BBM 101

Introduction to Programming I

Lecture #06 – Arrays and Lists

HACETTEPE UNIVERSITY

Fuat Akal & Erkut Erdem // Fall 2020

Last time… **Control Flow, Functions**

Repeating yourself

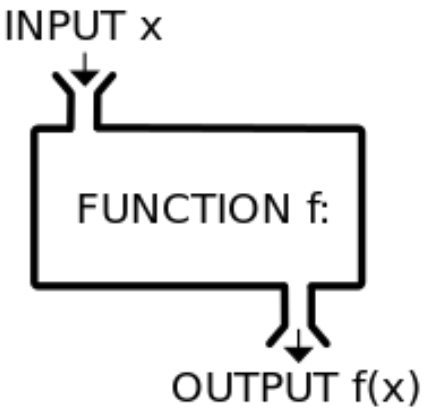
```
for f in [30,40,50]:
    print(f,(f-32)/9.0*5)
```

```
counter = 1
while counter <= n:
    s = s + counter
    counter += 1
```

Making decisions

```
if val < 0:
    result = - val
else:
    result = val
```

```
if height > 100:
  print("space")
elif height > 50:
  print("mesosphere")
elif height > 20:
  print("stratosphere")
else:
  print("troposphere")
```



Functions

```
def dbl_plus(x):
    return 2*x + 1
```

Lecture Overview

- Arrays
- Collections
  - Lists
  - Tuples
  - Sets
  - Dictionaries

We will cover these later.

Disclaimer: Much of the material and slides for this lecture were borrowed from
—Ruth Anderson, Michael Ernst and Bill Howe's CSE 140 class

Data Structures

- A *data structure* is way of organizing data
  - Each data structure makes certain operations convenient or efficient
  - Each data structure makes certain operations inconvenient or inefficient

- **Example**: What operations are efficient with:
  - a file cabinet sorted by date?
  - a shoe box?

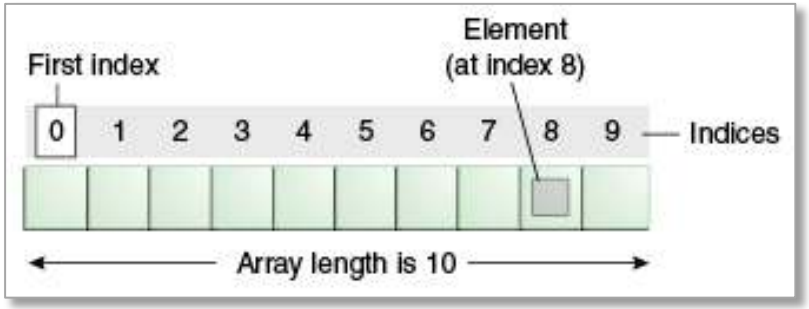
Lecture Overview

- Arrays
- Collections
  - Lists
  - Tuples
  - Sets
  - Dictionaries

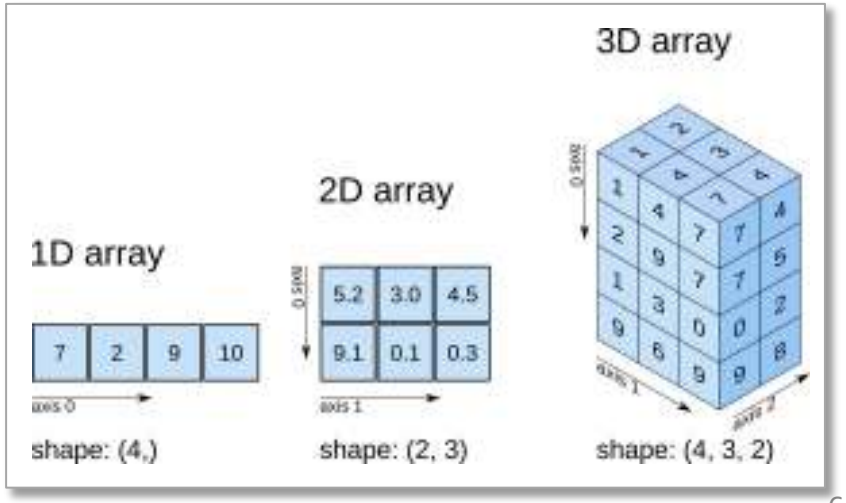
Disclaimer: Much of the material and slides for this lecture were borrowed from
—Ruth Anderson, Michael Ernst and Bill Howe's CSE 140 class

An Array is ...

- a container which can hold a **fixed** number of items, and these items should be of the **same** type.
  - Each item stored in an array is called an **element**.
  - Each location of an element in an array has a numerical **index**, which is used to identify the element.



Wait for ***Understanding Data*** lecture (Week 12) to learn more about arrays.



Lecture Overview

- Arrays
- Collections
  - Lists
  - Tuples
  - Sets
  - Dictionaries

Disclaimer: Much of the material and slides for this lecture were borrowed from
—Ruth Anderson, Michael Ernst and Bill Howe's CSE 140 class

A Collection Groups Similar Things

- List: ordered
- Set: unordered, no duplicates
- Tuple: unmodifiable list
- Dictionary: maps from values to values

  Example: word → definition

Lecture Overview

- Arrays
- Collections
  - Lists
  - Tuples
  - Sets
  - Dictionaries

Disclaimer: Much of the material and slides for this lecture were borrowed from
—Ruth Anderson, Michael Ernst and Bill Howe's CSE 140 class

What is a List?

