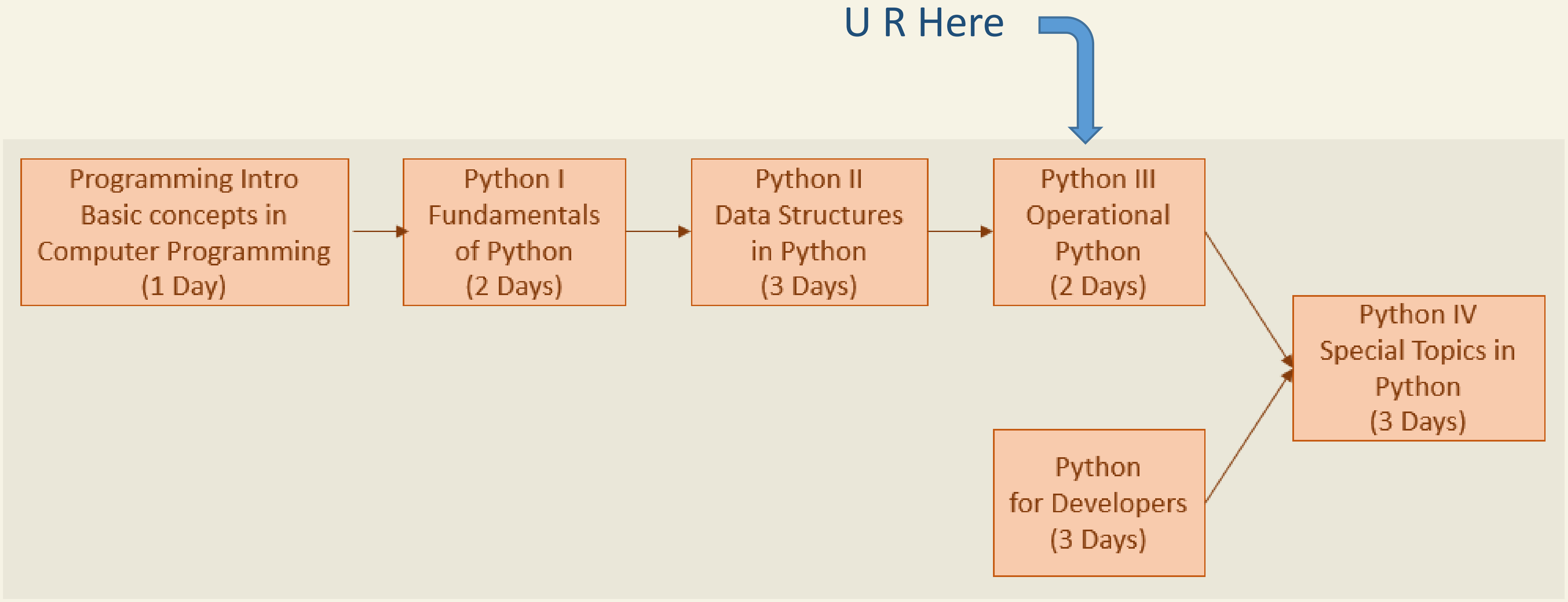
Python III

Rev 10/20/2019

Python Classes



U R Here
Programming Intro Basic concepts in Computer Programming (1 Day)
Python I Fundamentals of Python (2 Days)
Python II Data Structures in Python (3 Days)
Python III Operational Python (2 Days)
Python for Developers (3 Days)
Python IV Special Topics in Python (3 Days)

Objective:

- 20% Lecture
- 80% Lab
- Use Python V3

INTRODUCTIONS

- Instructor
- Students
    - What is your current job
    - When did you take Python II?
    - Python-wise, what have you done since Python II?
    - What is your objective/goal in taking this class?

