = (C_max - C_min)/float(n-1)            #                  Increment in C


Cdegrees = [0]*n                           # Cdegrees must be of correct length
for i in range(len(Cdegrees)):             #             Initially full of zeros
 Cdegrees[i] = -10 + i*dC


Fdegrees = [0]*n                           # Fdegrees must be of correct length
for i in range(len(Cdegrees)):             #             Initially full of zeros
 Fdegrees[i] = (9.0/5)*Cdegrees[i] + 32


for i in range(len(Cdegrees)):
 print '%5.1f %5.1f' % (Cdegrees[i], Fdegrees[i])
```

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Modify list elements

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Modify list elements

Consider some list of temperature values accessible with name `Cdegrees`

Suppose that we want to change the value of each of its elements

- We want to add `5` (degrees)

```
n = 21; C_min = -10; C_max = 40
dC = (C_max - C_min)/float(n-1)

Cdegrees = []
for i in range(0, n):
 C = -10 + i*dC
 Cdegrees.append(C)

for i in range(len(Cdegrees)):
 Cdegrees[i] += 5                    # Adjust the i-th element to be equal
                                     #                  to itself plus five
```

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Modify list elements (cont.)

Things that do NOT work

```
for c in Cdegrees:
 c += 5
```

```
...
c = Cdegrees[0]                  # Automatically done in a FOR statement
c += 5

c = Cdegrees[1]                  # Automatically done in a FOR statement
c += 5
...
```

Variable `c` can only be used to read list elements

⇝ It does not change them

⇝ Only `c` is changed

Things that DO work

Remark

To change a list element, `Cdegrees[i]`, an assignment must be used

```
Cdegrees[i] = ...                        # Change the i-th list element
```

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List comprehension

'Run thru a list and for each element create a new element in another list

- This is a frequently encountered task

⇝ (`Fdegrees[i]` from `Cdegrees[i]`)

Python has a special compact syntax for this

⇝ **List comprehension**

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List comprehension (cont.)

Definition

List comprehension

The general syntax for list comprehension

```
...

newlist = [E(e) for e in list]

...
```

`E(e)` *is some* `expression` *involving element* `e` *of list* `list`

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List comprehension (cont.)

Example

Consider the following code, the tasks should be familiar

```
Cdegrees = [-5+i*0.5 for i in range(n)]              #  List comprehension
                                                     # Build list Cdegrees

Fdegrees = [(9.0/5)*C+32 for C in Cdegrees]          #  List comprehension
                                                     # Build list Fdegrees

C_plus_5 = [C+5 for C in Cdegrees]                   # Build list C_plus_5
```

How does the computation evolve in each case?

What are the elements of the lists?

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Travessing multiple lists

Alternative implementations

Travessing multiple lists

Suppose that we want to use lists `Cdegrees` and `Fdegrees` to make a table

- We need to traverse both arrays

A `for element in list` construction is not suitable here

- It extracts elements from one list only

A solution is to use a `FOR-loop` over indices

- So that we can index both lists
- (We silently used this already)

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Travessing multiple lists (cont.)

Example

Consider this piece of code for printing a table of temperature values

```
n=21

Cdegrees = [-5+i*0.5 for i in range(n)]              # List comprehension
Fdegrees = [(9.0/5)*C+32 for C in Cdegrees]          # List comprehension

for i in range(len(Cdegrees)):
 print '%5d %5.1f' % (Cdegrees[i], Fdegrees[i])      # Print temperatures
```

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Travessing multiple lists (cont.)

It often happens that two or more lists need be traversed simultaneously

Python offers an alternative to the loop over indices

⇝ A special syntax

- The `zip` function

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Travessing multiple lists (cont.)

Definition

Zip

Function `zip` turns n lists (`list1`, `list2`, `...`) into a single list of n-tuples

```
for e1, e2, ... in zip(list1, list2, ...):
                                                 # Element e1 from list1
                                                 # Element e2 from list2
                                                 # ...
```

For each n-tuple (`e1`, `e2`, `...`),

- *The first element (`e1`) is from the first list (`list1`)*
- *The second element `e2` is from second list (`list2`)*
- *...*
- *The n-th element `e2` is from second list (`listn`)*

The loop stops when the end of the shortest list is reached

Travessing multiple lists (cont.)

Example

Consider the following code using list comprehension and the zip function