- A list is an ordered sequence of values, where each value is identified by an index.

- What operations should a list support efficiently and conveniently?
  - Creation
  - Querying/Lookup
  - Mutation

List Creation

- Use square brackets to specify a list.
- Separate each element with a comma.

```
a = [3, 4, 5]

b = [ 5, 3, 'hi' ]

c = [ 4, 'a', a ]

d = [ 3, 1, 2*2, 1, 10/2, 10-1 ]

e = []      # empty list
```

List Creation: Example - 1

```
L = ['I did it all', 4, 'love']

for i in range(len(L)):
    print(L[i])
```

```
>> I did it all
>> 4
>> love
```

List Creation: Example - 2

```
Techs = ['MIT', 'Caltech']
Ivys = ['Harvard', 'Yale', 'Brown']
Univs = [Techs, Ivys]
Univs1 = [['MIT','Caltech'],['Harvard','Yale','Brown']]

print('Univs =', Univs)
print('Univs1 =', Univs1)
print(Univs == Univs1)
```

```
>> Univs = [['MIT','Caltech'],['Harvard','Yale','Brown']]
>> Univs1 = [['MIT','Caltech'],['Harvard','Yale','Brown']]
>> True
```

List Creation: Example - 3

```
def findExtremeDivisors(n1, n2):
    """Assumes that n1 and n2 are positive ints
    Returns a list containing the smallest common
    divisor > 1 and the largest common divisor
    of n1 and n2"""
    minVal = None
    maxVal = None

    for i in range(2, min(n1, n2) + 1):
        if n1%i == 0 and n2%i == 0:
            if minVal == None or i < minVal:
                minVal = i
            if maxVal == None or i > maxVal:
                maxVal = i
    return [[minVal], [maxVal]]

extreme_divisors= findExtremeDivisors(100, 200)
print(extreme_divisors)
```

The **None** keyword is used to define a null value, or no value at all.

```
[[2], [100]]
```

How to Evaluate a List Expression

- `[a, b, c, d]` → list creation
  - To evaluate:
    - evaluate each element to a value, from left to right
    - make a list of the values
  - The elements can be arbitrary values, including lists
    - `["a", 3, 3.14*r*r, fahr_to_cent(-40), [3+4, 5*6]]`

Same tokens "`[]`" with two *distinct* meanings

List expression

- `a[b]` → list indexing or dereferencing
  - To evaluate:
    - evaluate the list expression to a value
    - evaluate the index expression to a value
    - if the list value is not a list, execution terminates with an error
    - if the element is not in range (not a valid index), execution terminates with an error
    - the value is the given element of the list value (counting from zero)

Index expression

List Expression Examples

What does this mean (or is it an error)?

```
["four", "score", "and", "seven", "years"][2]

["four", "score", "and", "seven", "years"][0,2,3]

["four", "score", "and", "seven", "years"][[0,2,3]]

["four", "score", "and", "seven", "years"][[0,2,3][1]]
```

List Expression Examples

```
>>> ["four", "score", "and", "seven", "years"][2]
'and'

>>> ["four", "score", "and", "seven", "years"][0,2,3]
TypeError: list indices must be integers or slices, not tuple

>>> ["four", "score", "and", "seven", "years"][[0,2,3]]
TypeError: list indices must be integers or slices, not list

>>> ["four", "score", "and", "seven", "years"][[0,2,3][1]]
'and'
```

List Lookup

- Extracting part of the list:
  - Single element: **`mylist[index]`**
  - Sublist ("slicing"): **`mylist[startidx : endidx]`**

- Find/lookup in a list
  - **`x in mylist`**
    - Evaluates to a boolean value
  - **`mylist.index(x)`**
    - Return the int index in the list of the first item whose value is x. It is an error if there is no such item.
  - **`list.count(x)`**
    - Return the number of times x appears in the list.

List Lookup: Exercise

```
def index(somelist, value):
    """Return the position of the first occurrence of
       the element value in the list somelist.
       Return None if value does not appear in
       somelist."""
  i = 0
  for c in somelist:
    if c == value:
      return i
    i = i + 1
  return None
```

```
gettysburg = ["four", "score", "and",
                  "seven", "years", "ago"]
index(gettysburg, "and")       # 2
index(gettysburg, "years")     # 4
gettysburg.count('seven')      # 1
```

List Mutation

- Insertion
- Removal
- Replacement
- Rearrangement

List Insertion

- **`mylist.append(x)`**
  - Extend the list by inserting x at the end

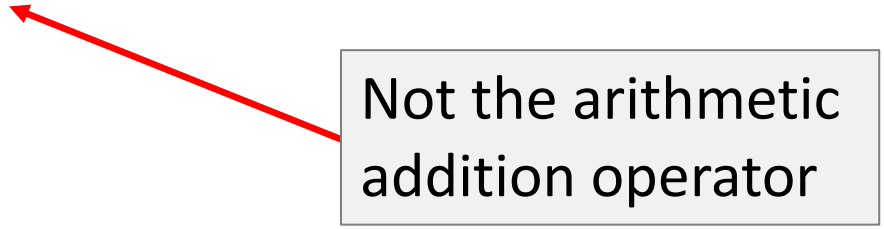
- **`mylist.extend(L)`**
  - Extend the list by appending all the items in the argument list