PAPERWORK

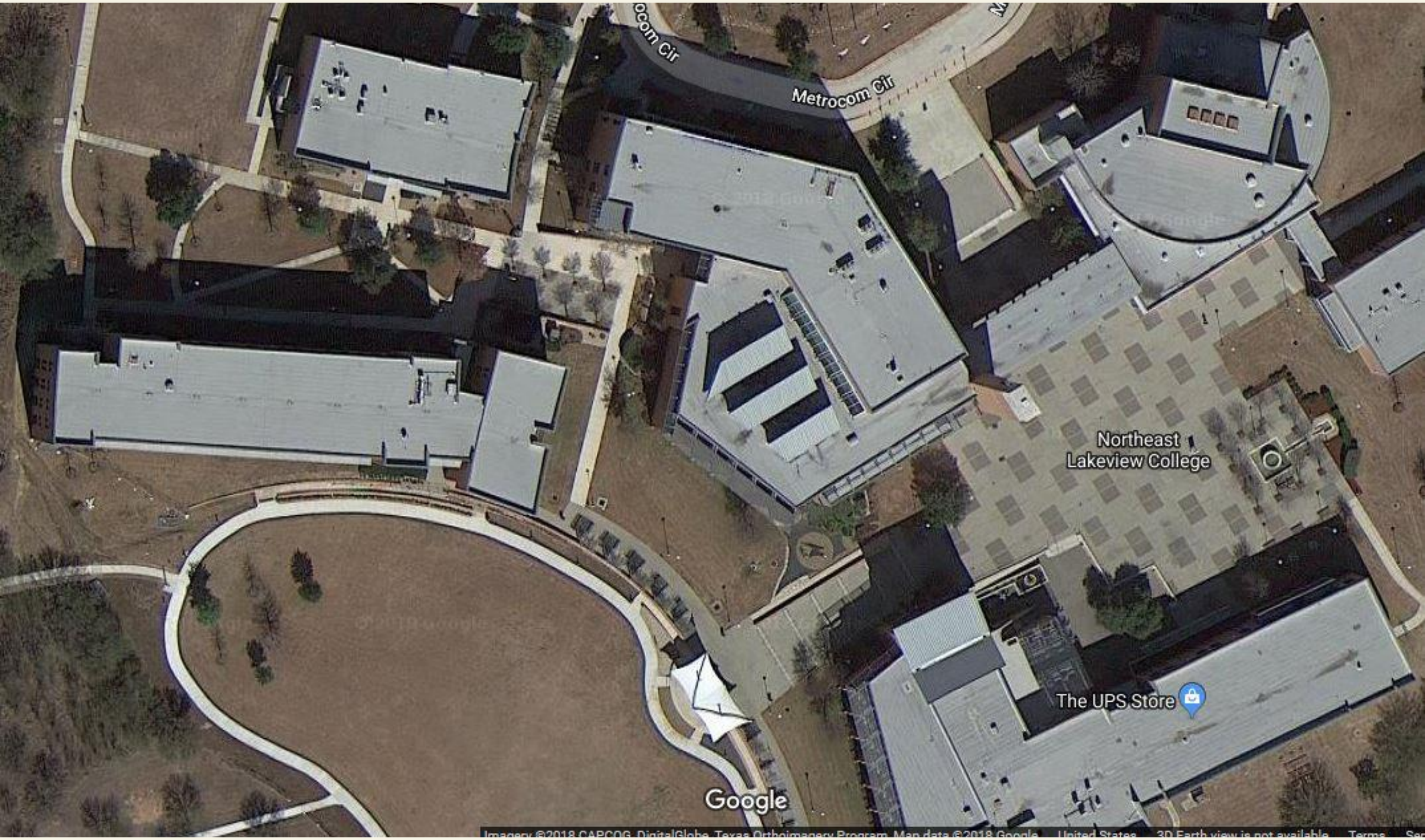
- Grant registration
  - Fill in at least the fields for gender, birth date and your name at the top and the signature line at the bottom. The rest is optional, but the ACCD would appreciate having it.
- Grant daily sign-in and sign-out sheet
- If you have questions, my e-mail is:
  - weastridge@gmail.com
  - Make the subject: Python

Castle Lab Environment

- ID – student, password - student
- IDLE Install
  - For CentOS: sudo yum install python-tools
  - For Ubuntu et al: sudo apt-get install idle
  - Windows and MacOS come with IDLE installed
    - Macs with retina displays may require a larger font size than the default to make underscores show properly.
- CentOS7 at the Castle has IDLE already installed.
- To create an icon for IDLE:
  Drag the file Idle3.desktop to the desktop, double-click it and trust it. This is your icon for IDLE.
- Data
  - go to bit.ly/pyhandouts
  - This file contains documents, samples and data for labs