```
n=21
Cdegrees = [-5+i*0.5 for i in range(n)]              # List comprehension
Fdegrees = [(9.0/5)*C+32 for C in Cdegrees]          # List comprehension

for C, F in zip(Cdegrees, Fdegrees):                 # Print temperatures
 print '%5.1f %5.1f' % (C, F)                          #   Use zip
     function
```

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Travessing multiple lists (cont.)

The result of the execution of the first part of the code

```
>>> Cdegrees
 [-5.0,
  -4.5,
  -4.0,
   ...
   4.0,
   4.5,
   5.0]

>>> Fdegrees
 [23.0,
  23.9,
  24.8,
   ...
  39.2,
  40.1,
  41.0]
```

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Travessing multiple lists (cont.)

The result of the execution of the second part of the code

```
 -5.0  23.0
 -4.5  23.9
 -4.0  24.8
 -3.5  25.7
 -3.0  26.6
 -2.5  27.5
 -2.0  28.4
 -1.5  29.3
 -1.0  30.2
 -0.5  31.1
  0.0  32.0
  0.5  32.9
  1.0  33.8
  1.5  34.7
  2.0  35.6
  2.5  36.5
  3.0  37.4
  3.5  38.3
  4.0  39.2
  4.5  40.1
  5.0  41.0
```

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Travessing multiple lists (cont.)

Consider the continuation code using the zip function and list comprehension

```
table = []
table = [[C,F] for C,F in zip(Cdegrees,Fdegrees)]
```

```
>>> table
[[-5.0, 23.0],
 [-4.5, 23.9],
 [-4.0, 24.8],
 [-3.5, 25.7],
 [-3.0, 26.6],
 [-2.5, 27.5],
 [-2.0, 28.4],
 [-1.5, 29.3],
 [-1.0, 30.2],
 [-0.5, 31.1],
 [0.0,  32.0],
 [0.5,  32.9],
 [1.0,  33.8],
 [1.5,  34.7],
 [2.0,  35.6],
 [2.5,  36.5],
 [3.0,  37.4],
 [3.5,  38.3],
 [4.0,  39.2],
 [4.5,  40.1],
 [5.0,  41.0]]
```

■

Nested lists

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Nested lists

Nested lists are `list objects`, the `list elements` are `list objects`

We use some examples to motivate the need for nested lists

- We shall also illustrate some basic operations

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A table as a row or column list

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A table as a row or column list

In our table of temperatures, we used a separate list for each table column

⇝ With n columns, we need n `list objects` to handle table data

```
n=21
Cdegrees = [-5+i*0.5 for i in range(n)]
Fdegrees = [(9.0/5)*C+32 for C in Cdegrees]
Kdegrees = [C+273.15 for C in Cdegrees]

table = []
table = [[C,F,K] for C,F,K in zip(Cdegrees,Fdegrees,Kdegrees)]
```

A table as a row or column list

```
>>> table
[[-5.0, 23.0, 268.15],
 [-4.5, 23.9, 268.65],
 [-4.0, 24.8, 269.15],
   ...,  ...,    ...
 [4.0,  39.2, 277.15],
 [4.5,  40.1, 277.65],
 [5.0,  41.0, 278.15]]
```


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A table as a row or column list (cont.)

We think of a table as a single entity, not a collection of n columns

- It is natural to use one argument for the whole table

In Python this can be achieved by using a **nested list**

- Each entry in the list is a list itself

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A table as a row or column list (cont.)

A `table object` is understood as a list of lists

We can see it as two different cases

- Either it is a list of the row elements of the table
- Or, it is a list of the column elements of the table

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A table as a row or column list (cont.)

Example

```
Cdegrees = range(-20, 41, 5)                         # -20, -15, ..., 35, 40
Fdegrees = [(9.0/5)*C + 32 for C in Cdegrees]

table = [Cdegrees, Fdegrees]
```

⇝ The table is a list of two columns
⇝ Each column is a list of numbers

```
>>> table
 [[ -20,-15, -10,  -5,   0,   5,  10,  15,  20,  25,  30,  35,   40],
  [-4.0,5.0,14.0,23.0,32.0,41.0,50.0,59.0,68.0,77.0,86.0,95.0,104.0]]
```

A table as a row or column list (cont.)