- **`mylist.insert(i, x)`**
  - Insert an item before a given position.
  - `a.insert(0, x)` inserts at the front of the list
  - `a.insert(len(a), x)` is equivalent to `a.append(x)`

List Concatenation using + operator

```
list1 = ["a", "b", "c"]
list2 = [1, 2, 3]

list3 = list1 + list2
print(list3)
```




```
["a", "b", "c", 1, 2, 3]
```

List Insertion: Examples

```
def findDivisors (n1, n2):
    """Assumes that n1 and n2 are positive ints
    Returns a list containing all common divisors
    of n1 & n2"""
    divisors = [] #the empty list
    for i in range(1, min (n1, n2) + 1):
        if n1%i == 0 and n2%i == 0:
            divisors = divisors + [i]
    return divisors

divisors = findDivisors(20, 100)
print(divisors)

total = 0
for d in divisors:
    total += d
print(total)
```

```
[1, 2, 4, 5, 10, 20]
42
```

List Insertion: Examples

Python statement	Content of list1
`>>> list1 = [1, 2, 3]`	`[1, 2, 3]`
`>>> list1.append(4)`	`[1, 2, 3, 4]`
`>>> list1.insert(2, 5)`	`[1, 2, 5, 3, 4]`
`>>> list2 = [10, 20]`	
`>>> list1.extend(list2)`	`[1, 2, 5, 3, 4, 10, 20]`
`>>> list1.append(list2)`	`[1, 2, 5, 3, 4, 10, 20, [10, 20]]`

```
>>> list1[7]
[10, 20]
>>> list1[7][0]
10
>>> list1[7][1]
20
```

List Removal

- **`list.remove(x)`**
  - Remove the first item from the list whose value is x
  - It is an error if there is no such item

- **`list.pop([i])`**
  - Remove the item at the given position in the list, and return it.
  - If no index is specified, a.pop() removes and returns the last item in the list.

Notation from the Python Library Reference:
The square brackets around the parameter, "[i]", means the argument is *optional*.
It does *not* mean you should type square brackets at that position.

List Removal - Examples

Python statement	Content of list1
`>>> list1 = [1, 2, 3]`	`[1, 2, 3]`
`>>> list1.remove(2)`	`[1, 3]`
`>>> list2 = list1.copy()`	
`>>> list1.extend(list2)`	`[1, 3, 1, 3]`
`>>> list1.remove(3)`	`[1, 1, 3]`
`>>> list1.pop()`	`[1, 1]`

How can you remove all occurences of an element?

List Replacement

- **`mylist[index] = newvalue`**

- **`mylist[start : end] = newsublist`**
  - Can change the length of the list
  - `start` is inclusive, `end` is not
  - `mylist[ start : end ] = []` # removes multiple elements
  - `a[len(a):] = L` # is equivalent to a.extend(L)

List Replacement - Examples

Python statement	Content of list1
`>>> list1 = [1, 2, 3]`	`[1, 2, 3]`
`>>> list1[len(list1)-1] = 9`	`[1, 2, 9]`
`>>> list2 = list1`	
`>>> list1[1:2] = list2`	`[1, 1, 2, 9, 9]`
`>>> list1[1:3] = list2`	`[1, 1, 1, 2, 9, 9, 9, 9]`
`>>> list2[3:8] = []`	`[1, 1, 1]`
`>>> list2 = [5, 6]`	`[5, 6]`

List Slicing

`mylist[startindex : endindex]` evaluates to a sublist of the original list

- **`mylist[index]`** evaluates to an element of the original list

- Arguments are like those to the **`range`** function
  - **`mylist[start : end : step]`**
  - start index is inclusive, end index is exclusive
  - *All* 3 indices are *optional*

- Can assign to a slice: **`mylist[s : e] = yourlist`**

List Slicing: Examples

```
test_list = ['e0', 'e1', 'e2', 'e3', 'e4', 'e5', 'e6']
```

From e2 to the end of the list:	`test_list[2:]`
From beginning up to (but not including) e5:	`test_list[:5]`
Last element:	`test_list[-1]`
Last four elements:	`test_list[-4:]`
Everything except last three elements:	`test_list[:-3]`
Reverse the list:	`test_list[::-1]`
Get a copy of the whole list:	`test_list[:]`

List Rearrangement

- **`list.sort()`**
  - Sort the items of the list, in place.
  - "in place" means by modifying the original list, not by creating a new list.

- **`list.reverse()`**
  - Reverse the elements of the list, in place.