NLC Lab Environment

- Lab machines are running Windows 10.
  - This image is refreshed nightly. Save your data (cloud, USB).
  - The image includes Python version 3.7
  - DO NOT LOCK THE COMPUTER WHEN YOU LEAVE THE ROOM!
- To get to IDLE:
  - Search on Python
  - Right click on IDLE and save on Start menu.
  - Drag from Start menu to Desktop if you want and icon there.
- Data
  - go to bit.ly/pyhandouts
  - This file contains documents, samples and data for labs


Metrocom Cir
Metrocom Cir
Northeast Lakeview College
The UPS Store
Google
Imagery ©2018 CAPCOG, DigitalGlobe, Texas Orthoimagery Program, Map data ©2018 Google
United States
3D Earth view is not available
Terms

Resources

- You should already have two books in PDF format:
  - Think Python
  - Python for Everybody
  - If you don't have these, let me know.
- DemoProgs – a collection of Python programs that concentrate on specific aspects of the language
- Samples - a set of screen shots designed to augment classroom discussion.
- LabsData – data and code to be used in lab exercises.
- Python Notes – a set of notes with explanations of various topics and pointers to articles containing more explanations. It is also a collection of methods used by various Python data structures.
- Python Notes Addendum – a short document containing pointers to intermediate-level Python topics.
- Completed Labs – made available online at bit.ly/pylastlab after each lab.

The Zen of Python, by TimPeters:

- Beautiful is better than ugly.
- Explicit is better than implicit.
- Simple is better than complex.
- Complex is better than complicated.
- Flat is better than nested.
- Sparse is better than dense.
- Readability counts.
- Special cases aren't special enough to break the rules.
  - Although practicality beats purity.
- Errors should never pass silently.
  - Unless explicitly silenced.
- In the face of ambiguity, refuse the temptation to guess.
- There should be one-- and preferably only one --obvious way to do it.
  - Although that way may not be obvious at first unless you're Dutch.
- Now is better than never.
  - Although never is often better than **right** now.
- If the implementation is hard to explain, it's a bad idea.
- If the implementation is easy to explain, it may be a good idea.
- NameSpaces are one honking great idea -- let's do more of those!

Class Structure

- We will use IDLE or Vim and command line. Remote users with Python installed locally will use that environment.
- Outline
  - Review
  - Python version 3 changes
  - Clarifying/Expanding – translate, with, sorting, copying
  - Comprehensions, lambda functions, generators and recursion
  - Classes, inheritance, namespaces, scoping and importing
  - System-oriented modules
  - Debugging tools
  - Using the 2to3 converter.

Review

- Which of the following are sequences? Iterables?
  strings, lists, tuples, dictionaries, sets, files
- How many bits does it take to define an ASCII character?
- What does ord ('a') produce? What does the chr() function do?
- Name four string methods we used in the previous class and their purpose.
- What operator concatenates two strings? Replicates a string?
- What function provides the number of characters in a string?
- How do you create a new string without the last character of the original string? Without the first character? Reversed?
- If the variable x is a string, what does x.split(',') do? How about x.split()?

Review

- Why is the following code considered sloppy?
  `updates = set(open('c:/pydata/serverupdates.txt', 'r'))`
- What are the two basic ways to create an empty list?
- What data types can a list contain? Must all items in a list be of the same type?
- In a two-dimensional list named my_lst, how do I access the third entry in the fifth row?
- What does x contain after executing the following: x = my_lst.sort()?
- What is an alias? How did we learn to prevent them?
- How would I remove the last item in a list and save it in variable y?
- What are the differences between the sort method and the sorted function?
- What does the splitlines method do? Where is it most useful?

Review

- What is a tuple and how does it differ from a list?
- Are there any methods that work on a tuple?
- Where did we see tuples in previous classes? How were they used?
- What are the two basic purposes of sets.
- What kind of data can a set contain?
- What will this set contain: x = set([12, 3, 2, 12, 5, 2, 3, 12, 5])?
- Name two methods used with sets and what they accomplish.
- What data type is x if x = {1, 2, 3}? If x = {}?
- Have you discovered an alternative to the following comparison:
  x >= 50 and x <= 100? (See chained comparisons)
- If x = 0 or "" or [], is it True or False? What if x = 1 or " " or [4]?