```
>>> table
[[ -20,-15, -10,  -5,   0,   5,  10,  15,  20,  25,  30,  35,   40],
 [-4.0,5.0,14.0,23.0,32.0,41.0,50.0,59.0,68.0,77.0,86.0,95.0,104.0]]
```

With `table[0]`, we access the first element in the table

⇝ (The `Cdegrees` list)

With `table[1]`, we access the first element in the table

⇝ (The `Fdegrees` list)

```
>>> table[0]
[-20, -15, -10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40]
>>> Cdegrees
[-20, -15, -10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40]

>>> table[1]
[-4.0, 5.0, 14.0, 23.0, 32.0, 41.0, 50.0, 59.0, 68.0, 77.0, 86.0, 95.0,
    104.0]
>>> Fdegrees
[-4.0, 5.0, 14.0, 23.0, 32.0, 41.0, 50.0, 59.0, 68.0, 77.0, 86.0, 95.0,
    104.0]
```


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A table as a row or column list (cont.)

`table[0][2]` is the third element in the first element (which is a list)

```
>>> table[0]
[-20, -15, -10, -5, 0, 5, 10, 15, 20, 25, 30, 35, 40]

>>> table[0][2]
-10
```

That is also `Cdegrees[2]`

■

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A table as a row or column list (cont.)

Consider tabular data with rows and columns

- The underlying data are a nested list
- The first index counts the rows
- The second index counts the columns

This is the convention for indexing elements

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A table as a row or column list (cont.)

Example

We can construct `table` as a list of `[C, F]` pairs

- The first index will then run over rows `[C, F]`

```
Cdegrees = range(-20, 41, 5)
Fdegrees = [(9.0/5)*C + 32 for C in Cdegrees]

table = []
for C, F in zip(Cdegrees, Fdegrees):
 table.append([C, F])
```

This construction is based on looping through pairs `C` and `F`

- At each pass, we create a list element `[C, F]`
- Then, we append it as last element to `table`

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```
Cdegrees = range(-20, 41, 5)
Fdegrees = [(9.0/5)*C + 32 for C in Cdegrees]

table = []
for C, F in zip(Cdegrees, Fdegrees):
 table.append([C, F])
```

```
>>> table
 [[-20, -4.0],
  [-15,  5.0],
  [-10, 14.0],
  [-5,  23.0],
  [0,   32.0],
  [5,   41.0],
  [10,  50.0],
  [15,  59.0],
  [20,  68.0],
  [25,  77.0],
  [30,  86.0],
  [35,  95.0],
  [40, 104.0]]

>>> table[5]
 [5, 41.0]

>>> table[5][1]
 41.0
```

`table[5]` refers to the sixth element in `table`, a `[C, F]` pair

- With `table[5][0]`, we access the `C` value
- With `table[5][1]`, we access the `F` value

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A table as a row or column list (cont.)

```
Cdegrees = range(-20, 41, 5)
Fdegrees = [(9.0/5)*C + 32 for C in Cdegrees]

table = []
for C, F in zip(Cdegrees, Fdegrees):
 table.append([C, F])
```

More compactly, we can obtain the same resultby using list comprehension

```
Cdegrees = range(-20, 41, 5)
Fdegrees = [(9.0/5)*C + 32 for C in Cdegrees]

table = [[C, F] for C, F in zip(Cdegrees, Fdegrees)]
```

This construction is based on looping through pairs `C` and `F`

- At each pass, we create a list element `[C, F]`
- (The process of appending it not explicit)