Sorting

```
hamlet = "to be or not to be that is the
                                        question".split()
print("hamlet:", hamlet)

print("sorted(hamlet):", sorted(hamlet))

print("hamlet:", hamlet)

print("hamlet.sort():", hamlet.sort())
print("hamlet:", hamlet)

print("hamlet.reverse():", hamlet.reverse())
print("hamlet:", hamlet)
```

Sorting

```
hamlet: ['to', 'be', 'or', 'not', 'to', 'be', 'that', 'is',
'the', 'question']

sorted(hamlet): ['be', 'be', 'is', 'not', 'or', 'question',
'that', 'the', 'to', 'to']

hamlet: ['to', 'be', 'or', 'not', 'to', 'be', 'that', 'is',
'the', 'question']

hamlet.sort(): None

hamlet: ['be', 'be', 'is', 'not', 'or', 'question', 'that',
'the', 'to', 'to']

hamlet.reverse(): None

hamlet: ['to', 'to', 'the', 'that', 'question', 'or', 'not',
'is', 'be', 'be']
```

Customizing the Sort Order

Goal: sort a list of names ***by last name***

```
names = ["Isaac Newton", "Albert Einstein", "Niels
Bohr", "Marie Curie", "Charles Darwin", "Louis
Pasteur", "Galileo Galilei", "Margaret Mead"]

print("names:", names)
```

This does NOT work:

```
print("sorted(names):", sorted(names))
```

When sorting, how should we compare these names?

```
"Niels Bohr"
"Charles Darwin"
```

```
sorted(names): ['Albert Einstein', 'Charles
Darwin', 'Galileo Galilei', 'Isaac Newton',
'Louis Pasteur', 'Margaret Mead', 'Marie
Curie', 'Niels Bohr']
```

Sort Key

A sort key is a different value that you use to sort a list, instead of the actual values in the list

```
def last_name(str):
    return str.split(" ")[1]

print('last_name("Isaac Newton"):',
last_name("Isaac Newton"))
```

Two ways to use a sort key:

1. Create a new list containing the sort key, and then sort it
2. Pass a key function to the sorted function

1. Use a sort key to create a new list

Create a different list that contains the sort key, sort it, then extract the relevant part:

```
names = ["Isaac Newton", "Fred Newton", "Niels Bohr"]
# keyed_names is a list of [lastname, fullname] lists
keyed_names = []
for name in names:
  keyed_names.append([last_name(name), name])
```

1) Create the new list.

Take a look at the list you created, it can now be sorted:

```
print("keyed_names:", keyed_names)
print("sorted(keyed_names):", sorted(keyed_names))
print("sorted(keyed_names, reverse = True):")
print(sorted(keyed_names, reverse
```

sorted_names: ['Isaac Newton', 'Fred Newton', 'Niels Bohr']

(This works because Python compares two elements that are lists *elementwise*.)

```
sorted_keyed_names = sorted(keyed_names, reverse = True)
sorted_names = []
for keyed_name in sorted_keyed_names:
  sorted_names.append(keyed_name[1])
print("sorted_names:", sorted_names)
```

2) Sort the list new list.

3) Extract the relevant part.

1. Use a sort key to create a new list

Create a different list that contains the sort key, sort it, then extract the relevant part:

```
names = ["Isaac Newton", "Fre
# keyed_names is a list of [l
keyed_names = []
for name in names:
  keyed_names.append([last_na
```

keyed_names: [['Newton', 'Isaac Newton'], ['Newton', 'Fred Newton'], ['Bohr', 'Niels Bohr']]

sorted(keyed_names): [['Bohr', 'Niels Bohr'], ['Newton', 'Fred Newton'], ['Newton', 'Isaac Newton']]

sorted(keyed_names, reverse = True): [['Newton', 'Isaac Newton'], ['Newton', 'Fred Newton'], ['Bohr', 'Niels Bohr']]

Take a look at the list you created, it can no

```
print("keyed_names:", keyed_names)
print("sorted(keyed_names):", sorted(keyed_names))
print("sorted(keyed_names, reverse = True):")
print(sorted(keyed_names, reverse
```

sorted_names: ['Isaac Newton', 'Fred Newton', 'Niels Bohr']

(This works because Python compares two elements that are lists *elementwise*.)

```
sorted_keyed_names = sorted(keyed_names, reverse = True)
sorted_names = []
for keyed_name in sorted_keyed_names:
  sorted_names.append(keyed_name[1])
print("sorted_names:", sorted_names)
```

2) Sort the list new list.

3) Extract the relevant part.

2. Use a sort key as the **`key`** argument

Supply the **`key`** argument to the **`sorted`** function or the **`sort`** function

```
def last_name(str):
    return str.split(" ")[1]

names = ["Isaac Newton", "Fred Newton", "Niels Bohr"]
print("sorted(names, key = last_name):")
print(sorted(names, key = last_name))

print("sorted(names, key = last_name, reverse = True):")
print(sorted(names, key = last_name, reverse = True))

print(sorted(names, key = len))

def last_name_len(name):
    return len(last_name(name))

print(sorted(names, key = last_name_len))
```