Review (sort of)

- Determine how the following code will be evaluated:

```
x = 'b'
y = ''
z = [1, 2, 3]
w = []
if x:  print('x True')
if y:  print('y True')
if z:  print('z True')
if w:  print('w True')
if x == 'a' or 'b':  print('True')  # Common semantic error
if x == 'a' or 'c':  print('True')
```

Review

- What is the structure and purpose of a dictionary?
- If x = 'abcd' and y = ['a', 'b', 'c', 'd'], what happens if I execute:
  y[2] = 'z'; x[2] = 'z'
- What does the len function produce when applied to a dictionary? The in operator?
- Why would you get a KeyError exception accessing a dictionary? What method will avoid this error?
- What type of data can reside in the key portion of a dictionary? In the value portion?
- For the dictionary dc1, what does dc1.keys() produce? dc1.values()? dc1.items()? See dictionary.views.py in DemoProgs.
- Review some of the differences between Python versions 2 and 3.

Lab 01 - Review

- In your data you will find the file labeled, “alice_in_wonderland.dat.” You will also find a file labeled, “words.txt.” The latter file contains over 113,000 English-language words. Your job is to perform the following:
  - Create a dictionary for counting using the entries from words.txt as the keys.
  - Parse the text in alice_in_wonderland.data isolating each word.
  - Find each word from the book in your dictionary and increase the count for that word by one.
  - If a word is not found in the dictionary, place it in a list with other unfound words.
  - When you have processed the entire book, determine the percentage of words in the dictionary that were used in the book. and which word was used the most.
  - Remove the duplicates from the list of unfound words, sort it and print it.
- Don't try too hard to make this perfect. It won't happen!
- Hint: Remove apostrophes and replace all other punctuation with spaces.

Completing Labs

- We will be doing a lot of labs.
- Many people going through this class are unable to complete all of these labs.
- Actually completing the lab is not as critical as making a serious effort to do so.
  - This will make the explanation of the completed lab make more sense to you.
- An inability to finish the labs is no reason to become discouraged. This happens to most people going through this class.

with Statement

- This statement is a "context manager" which can handle a wide variety of situations.
- The simplest of these involves files.
  - Garbage collection/cleanup routines close files most of the time.
  - Good programming technique requires that you don't depend on it.
- What does this code do?

  -
    ```
    try:
        filein = open('some file', 'r')
        do a bunch of other stuff with the file
    finally:
        filein.close()
    ```

with Statement

- The with statement makes this simpler
  - with open('some file', 'rt') as filein:
        do a bunch of other stuff with the file
  - The above code does the same as the try/finally
  - As usual, everything you do with the file has to be indented.
  - At the end of the suite of code, the file is closed automatically
- Continuations (from PEP 8)

```
with open('/path/to/some/file') as file_1, \
     open('/path/to/another/file', 'w') as file_2:
     file_2.write(file_1.read())
```

- Have you discovered the r+ and w+ options in opening a file? See io_rplustest.py and io_wplustest.py in DemoProgs.

Lab 02

Go back and change the last lab to open both files in a with statement. Remember, this precludes the need to close the file. My version of the last lab is available online.

fromkeys Dictionary Method

- The fromkeys method can be used to easily and efficiently initialize a dictionary. It is our first static method.
- A static method does not use the object it is attached to. Python still forces you to attach it to the correct data type.
- General format: dict.fromkeys(iterable[, init]) init defaults to None
- Comparison: (Do these in the shell displaying z1 and z2 contents)

```
x = 'abcd'
y = ['wrd1', 'wrd2', 'wrd3', 'wrd4']
z1 = dict.fromkeys(y); z2 = dict.fromkeys(y, 0)  # The dictionary dict is
z1 = {}.fromkeys(y); z2 = {}.fromkeys(y, 0)  #  irrelevant  as is {}
z1 = dict.fromkeys(x, -1)  # works the same with a string
```

Lab 03a

Go back to the last lab and create the dictionary from words.txt by using the fromkeys method. Remember, you have to remove the newline character from each word. Consider reading the whole file into memory and using the splitlines method.

My version of the last lab is available online.

translate Method

- An easier way to do multiple conversions/deletions in a string is with translate.
- Translate takes one required argument. It is a dictionary containing each character to be replaced or deleted.
  - You use the maketrans static method to create this dictionary.
- Maketrans produces the dictionary required by translate. It has two required arguments and an optional argument:
  - The first argument contains the string of characters you wish to modify.
  - The second contains the corresponding replacement characters. It must be the same length as the first argument.
  - The optional third argument contains the characters you want to delete.
  - Maketrans is now a built-in, static, string method. No import required.

translate Examples