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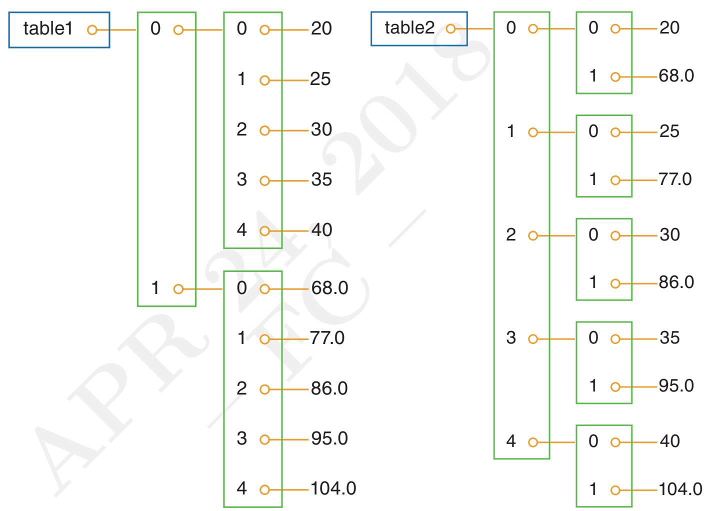
A list of columns and a list of pairs



The first index looks up an element in the outer list

- This element can be indexed with the second index

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Printing objects

Nested lists

Printing objects

To immediately view the nested list `table`, we may write `print table`

- Any object `obj` can be printed to screen by `print obj`

The output is usually one line, which may be very long with packed lists

Example

A long list, like the `table` variable, needs a long line when printed

```
[[-20, -4.0], [-15, 5.0], [-10, 14.0], ..., ..., [40, 104.0]]
```

Splitting the output over shorter lines makes the layout more readable

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Printing objects (cont.)

The `pprint module` offers a **pretty print** embellishing functionality

Example

```
import pprint
pprint.pprint(table)
```

```
[[-20,  -4.0],
 [-15,   5.0],
 [-10,  14.0],
 [-5,   23.0],
 [0,    32.0],
 [5,    41.0],
 [10,   50.0],
 [15,   59.0],
 [20,   68.0],
 [25,   77.0],
 [30,   86.0],
 [35,   95.0],
 [40,  104.0]]
```

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Printing objects (cont.)

The book offers a modified `pprint module`, named `scitools.pprint2`

- Format control over printing of `float objects` in `list objects`
- `scitools.pprint2.float_format`, as `printf format` string

Example

How the output format of real numbers can be changed

```
>>> import pprint, scitools.pprint2
>>> somelist = [15.8, [0.2, 1.7]]
>>> pprint.pprint(somelist)
    [15.800000000000001, [0.20000000000000001, 1.7]]

>>> scitools.pprint2.pprint(somelist)
    [15.8, [0.2, 1.7]]

>>> # default output is '%g', change this to
>>> scitools.pprint2.float_format = '%.2e'
>>> scitools.pprint2.pprint(somelist)
    [1.58e+01, [2.00e-01, 1.70e+00]]
```

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Printing objects (cont.)

The `pprint module` writes floating-point numbers with lots of digits

- To explicitly facilitate detection of round-off errors

Many find this type of output annoying and prefer the default output

- `scitools.pprint2` returns a conventional output

Printing objects (cont.)

Definition

pprint and scitools.pprint2 modules have function pformat

- *It returns a formatted string, rather than printing a string*
- *It works as pprint*

```
s = pprint.pformat(somelist)
print s
```

The print statement prints like pprint.pprint(somelist)

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Printing objects (cont.)

Tabular data like in `nested table lists` are not printed in a pretty way

⇝ A limitation of the `pprint module`

The expected pretty output is two aligned columns

We will have to code the formatting

⇝ To produce such output

Example

Loop over each row, extract the two elements `C` and `F` in each row

- Print these in fixed width fields
- Use the `printf` syntax

```
for C, F in table:
 print '%5d %5.1f' % (C, F)
```

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Extracting sublists

Python has a syntax for extracting/accessing parts of a `list` structure

- **Sublists** or **slices**

Extracting sublists (cont.)

`A[i:]` refers to the sublist of `A` starting with index `i` in `A` till the end of `A`

```
>>> A = [2, 3.5, 8, 10]
    #    0    1  2   3

>>> A[2:]
    [8, 10]
```

`A[:i]` refers to the sublist of `A` starting with index of `0` in `A` till index `i-1`

```
>>> A = [2, 3.5, 8, 10]
    #    0    1  2   3

>>> A[:3]
    [2, 3.5, 8]
```

- The last index that is considered is `i-1`
- (This is important to remember)

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Extracting sublists (cont.)