2. Use a sort key as the **`key`** argument

Supply the **`key`** argument to the **`sorted`** function or the **`sort`** function

```
def last_name(str):
    return str.split(" ")[1]

names = ["Isaac Newton", "Fred Newton", "Niels Bohr"]
print("sorted(names, key = last_name):")
print(sorted(names, key = last_name))

print("sorted(names, key = last_name, reverse = True):")
print(sorted(names, key = last_name, reverse = True))

print(sorted(names, key =

def last_name_len(name):
    return len(last_name(n

print(sorted(names, key =
```

```
sorted(names, key = last_name): ['Niels Bohr',
'Isaac Newton', 'Fred Newton']

sorted(names, key = last_name, reverse = True):
['Isaac Newton', 'Fred Newton', 'Niels Bohr']

['Niels Bohr', 'Fred Newton', 'Isaac Newton']
['Niels Bohr', 'Isaac Newton', 'Fred Newton']
```

Sorting: strings vs. numbers

- Sorting the powers of 5:

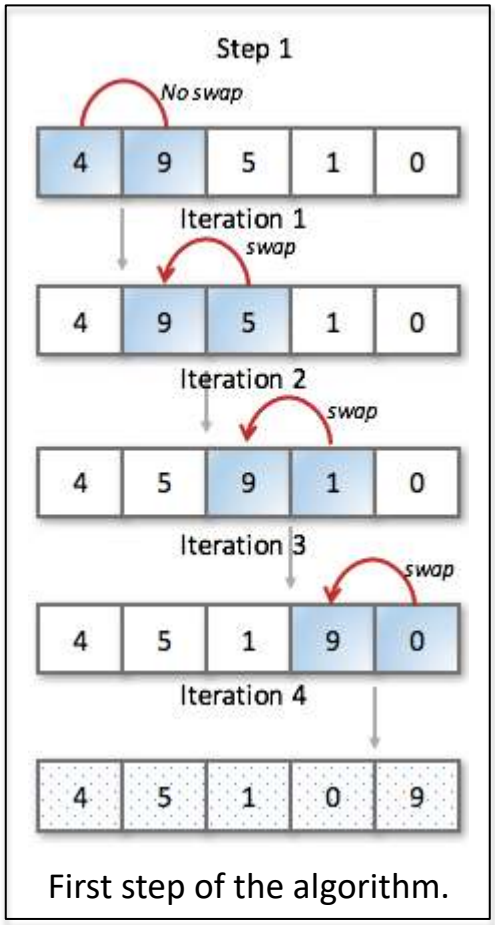
```
>>> sorted([125, 5, 3125, 625, 25])
[5, 25, 125, 625, 3125]

>>> sorted(["125", "5", "3125", "625", "25"])
['125', '25', '3125', '5', '625']
```

Sorting Algorithms Revisited

Bubble Sort

- It repeatedly steps through the list to be sorted,
- compares each pair of adjacent items and swaps them if they are in the wrong order.
- The pass through the list is repeated until no swaps are needed, which indicates that the list is sorted.
- The algorithm, which is a comparison sort, is named for the way smaller elements "bubble" to the top of the list.



First step of the algorithm.

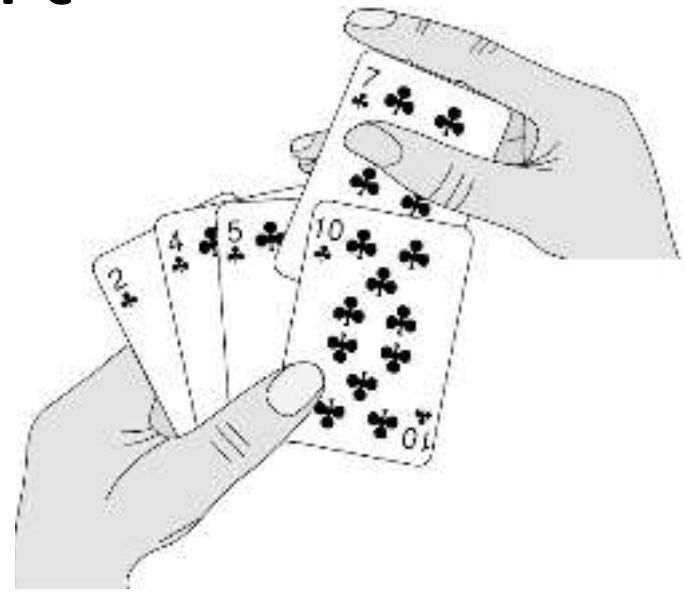
Image credit: http://www.equestionanswers.com

