Arrays

5	3	2	4	7	1	3	30	8	
0	1	2	3	4	5	6	7	8	9

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Problem: Basic statistics program

Write a program to output the average, ***a***, the **median, x,** and the **standard deviation, s,** of a series of test values typed in by the user.

- **The median** is the middle value in a list of values.
- **The standard deviation** is a measure of how spread-out the data is and is calculated using this fomula:

$$s = \sqrt{\frac{\sum(\bar{x} - x_i)^2}{n-1}}$$

standard deviation: a quantity expressing by how much the members of a group differ from the mean value for the group.

We can calculate the average

module: 1skeleton_median_std_dev.py

Checkpoint (for test):

What kind of errors occur when writing code for average?

What would be a good testing strategy?

What input values values do we need for a complete statement test?

What input values values do we need for a complete path test?

What are the equivalence classes and boundary values?

We can calculate the average

module: 1skeleton_median_std_dev.py

… but we don’t yet have the tools for the median and standard deviation. We need…..

Concept: Arrays

An array is an **indexed sequence** of values associated with **one variable**.

Array values:	5	3	2	4	7	1	3
index	0	1	2	3	4	5	6

- Arrays can be fixed length or variable length.
- Arrays can hold multiple values of the same type or different types.

Python Arrays: Lists

In Python, an array is called a **list**.

To create a list:

- list1 = [ ] # empty list
- nums = [1, 2, 3, 4, 7, 8, 9, 10, 13, 14, 15] # list of numbers
- animals = ['cat', 'dog', ’baboon', 'bison’] # list of strings
- stuff = [1, 2, 'hello'] # mixed type list (yes we can do that)

Common Operations 1/5

Adding an item to a list

X =

5	3	2	4

↓

X.append (3)

↓

X =

5	3	2	4	3

Common Operations 2/5

Accessing an item in a list

X =

5	3	2	4

↓

print (X[1])

↓

3

Common Operations 2/5

Accessing the last item in a list

X =

5	3	2	4

↓

```
print (X[-1])
```

↓

4

Common Operations 4/5

Changing an item in a list

X =

5	3	2	4

↓

X[2] = 7

↓

X =

5	3	7	4

Common Operations 5/5

Iterating over items in list – processing each item in the list individually.

- When you do **not** need to know the **indices** use -

```
for a in X:
    print(a)
```

- When you do **need** to know the **indices** use -

```
for n in range (len (X)):
    print(n, X[n])
```

Checkpoint/reminder

This function finds the first occurrence of an item in a list:

```
def index (values, item):
    for i in range (len(values)):
        if values[i] == item:
            return i
    return -1
```

*How many test values are required for **exhaustive testing** of this function?*

Checkpoint

This function finds the first occurrence of an item in a list:

```
def index (values, item):
    for i in range (len(values)):
        if values[i] == item:
            return i
    return -1
```

Does the following set of input values constitute a **statement coverage test** of the code?

[1,2,3], 0
[3,4,5], 3

Checkpoint

This function finds the first occurrence of an item in a list:

```
def index (values, item):
    for i in range (len(values)):
        if values[i] == item:
            return i
    return -1
```

Provide a set of input values that will constitute a **path test** of the code.

Checkpoint

This function finds the first occurrence of an item in a list:

```
def index (values, item):
    for i in range (len(values)):
        if values[i] == item:
            return i
    return -1
```

*Describe the **equivalence classes** for this code, and give **candidate input values** for each class.*

Checkpoint

This function finds the first occurrence of an item in a list:

```
def index (values, item):
    for i in range (len(values)):
        if values[i] == item:
            return i
    return -1
```

*Describe the **boundary values** for this code, and give an example of each.*

Common Pitfall/Error

Accessing an item that is not in the list!

- Python's response:

```
Traceback (most recent call last):
  File "<string>", line 1, in <fragment>
builtins.IndexError: list index out of range
```

- Solution:
  - Check the list length first and make sure the item exists!

Basic List Manipulation

Operation	Syntax	Example	Example output
Merging lists (concatenation)	<list1> + <list2>	X = [1,2] Y = [3,4]	[1,2,3,4]
Checking for item (**membership**)	<item> in <list>	X = [1, 2] 1 in X	True
Multiplying content of lists (repetition)	<list> * <n>	X = [1,2] X * 2	[1,2,1,2]
Access list item **(indexing)**	<list>[<index>]	X = [1,2,3] X[2]	3
Get length of list **(length)**	len(<list>)	X = [1,2,3,4] len(X)	4
Delete item	del <list>[<i>]	X=[1,5,6,7] del X[2]	X=[1,5,7]
Get **slice** of list (slicing)	<list>[start:stop:step]	X = [4,5,6,7] X[1:3]	[5,6]
Iterate over list (iteration)	for <var> in <list>:	X = [2,4,6] for a in X: print (a+1)	3 5 7