`A[i:j]` refers to the sublist of `A` starting with index `i` in `A` till index `j-1`

```
>>> A = [2, 3.5, 8, 10]
    #    0    1  2   3

>>> A[1:3]
    [3.5, 8]
```

- The last index that is considered is `j-1`
- (This is important to remember)

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Extracting sublists (cont.)

`A[1:-1]` extracts all elements except the first and the last

- (Index `-1` refers to the last element)

```
>>> A = [2, 3.5, 8, 10]
    #    0    1  2   3

>>> A[1:-1]
 [3.5, 8]
```

`A[:]` refers to the whole list

```
>>> A[:]
 [2, 3.5, 8, 10]
```

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Extracting sublists (cont.)

```
[[-20,  -4.0],    # table[0]
 [-15,   5.0],    # table[1]
 [-10,  14.0],    # table[2]
 [-5,   23.0],    # table[3]
 [0,    32.0],    # table[4]
 [5,    41.0],    # table[5]
 [10,   50.0],    # table[6]
 [15,   59.0],    # table[7]
 [20,   68.0],    # table[8]
 [25,   77.0],    # table[9]
 [30,   86.0],    # table[10]
 [35,   95.0],    # table[11]
 [40,  104.0]]    # table[12]
```

With nested lists, it is possible to use slices in the first index

```
>>> table[4:]
    [[0, 32.0], [5, 41.0], [10, 50.0], [15, 59.0], [20, 68.0],
    [25, 77.0], [30, 86.0], [35, 95.0], [40, 104.0]]
```

Extracting sublists (cont.)

```
[[-20,   -4.0],     # table[0]
 [-15,    5.0],     # table[1]
 [-10,   14.0],     # table[2]
 [-5,    23.0],     # table[3]
 [0,     32.0],     # table[4]
 [5,     41.0],     # table[5]
 [10,    50.0],     # table[6]
 [15,    59.0],     # table[7]
 [20,    68.0],     # table[8]
 [25,    77.0],     # table[9]
 [30,    86.0],     # table[10]
 [35,    95.0],     # table[11]
 [40,   104.0]]     # table[12]
```

We can also slice the second index, or both indices

```
>>> table[4:7][0:2]
    [[0, 32.0], [5, 41.0]]
```

`table[4:7]` makes a 3-element list

- Indices `4`, `5` and `6`

⤳ `[[0,32.0],[5,41.0],[10,50.0]]`

Slice `[0:2]` acts on it, picks its first two elements

- Indices `0` and `1`

⤳ `[[0,32.0],[5,41.0],[10,50.0]]`

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Extracting sublists (cont.)

Sublists are always copies of the original list

- This is important

Example

```
>>> list_1 = [1, 4, 3]                                  # Define list_1

>>> list_2 = list_1[:-1]                                # Define list_2
                                             # It is a sublist of list_1
                                             #          Elements 0 to -2
>>> list_2
    [1, 4]

>>> list_1[0] = 100                          #   First element of list_1
>>> list_1                                   #         List_1 is modified
    [100, 4, 3]

>>> list_2                                   #    List_2 is not modified
    [1, 4]
```

■

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Extracting sublists (cont.)

Remark

Suppose that you have pre-defined/available some list

- Suppose that you extract some sublist from it
- Suppose that you modify such sublist

Whatever the modification on the sublist, the original list remains unaltered

- The *vice versa* is also true

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Extracting sublists (cont.)

Remark

`B == A` is `True` if all elements in `B` equal corresponding elements in `A`

The test `B is A` is `True` if `A` and `B` are names for the same list

■

Extracting sublists (cont.)

Example

Consider the following piece of code

```
>>> A = [2, 3.5, 8, 10]
>>> B = A[:]
>>> C = A

>>> B == A
    True

>>> B is A
    False

>>> C is A
    True
```

Setting `B = A[:]` makes `B` refer to a copy of the list referred to by `A`

Setting `C = A` makes `C` refer to the same list object as `A`

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Extracting sublists (cont.)