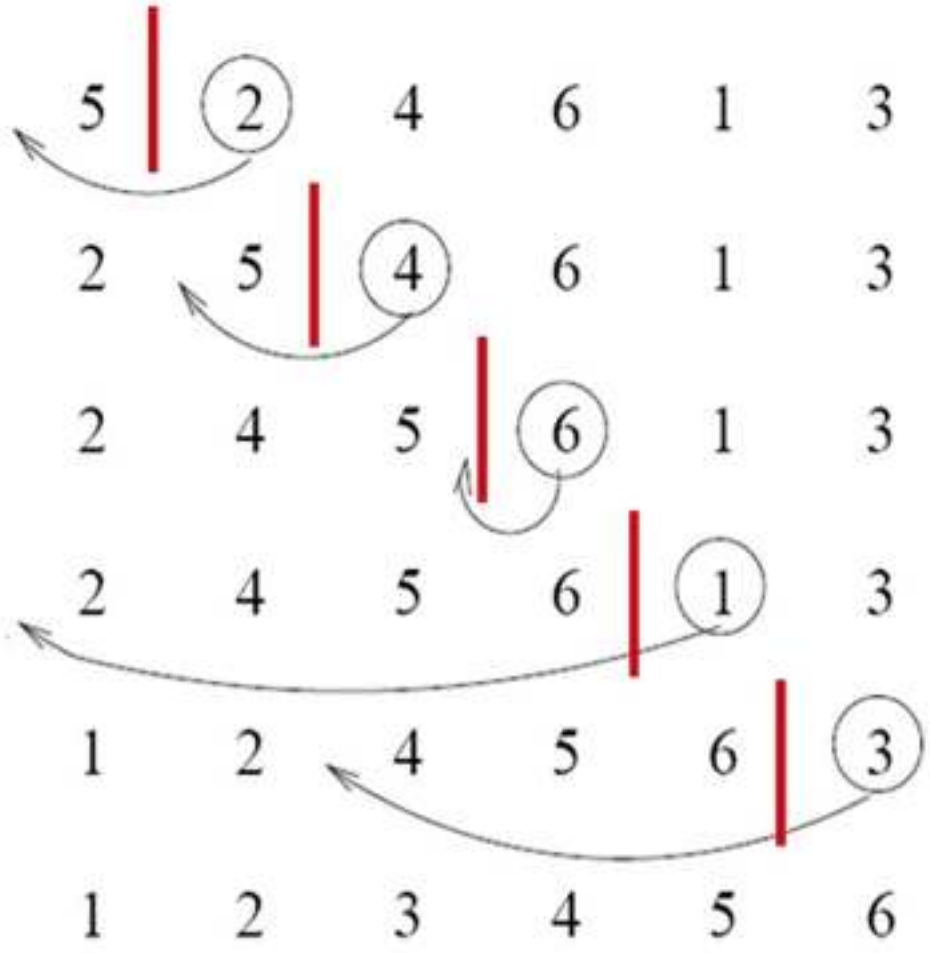
Bubble sort

```
def bubbleSort(alist):
    for passnum in range(len(alist)-1,0,-1):
        for i in range(passnum):
            if alist[i]>alist[i+1]:
                temp = alist[i]
                alist[i] = alist[i+1]
                alist[i+1] = temp

alist = [54,26,93,17,77,31,44,55,20]
bubbleSort(alist)
print(alist)
```

Insertion sort





- maintain a sorted sublist in the lower positions of the list.
- Each new item is then "inserted" back into the previous sublist such that the sorted sublist is one item larger.

Done !

Insertion Sort

```
def insertionSort(alist):
    for index in range(1,len(alist)):
        currentvalue = alist[index]
        position = index

        while position>0 and alist[position-1]>currentvalue:
              alist[position]=alist[position-1]
              position = position-1

        alist[position]=currentvalue

alist = [54,26,93,17,77,31,44,55,20]
insertionSort(alist)
print(alist)
```

Merge Sort

- Merge sort is a prototypical divide-and-conquer algorithm.
  - Split list into sub-lists in two until you reach pair of value
  - Sort/swap pair of values if needed
  - Merge and sort sub-lists and repeat process untill you merge to the full list.

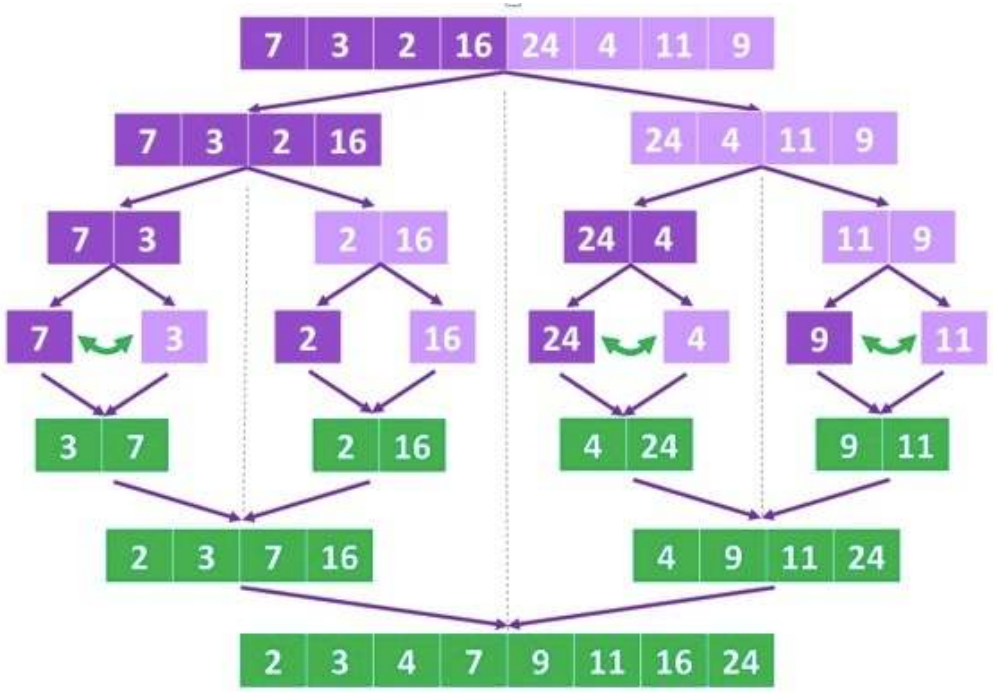


Image credit: https://www.101computing.net/merge-sort-algorithm/

Merge Sort

```
def merge(left, right):
    result = []
    (i,j) = (0, 0)

    while i<len(left) and j<len(right):
       if left[i]<right[j]:
          result.append(left[i])
          i = i + 1
       else:
          result.append(right[j])
          j = j + 1

    while i<len(left):
       result.append(left[i])
       i = i + 1

    while j<len(right):
       result.append(right[j])
       j = j + 1

    return result
```