```
x = "Don't worry-be happy!"
temp = str.maketrans('y!', 'i?', "'")
y = x.translate(temp) # or
y = x.translate(str.maketrans('y!', 'i?', "'"))
y now contains:
        "Dont worri-be happi?"
z = y.translate(str.maketrans('', '',  '-?'))
z now contains:
        "Dont worribe happi"
```

Lab 03b

Go back to the last lab and use the translate and maketrans methods to deal with the replacement or removal of punctuation.

My version of the last lab is available online.

Sorting

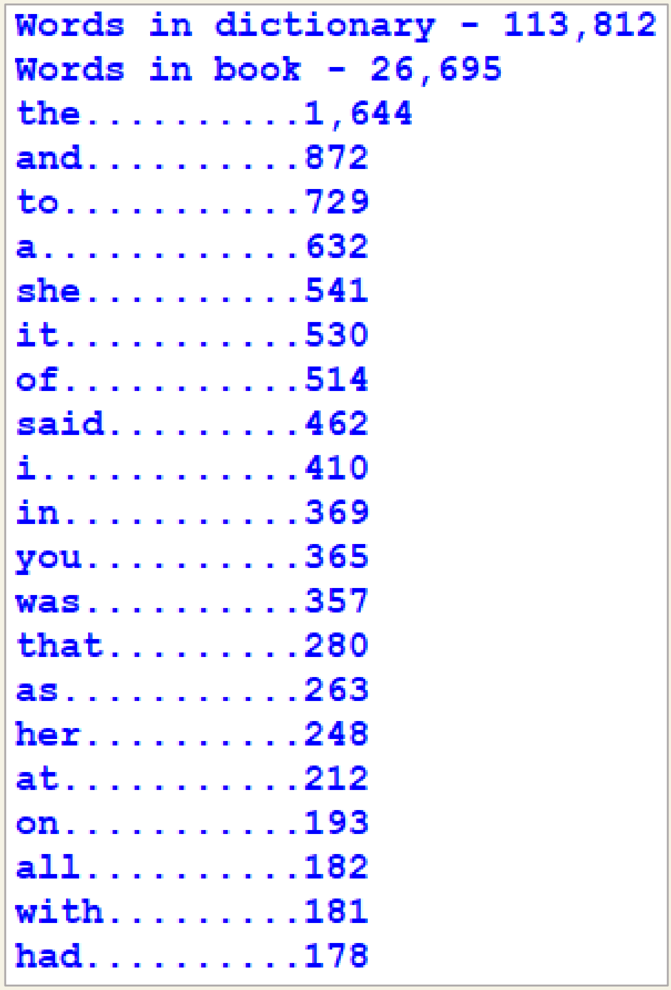
- The sort and reverse methods operate only on lists
- The sorted and reversed functions operate on any iterable.
  - Also, they produce a result and leave the original object intact.
- Given x = (12, 18, 200, 5, 1, 10), what do these produce?
  - y = sorted(x); z = reversed(y) – data type and contents
  - Given what we have covered in Python II, how can we combine the above operations?
- Review b0sort.jpg in Samples.

Sorting

- Both the sort method and the sorted function have more options:
  - key= and reverse=
- reverse= allows reverse to be incorporated into the sort
  - Ex: reverse = True – reverses an ascending sort
- key= allows the passing of a function along with a method if desired.
  - Ex: key = str.lower – sorts as though all text data is lower case.
- Using itemgetter "function" in the operator module to specify which item(s) to sort on in two-dimensional lists.
  - See b1Sort.jpg and b2Sort.jpg in Samples.

Lab 04

Modify the results of Lab 03 (available online) to print just the top 20 words along with their respective use counts. Print them in descending order by use count. Do the sorting in one statement using the capabilities we have just reviewed. It isn't necessary to print all the data we have printed previously. The objective here is to ensure you can sort using the capabilities we just reviewed. Unload the dictionary with the items method and sort those results directly. Also, some code later in the program needs to be changed. Determine what that is.