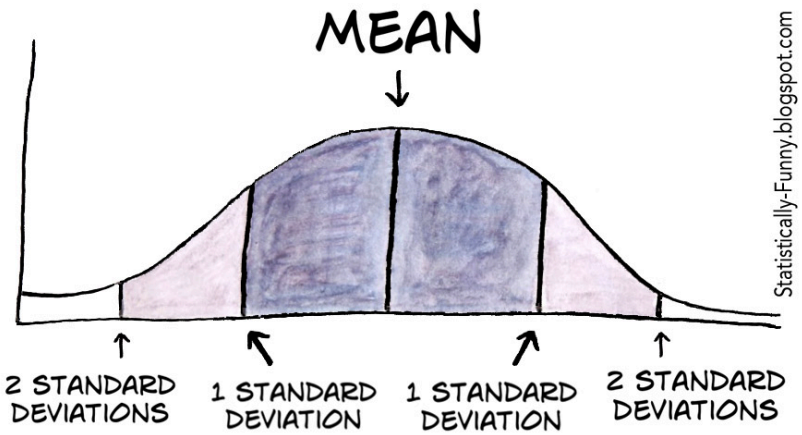
Common List Functions

Function	Syntax	Example	X
		X = [1,3,5,4,2]	
Add element to end	<list>.append(<item>)	X.append(6)	X=[1,3,5,4,2,6]
Sort list	<list>.sort()	X.sort()	X=[1,2,3,4,5,6]
Reverse items	<list>.reverse()	X.reverse()	X=[6,5,4,3,2,1]
Find position of item	<list>.index(<item>)	Y = X.index(4)	Y=2
Insert item into list	<list>.insert(<i>,<item>)	X.insert(2,2)	X=[6,5,2,4,3,2,1]
Count occurrences of item	<list>.count(<item>)	Y=X.count(2)	Y=2
Remove first occurrence of item	<list>.remove(<item>)	X.remove(2)	X=[6,5,4,3,2,1]
Remove and return specified item	<list>.pop(<i>)	Y=X.pop(1)	Y=5, X=[6,4,3,2,1]
Split string into list	<string>.split(<sep>)	“4,7,3”.split(“,”)	['4','7','3']
Join list into string	<sep>.join(<list>)	“-”.join(['4','7','3'])	“4-7-3”

Problem – can we do this now?

- Write a program to output **the median,(x),** and the **standard deviation (s)** of a series of values typed in by the user.

$$s = \sqrt{\frac{\sum(\bar{x} - x_i)^2}{n-1}}$$



A plot of a normal distribution (or bell-shaped curve) where each band has a width of 1 standard deviation

Problem – can we do all this now?

- Write a program to output **the median,(x),** and the standard deviation (s) of a series of values typed in by the user.

$$s = \sqrt{\frac{\sum(\bar{x} - x_i)^2}{n-1}}$$

Problem

Write a program to act as the “Magic 8-ball”.

The Magic 8-Ball is a toy used for fortune-telling or seeking advice, developed in the 1950s and manufactured by Mattel.

It is often used in fiction, often for humor related to its giving accurate, inaccurate, or otherwise statistically improbable answers. [Wikipedia]

Problem

Write a program to perform some common list functions without using the built-in functions:

- reverse
- Index
  - Did this one already
- count

Problem

Write a program to generate custom spam.

- The user must enter a list of names and a message.
- Then the program must print out a customised message, in each case with <name> replaced by the actual name.

(This is called “templating”.)

e.g.

Congratulations <name> you have won R10 000 000! To claim your reward <name>, send your banking details to Ms Connie Art at another.mark@gmail.com. Don’t forget to include your bank login details!

The prefix-sum problem

Given a list of integers, **`input`**, produce **`output`** where **`output[i]`** is the sum of **`input[0]+input[1]+…+input[i]`**

Also called cumulative sum or scan.

The Python Standard Library

https://docs.python.org/3/library/

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The Python Standard Library

While The Python Language Reference describes the exact syntax and semantics of the Python the standard library that is distributed with Python. It also describes some of the optional co distributions.

Python's standard library is very extensive, offering a wide range of facilities as indicated by t contains built-in modules (written in C) that provide access to system functionality such as Python programmers, as well as modules written in Python that provide standardized solu programming. Some of these modules are explicitly designed to encourage and enhance the p platform-specifics into platform-neutral APIs.

The Python installers for the Windows platform usually include the entire standard library and For Unix-like operating systems Python is normally provided as a collection of packages, so provided with the operating system to obtain some or all of the optional components.

In addition to the standard library, there is a growing collection of several thousand compo packages and entire application development frameworks), available from the Python Package

2-Dimensional Arrays

Each item in an list could itself be a list.

- For example:

```
X = [[1,2], [3,4]]
```

2-D arrays/lists are equivalent to matrices or grids.

- All operations work just as before, but every item is now a list.
- To access an item, remember that X[0] will give us a list, so X[0][0] gives us the item in position (0,0) of the grid.

2-Dimensional Arrays

X

[0][0]	[0][1]	[0][2]	[0][3]
[1][0]	[1][1]	[1][2]	[1][3]
[2][0]	[2][1]	[2][2]	[2][3]
[3][0]	[3][1]	[3][2]	[3][3]

Problem

- In computer graphics, a gradient fill is when the colour of an area gradually changes from one colour to another.
  - Write a program to output the result of a gradient fill on a 4x4 grid of pixels where the top-left pixel is 0 and the bottom-left is 6.