Merge Sort

Visit this slide later when we learned about recursion.

```
def mergeSort(L):
    if len(L)<2:
        return L[:]
    else:
        middle = len(L)//2
        left = mergeSort(L[:middle])
        right = mergeSort(L[middle:])
        return merge(left, right)

a = mergeSort([2,1,3,4,5,-1,8,6,7])
```

Three Ways to Define a List

- Explicitly write out the whole thing:

```
squares = [0, 1, 4, 9, 16, 25, 36, 49]
```

- Write a loop to create it:

```
squares = []
for i in range(8):
    squares.append(i*i)
```

- Write a **list comprehension**:

```
squares = [i*i for i in range(8)]
```

A list comprehension is a concise description of a list
A list comprehension is shorthand for a loop

Two ways to convert Centigrade to Fahrenheit

```
ctemps = [17.1, 22.3, 18.4, 19.1]
```

With a loop:

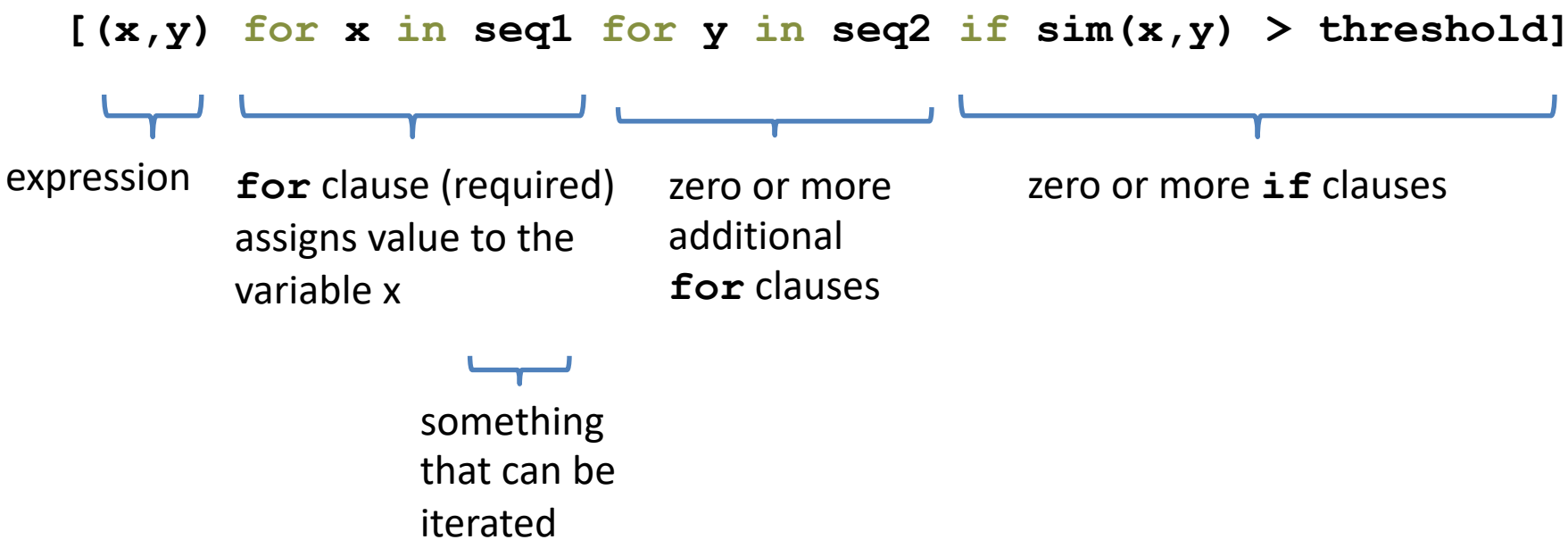
```
ftemps = []
for c in ctemps:
  f = celsius_to_farenheit(c)
  ftemps.append(f)
```

With a list comprehension:

```
ftemps = [celsius_to_farenheit(c) for c in ctemps]
```

The comprehension is usually shorter, more readable, and more efficient.

Syntax of a Comprehension



Semantics of a comprehension

```
[(x,y) for x in seq1 for y in seq2 if sim(x,y) > threshold]
```

```
result = []
for x in seq1:
   for y in seq2:
      if sim(x,y) > threshold:
         result.append( (x,y) )
… use result …
```

Types of comprehensions

List

```
[ i*2 for i in range(3) ]
```

Set

```
{ i*2 for i in range(3)}
```

Dictionary

{ *key*: *value* for *item* in *sequence* …}

```
{ i: i*2 for i in range(3)}
```

We will learn more on sets and dictionaries next week.