```
Words in dictionary - 113,812
Words in book - 26,695
the..........1,644
and..........872
to...........729
a............632
she..........541
it...........530
of...........514
said.........462
i............410
in...........369
you..........365
was..........357
that.........280
as...........263
her..........248
at...........212
on...........193
all..........182
with.........181
had..........178
```

Copying Mutables

- Copying lists and dictionaries is NOT straightforward.
- Aliases are very easy to create unintentionally
- x = [1, 2, 3, 4]; y = list(x)
  - We have just created a shallow copy
  - Only the first level is unique
  - That works fine with this example
- Successive levels beyond the first will be aliased.
- The deepcopy function in the copy module helps with this problem.
- Deepcopy works with more object types. We are only using it for lists and dictionaries here.

Copying Mutables

- List examples:
  - Review d1Deepcopy.jpg in Samples.
  - Review d2Alias1.jpg and d2Alias2.jpg in Samples.
    - Be very careful in initializing lists
    - Deepcopy will not help you here
    - List comprehensions will make this process easier
- Dictionary entries are vulnerable to aliasing.
- d1 = dict(d2) creates a shallow copy of dictionary d2.
- If your dictionary contains lists and/or other dictionaries:
  - Use deepcopy to get an independent copy

Shebang and Encoding

- The shebang allows you to execute the program as a script
  - #!/usr/bin/env python3
  - #!/usr/bin/python3
- Use chmod to make them executable
- On Windows, simply open with python.exe. The shebang is good if you want to be Linux-compatible.

- Python2 uses ASCII by default. Python3 uses Unicode.
- If your Python 2 code goes beyond ASCII use:
  - # -*- coding: utf-8 -*-   or, # -*- coding: latin-1 -*-
  - Refer to Python Notes for encoding articles
  - See ucode.py and ulatin_print.py in DemoProgs

Review – Filter and Map

```
# This loop selects only the even numbers to be included in a new list
# This is an example of filtering.
y = []
for i in range(2,20,3) :
    if i % 2 == 0:
        y.append(i)
print y

# This loop creates a new list containing the square of each entry in
# list x.  This is an example of mapping.
y = []
for i in range(2,20,3) :
    y.append(i**2)
```

List Comprehensions

- General Format:
  [expression for item1 in iterable1 (if condition1)
  for item2 in iterable2 (if condition1) …]
- All values of expression that meet the optional conditions are included in the final list.
- Nesting is not recommended as it makes the code difficult to read.
- Examples:
  [x*2.5 for x in range(5)]
  result - [0.0, 2.5, 5.0, 7.5, 10.0]
- [x for x in range(10) if x % 2 == 0]
  result - [0, 2, 4, 6, 8]
- Convenient way of initializing a list with an arbitrary expression.

List Comprehensions

- General Format:
  [expression for item1 in iterable1 (if condition1)
  for item2 in iterable2 (if condition1) …]

```
y = []
for i in range(2,20,3):
    y.append(i**2)
```

```
y = [i**2 for i in range(2,20,3)]
```

```
y = []
for i in range(2,20,3):
    if i % 2 == 0:
        y.append(i)
```

```
y = [i for i in range(2,20,3) if i % 2 == 0]
```

- Note – review iList8.jpg and jDictionary2.jpg in Samples

Dictionary and Set Comprehensions

- As you have seen with lists, these:
    - are a shorthand way of initializing these data structures.
    - allow control of the number of elements, and built-in filtering all in one operation.
    - The alternative is to use for loops which are sometimes more readable and sometimes not.
- Examples (can you guess which is which?):
    - y = {x**2 for x in range(5)}
    - y = {(x, x**2) for x in range(5)}
    - z = {x: chr(x+65) for x in range(20)}

Lab 06

Using range(-40, 120, 10) as input, create three comprehensions. Assume the values in the range represent Fahrenheit temperatures. The comprehensions should calculate the corresponding Centigrade temperature. (Centigrade = 5.0/9.0 * (Fahrenheit - 32))

- Create a list and a set using comprehensions. Both the list and the set should contain tuples which contain each Fahrenheit/Centigrade pair. Exclude the entries for Fahrenheit temperatures zero and 50.
- Create a dictionary comprehension with the Fahrenheit temperatures as keys and Centigrade temperatures as values. Use the same exclusions as above.

Functions

- Functions are objects just like everything else in Python
  - They can be contained in / pointed to by another variable
- Also, functions come in several flavors:
  - Lambda functions – unnamed one liners
  - Generators – produce results as needed
  - Recursive functions – call themselves
- We will study all three of these function types

Function Basics