Example

Write the part of the table list of `[C, F]` rows where the degrees Celsius are between `10` and `35` (not including `35`)

```
>>> for C, F in table[Cdegrees.index(10):Cdegrees.index(35)]:
    ... print '%5.0f %5.1f' % (C, F)
    ...


  10 50.0
  15 59.0
  20 68.0
  25 77.0
  30 86.0
```

- `Cdegrees.index(10)` is the index of value `10` in the `Cdegrees` list
- `Cdegrees.index(35)` is the index of value `35` in the `Cdegrees` list

A `FOR-loop` does an equivalent job

⇝ `for C, F in table[6:11]:`

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Travessing nested lists

Traversing the `nested list` `table` could be done by a loop

```
for C, F in table:
 <process C and F>
```

Natural, when we know that `table` is a list of `[C, F]` lists

More general nested lists must be handled differently

- Unknown how many elements there are in each list
- (Lists are the element of the main list)

Travessing nested lists (cont.)

Example

Consider a nested list `scores` recording the scores of players in some game

- `scores[i]` holds the list of scores obtained by player number `i`

Different players have played the game a different number of times

- The length of `scores[i]` depends on `i`, the player

```
scores = []

# Hypothetical scores of player no. 0:
scores.append([12, 16, 11, 12])                    # Length 4

# Hypothetical scores of player no. 1:
scores.append([9])                                 # Length 1

# Hypothetical scores of player no. 2:
scores.append([6, 9, 11, 14, 17, 15, 14, 20])      # Length 8
```

The list has three elements, each element corresponds to a player

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Travessing nested lists (cont.)

```
scores = []

# Hypothetical scores of player no. 0:
scores.append([12, 16, 11, 12])                    # Length 4

# Hypothetical scores of player no. 1:
scores.append([9])                                 # Length 1

# Hypothetical scores of player no. 2:
scores.append([6, 9, 11, 14, 17, 15, 14, 20])      # Length 8
```

Consider element number `g` in the list `scores[p]`, `scores[p][g]`

- It corresponds to the score in game `g` played by player `p`

The length of the individual lists `scores[p]` varies

- It equals `4`, `1`, and `8` for `p` equal `0`, `1`, and `2`, respectively

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Travessing nested lists (cont.)

Remark

Consider `n` players, some may have played a large number of times

This makes `scores` a big nested list, potentially

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Travessing nested lists (cont.)

Example

Consider the data initialised earlier, the table of scores

The scores can be written out in the following form

```
12 16 11 12
 9
 6  9 11 14 17 15 14 20
```

How to traverse the list and put it in table format

⇝ With well formatted columns?

The esired properties of the table formatting

1. Each row must correspond to a player
2. Columns must correspond to scores

Travessing nested lists (cont.)

```
12 16 11 12
 9
 6  9 11 14 17 15 14 20
```

We may use two nested loops

- One loop for the elements in `scores`
- One loop for the elements in the sublists of `scores`

There are two basic ways of traversing a nested list

- We use integer indices for each index
- We use variables for the list elements

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Travessing nested lists (cont.)

An index-based version

```
scores = []
scores.append([12, 16, 11, 12])
scores.append([9])
scores.append([6, 9, 11, 14, 17, 15, 14, 20])

for p in range(len(scores)):
 for g in range(len(scores[p])):
  score = scores[p][g]
  print '%4d' % score,
 print
```

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Travessing nested lists (cont.)

We used the trailing comma after ‘`print string`’

```
scores = []
scores.append([12, 16, 11, 12])
scores.append([9])
scores.append([6, 9, 11, 14, 17, 15, 14, 20])

for p in range(len(scores)):
 for g in range(len(scores[p])):
  score = scores[p][g]
  print '%4d' % score,
 print
```

The `print` after the loop over `p` adds a new (empty) line after each row

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Travessing nested lists (cont.)

With variables for iterating over the elements in `scores` and its sublists

```
for player in scores:
 for game in player:

  print '%4d' % game,
 print
```

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Travessing nested lists (cont.)

Definition

Consider the general case of nested lists with many indices

⇝ `somelist [i1][i2][i3] ...`

Suppose that we are interested in visiting each element in the list

We can use as many nested `FOR-loops` as there are indices

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Travessing nested lists (cont.)