Cubes of the first 10 natural numbers

Goal:

Produce: [0, 1, 8, 27, 64, 125, 216, 343, 512, 729]

With a loop:

```
cubes = []
for x in range(10):
  cubes.append(x**3)
```

With a list comprehension:

```
cubes = [x**3 for x in range(10)]
```

Powers of 2, 2^0 through 2^{10}

Goal: [1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024]

```
[2**i for i in range(11)]
```

Even elements of a list

Goal: Given an input list **`nums`**, produce a list of the even numbers in **`nums`**

```
nums = [3, 1, 4, 1, 5, 9, 2, 6, 5]
```

$\Rightarrow$ [4, 2, 6]

```
[num for num in nums if num % 2 == 0]
```

Dice Rolls

Goal: A list of all possible dice rolls.

With a loop:

```
rolls = []
for r1 in range(1,7):
  for r2 in range(1,7):
     rolls.append((r1,r2))
```

With a list comprehension:

```
rolls = [ (r1,r2) for r1 in range(1,7)
                  for r2 in range(1,7)]
```

All above-average 2-die rolls

Goal: Result list should be a list of 2-tuples:

```
[(2, 6), (3, 5), (3, 6), (4, 4), (4, 5), (4, 6), (5, 3),
(5, 4), (5, 5), (5, 6), (6, 2), (6, 3), (6, 4), (6, 5), (6, 6)]
```

```
[(r1, r2) for r1 in [1,2,3,4,5,6]
          for r2 in [1,2,3,4,5,6]
             if r1 + r2 > 7]
```

OR

```
[(r1, r2) for r1 in range(1, 7)
          for r2 in range(8-r1, 7)]
```

Making a Matrix

Goal: A matrix were each element is the sum of it's row and column numbers.

With a loop:

```
matrix = []
for i in range(5):
    row = []
    for j in range(5):
        row.append(i+j)
    matrix.append(row)
```

```
[[0, 1, 2, 3, 4],
 [1, 2, 3, 4, 5],
 [2, 3, 4, 5, 6],
 [3, 4, 5, 6, 7],
 [4, 5, 6, 7, 8]]
```

With a list comprehension:

```
matrix = [[i+j for j in range(5)] for i in range(5)]
```

Function $4x^2 - 4$

With a loop:

```
num_list = []
for i in range(-10,11):
    num_list.append(4*i**2 - 4)
```

With a list comprehension:

```
num_list = [4*i**2 - 4 for i in range(-10,11)]
```

Normalize a List

With a loop:

```
num_list = [6,4,2,8,9,10,3,2,1,3]
total = float(sum(num_list))
for i in range(len(num_list)):
    num_list[i] = num_list[i]/float(total)
```

With a list comprehension:

```
num_list = [i/total for i in num_list]
```

Dictionary Mapping Integers to Multiples Under 20

With a loop:

```
for n in range(1,11):
    multiples_list = []
    for i in  range(1,21):
        if i%n == 0:
            multiples_list.append(i)
    multiples[n] = multiples_list
```

With a dictionary comprehension:

```
multiples = {n:[i for i in range(1,21) if i%n == 0]
for n in range(1,11) }
```

Revisit this slide next week.

{1: [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20], 2: [2, 4, 6, 8, 10, 12, 14, 16, 18, 20], 3: [3, 6, 9, 12, 15, 18], 4: [4, 8, 12, 16, 20], 5: [5, 10, 15, 20], 6: [6, 12, 18], 7: [7, 14], 8: [8, 16], 9: [9, 18], 10: [10, 20]}

A Word of Caution

List comprehensions are great, but they can get confusing. Error on the side of readability.

```
nums = [n for n in range(100) if
        sum([int(j) for j in str(n)]) % 7 == 0]

nums = []
for n in range(100):
   digit_sum = sum([int(j) for j in str(n)])
   if digit_sum % 7 == 0:
      nums.append(n)
```

Ternary Assignment

A common pattern in python

```
if x > threshold:
    flag = True
else:
  flag = False
```

Or

```
flag = False
if x > threshold:
  flag = True
```

Ternary Assignment

A common pattern in python

```
if x > threshold:
    flag = True
else:
  flag = False
```

```
flag = True if x > threshold else False
```

Ternary Expression
Three elements

Ternary Assignment

```
flag = True if x > threshold else False
```

Result if true

Condition

Result if false

- Only works for single expressions as results.
- Only works for if and else (no elif)

Ternary Assignment

Goal: A list of 'odd' or 'even' if that index is odd or even.

```
the_list = []
for i in range(16):
    if i%2 == 0:
        the_list.append('even')
    else:
        the_list.append('odd')
```

```
the_list = []
for i in range(16):
    the_list.append('even' if i%2 == 0 else 'odd')
```

```
the_list = ['even' if i%2 == 0 else 'odd' for i in range(16)]
```

Next time… **Tuples, Sets, and Dictionaries**

Tuples

```
t1 = ()
t2 = (1, 'two', 3)
print(t1)
print(t2)

>> ()
>> (1, 'two', 3)
```

Sets

```
odd = set([1, 3, 5])
prime = set([2, 3, 5])
empty = set([])
```

Dictionaries