0	1	2	3
1	2	3	4
2	3	4	5
3	4	5	6

n-Dimensional Arrays

Lists can easily contain more than 2 dimensions.

- For example a 3-d structure can be:
  - X=[[[1,2],[3,4]], [[5,6],[7,8]], [[9,10],[[11,12]]]
  - X[1][1][0]= ?

Suppose we want to store a list of students, with a list of courses for each student, and a list of test dates for each course, and a list of chapters per test, we could use the following 4-d list:

- students = [['saleem',['csc1015f',['12 april',['5','6','7']]]]]

Dictionaries

Instead of a sequence with indices, Python also has a data structure with arbitrary index values and no order - this is called a dictionary.

- A dictionary is a set of key=value pairs.
- Dictionaries are very efficient for storing/retrieving values and mapping one list to another.

- Define as follows:
  - D={'a':'apples', 'b':'bananas', 'p':'pears'}

Common Dictionary Operations

Function	Syntax	Example	X
Checking for key	<key> in <dict>	X = {1:2} 1 in X	True
Access dictionary item	<dict>[<key>]	X = {1:2, 3:4} X[3]	4
Get keys	<dict>.keys()	X= {1:2, 3:4} X.keys()	[1,3]
Get values	<dict>.values()	X= {1:2, 3:4} X.values()	[2,4]
Delete item	del <dict>[<key>]	X= {1:2, 3:4} del X[3]	X={1:2}
Clear dictionary	<dict>.clear()	X = {1:2, 3:4} X.clear()	X={}
Iterate over keys	for <var> in <dict>:	X={1:'One',2:'Two',3:'Three'} for a in X: print (X[a])	One Two Three

Problem

- Count the number of times each unique word occurs in a sentence. E.g.

It was a bright cold day in April, and the clocks were striking thirteen. Winston Smith, his chin nuzzled into his breast in an effort to escape the vile wind, slipped quickly through the glass doors of Victory Mansions, though not quickly enough to prevent a swirl of gritty dust from entering along with him.

Generic structures

- Every data structure is generic. So just as it is possible to have n-dimensional lists, you can have dictionaries of lists, list of dictionaries, etc.

```
D = {'kayleigh':[12,23,31],
'callum':[45,54,55]}

E = [{'name':'palesa','year':1},
{'name':'luqmaan','year':1}]
```

Challenge

- Write a single-player Battleships game
  - the user is presented with a 10x10 grid with hidden warships and must guess the locations of these warships until all are hit.

Arrays in Functions

- Passing arrays to functions

  In Python, the values of actual parameters cannot be changed in a function.

  - Arrays cannot be replaced.

  HOWEVER, the contents of arrays can be changed.

  - This is a way of passing back multiple values from a function

Checkpoint

What is the **exact output** of this code?

```
#scope.py - illustrating scope
def tester(myArr):
    print("In function, before append",myArr)
    myArr.append('a')
    print("In function, after append",myArr)
    myArr=['a','b','c']
    print("In function, after reassignment",myArr)

print()
arrMain=["one","two","three"]
print("Before function call", arrMain)
tester(arrMain)
print("After function call", arrMain)
```

Reminder: Variable Scope and lifetime

Not all variables are accessible from all parts of our program, and not all variables exist for the same amount of time.

Where a variable is accessible and how long it exists depend on how it is defined.

- the part of a program where a variable is accessible or modifiable called its **scope**
- the duration for which the variable exists is its **lifetime.**

formal parameters can also only be seen inside the function

- even if they have the same name

Reminder: Scope

A variable which is defined in the main body of a file is called a **global** variable.

- It will be visible throughout the file, and also inside any file which imports that file.

A variable which is defined inside a function is **local** to that function.

- It is accessible from the point at which it is defined until the end of the function, and exists for as long as the function is executing.
- The parameter names in the function definition behave like local variables
  - but they contain the values that we pass into the function when we call it.

Reminder: Global variables

- global / nonlocal
  - Python parameters can be declared as **global** in a function to indicate that the variable being used is actually declared outside any functions (not recommended)
  - **nonlocal** can be used similarly for nested functions.

Checkpoint

Describe briefly, and in clear English, what the function Enigma returns

```
def Enigma(lst,item):
    tmp=[]
    for i in lst:
        if i!= item:
            tmp.append(i)
    return tmp
```

Checkpoint

Write down the exact output:

```
def main():
    list1=[2,4,6,6,8,10]
    list2=["Skipper","Kowalski","Rico","Private","King
   Julian"]
    list3=[[1,2],[3,4],[5,6]]
    print(Enigma(list2,"King Julian"))
    print(Enigma(list1,9))

main()
```

Checkpoint

Rewrite the code for the function Enigma(lst, item) so that it works as follows. This function should return True if every element in lst is greater than item.

For example (in the Python3 interpreter):

```
>>>Enigma(["buffalo","zebra","goldfish"],"aardvark")
>>>True
>>>Enigma([1,2,3,1,5,6],3)
>>>False
```