As a practical example consider a nested list with four indices

```
for i1 in range(len(somelist)):
 for i2 in range(len(somelist[i1])):
  for i3 in range(len(somelist[i1][i2])):
   for i4 in range(len(somelist[i1][i2][i3])):

    value = somelist[i1][i2][i3][i4]
    # perform some operation with this current value
```

This is what iterating over integer indices looks like

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Travessing nested lists (cont.)

The corresponding version by iterating over sublists

```
for sublist1 in somelist:
 for sublist2 in sublist1:
  for sublist3 in sublist2:
   for sublist4 in sublist3:

    value = sublist4
    # perform some operation with this current value
```

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Some list operations

Nested lists

Some list operations

Construct	Explaination
`a = []`	Initialise an empty string
`a = [1, 4.4, 'run.py']`	Initialise a list
`a.append(elem)`	Add `element`
`a + [1.3]`	Add two lists
`a.insert(i, e)`	Insert element `e` before index `i`
`a[3]`	Index a list element
`a[-1]`	Get last lists element
`a[1:3]`	Slide: Copy data to sublist
`del a[3]`	Delete an element
`a.remove(e)`	Remove an element with value `e`

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Some list operations (cont.)

Construct	Explaination
`a.index('run.py')`	Index corresponding to element's value
`'run.py' in a`	Test if a value is in the list
`a.count(v)`	Count elements with value `v`
`len(a)`	Number of elements in list `a`
`min(a)`	The smallest element in list `a`
`max(a)`	The largest element in list `a`
`sum(a)`	Add all elements in `a`
`sorted(a)`	Return sorted version of `a`
`reversed(a)`	Return returned version of `a`
`b[3][0][2]`	Nested list indexing
`isinstance(a, list)`	`True` if `a` is a list
`type(a) is list`	`True` if `a` is a list

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Lists and loops

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Tuples

Tuples are similar to `lists`, but `tuple objects` cannot be changed

- A `tuple object` can be viewed as a constant `list object`

`Lists` use square brackets, `tuples` employ standard parentheses

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Tuples (cont.)

```
t = (2, 4, 6, 'temp.pdf')                          #  Define a tuple
                                                   #          Name t

t = 2, 4, 6, 'temp.pdf'                            #  Define a tuple
                                                   #          Name t
                                                   # W/O parenthesis
```

A comma-separated sequence of objects is a `tuple object`

- Parentheses are not necessary, though common

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Tuples (cont.)

We can use `FOR-loop` to loop over a tuple

```
for element in 'myfile.txt', 'urfile.txt', 'herfile.txt':
 print element,
```

Note the trailing comma (`,`) in the `print` statement

```
myfile.txt yourfile.txt herfile.txt
```

The comma suppresses the final newline that `print` command would add

- The output of `print` is a `string object`

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Tuples (cont.)

Many of the usual functionalities for lists are also available for tuples

```
>>> t = (2, 4, 6, 'temp.pdf')                       # Define a tuple

>>> t = t + (-1.0, -2.0)                            # Add two tuples
>>> t                                               # Define a tuple
    (2, 4, 6, 'temp.pdf', -1.0, -2.0)

>>> t[1]                                                  # Indexing
    4

>>> t[2:]                                           # Subtuple/slice
    (6, 'temp.pdf', -1.0, -2.0)

>>> 6 in t                                              # Membership
    True
```

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Tuples (cont.)

Operations for lists that change the list do not work for tuples

```
>>> t[1] = -1
    ...
    TypeError: object does not support item assignment

>>> t.append(0)
    ...
    AttributeError: 'tuple' object has no attribute 'append'

>>> del t[1]
    ...
    TypeError: object doesn't support item deletion
```

Some methods for lists (like `index`) are not available for tuples

Tuples (cont.)

So why do we need tuples at all when lists can do more than tuples?

- ⤳ Tuples protect against accidental changes of their contents
- ⤳ Code based on tuples is faster than code based on lists
- ⤳ Tuples are often used in Python software that you will use
- (You need to know this data type!)

There is also a fourth argument, the data-type called dictionaries

- Tuples can be used as keys in dictionaries
- Lists cannot