```
def convert(f_temp):
    c_temp = 5.0 / 9.0 * (f_temp - 32)
    return c_temp

f_to_c = convert  # without the parens, this just assigns the function
for temp in range(-40, 120, 10):
    ftemp = float(temp)
    if ftemp == 0 or ftemp == 50:
        continue
    ctemp = f_to_c(ftemp)
    print('{0:.1f} degrees Fahrenheit is {1:.1f} degrees Centigrade'
            .format(ftemp, ctemp))
```

Lambda Functions

- Lambda functions are anonymous, one-line functions composed of an expression and often assigned to variables.
- They are used to avoid littering your program with small functions.
- A lambda function can take multiple arguments and produce one result - just like any other function.
- General syntax
  - lambda input variable(s): expression to create a return
- Examples:
  a1 = lambda x : x ** 2 # one input - x
  a1(5) produces 25
  f = lambda x, y : x + y # two inputs – x and y
  f(14, 12) produces 26
- Run these examples in the Python shell.
  Then try f = lambda x, y : (x + y, x * y)
  What is returned for f(14, 12)?

Lambda Functions

- Typically, you do not assign lambdas to a variable.
  - We do it here for purposes of illustration and learning.
  - Lambdas are usually used wherever you can place an expression.
  - Often, lambdas are passed to other programs (e.g., sort)
- Examples:

```
a1 = lambda x : x ** 2  # from the last slide
def a1(x):  return x ** 2  # Use this definition instead

f = lambda x, y : x + y  # from the last slide
def f(x, y): return x + y # Use this definition instead
```

- See Programming Recommendations in PEP8

Lab 07 - Lambda Functions

Take the program tempconversion.py in your data folder containing a function and replace the function that does the conversion with a lambda function to do the same thing. This does require assigning the lambda function to a variable.

Filter, Map, Reduce

- All of these can be done using techniques we have learned.
- They can also be done using built-in functions and lambdas.
  - Filter(), Map(), Reduce() and Lambda functions
- The initial developer of Python, Guido van Rossum, wanted all three of these built-ins as well as lambda functions removed from Python 3.0. He was unsuccessful.
  - Reduce() did get moved to the functools module and has to be imported.
- Example: (Try in the shell)
  - y = [2, 6, 9] # map and filter produce iterators in Python 3.x
  - x = map(lambda z : z ** 2, y); print(list(x))
  - x = filter(lambda z : z % 2 == 0, y) ; print(list(x))

Another Lambda Example

- Sorting alternative

  x = [(0, -1, 3), (-1, 0, 4), (2, -6, -5), (1, 3, -2), (3, 2, 1)]

  - How do I sort on the absolute value of the second element?

  sorted(x, key=lambda y: abs(y[1]))   Result:

  [(-1, 0, 4), (0, -1, 3), (3, 2, 1), (1, 3, -2), (-2, -6, -5)]

- Lambdas are used extensively in GUI's (tkinter, wxPython)
- See sortkey.py and sortrand.py in DemoProgs
- Also, see how functions can be passed in kFunctions in Samples

Iteration, Iterable and Iterator

- Iteration is a general term for taking each item of something, one after another. Any time you use a loop, explicitly or implicitly, to go over a group of items, that is iteration.
- In Python, iterable and iterator have specific meanings:
  - An iterable is anything that can be looped over. As you have seen, you can loop over a string, a file and a number of other objects.
  - An iterator is an object with state that remembers where it is during iteration, returns the next value in the iteration, updates the state to point at the next value and signals when it is done by raising a StopIteration condition.
- Whenever you use a for loop and a number of other tools in Python, the next method is called automatically to get each item from the iterator, thus going through the process of iteration. It also handles the StopIteration condition.

yield Statement

- yield is similar to return, but suspends execution of the called function instead of ending the function
- On the next call to the function, yield picks up where it left off, with all identifier values still holding the same values (a return loses its identifier values)
- This type of function is called a generator which is a type of iterator
- A standard return (explicit or implicit) stops the generator.

Generators

- Generators are functions that return a series of values one at a time.
- A generator is identified by a function that uses the yield statement
- Generators are just iterators that generate the results only when needed.
- Called with next() just like any iterator. The for statement has handled this for us so far.
- Saves memory: does not pre-build returned object
  - Examples: the range and reversed functions
- If a return statement is used (explicitly or implicitly) anywhere in a generator, it ends the generator.
- See generator_test.py in DemoProgs

Review - Parameter Collectors

- def fn(*varname) varname is usually args
  - The * is used only in the function definition
- *varname parameter receives all excess positional arguments
  - "Packs" them into a tuple
- See varyargs.py in DemoProgs
- If you have a variable number of parameters, how do you test them for validity?
  - Use isinstance built-in function to test argument type.
  - Example: if isinstance(x, type) where type is int, float, str, etc.
  - Or: if isinstance(x, (type1, type2, …)) for multiple types
  - Do not put the type in quotes.
  - some valid types - float, int, str, list, dict, tuple, set, bool

Lab 08a

Write a generator that duplicates the range function for positive numbers only. Your generator should be able to accept 1 to 3 arguments which correspond to the same arguments for the range function. You should not check the validity of the individual arguments. Just make sure there are a valid number of them. If the number of arguments is incorrect, print an error message, and issue a return to shut down the generator. You can use the starter program generator2.py included in the data you downloaded.

Hint: The generator itself is a very small loop. Most of the code goes toward setting up the variables that are used in the loop. Make sure you understand the implications of receiving one, two or three arguments.

Generating Decimal Numbers

- Generators can be used in place of the range function to generate floats. Working with floats requires caution.
- Implement the following program. Does it work as expected? If not, why?

```
def frange(start, stop, step):
    i = start
    while i < stop:
        yield i
        i += step

for x in frange(0.5, 1.0, 0.1):
    print(x)
```

Decimal Module

- The previous slide shows that many floating-point numbers are not precisely represented.
- For this reason, most languages advise you not to use floats for tracking monetary values.
- Within Python's decimal module, the Decimal class allows you to avoid this problem.
- The demo program shows how this works at its simplest. (generatordecimals.py)

Recursion

- Python supports recursive functions
  - Functions that call themselves
- Recursion is a somewhat advanced topic and not used often
- Why bother to study it?
  - It helps you to understand the abstract nature of Python.
  - It allows programs to traverse arbitrarily shaped structures.
  - Used alternatively to loops and iteration – usually unnecessarily.
- Review recursive_blastoff.py and irregular_sum.py in DemoProgs
  - Taken from the Think Python and Learning Python books.
  - Also, recursive_sum.py (in DemoProgs) shows a number of Python features.

Lab 10

Write a program to calculate a factorial recursively. In mathematics, the factorial of a positive integer n is denoted by n! and is the product of all positive integers less than or equal to n. For example, 4! = 4 * 3 * 2 * 1 and 5! = 5 * 4 * 3 * 2 * 1 and so on

Your program should receive an integer from the keyboard and use a recursive function to resolve it. The table to the right provides some correct answers for checking your results.

0	1
1	1
2	2
3	6
4	24
5	120
6	720
7	5 040
8	40 320
9	362 880
10	3 628 800
11	39 916 800
12	479 001 600
13	6 227 020 800
14	87 178 291 200
15	1 307 674 368 000
16	20 922 789 888 000
17	355 687 428 096 000
18	6 402 373 705 728 000
19	121 645 100 408 832 000
20	2 432 902 008 176 640 000

Python Classes

- Classes are Python's main object-oriented programming (OOP) tool.
- At their most basic, classes are another way to modularize your code for reuse.
- Classes themselves have no use until they are used in what is called an instance.
  - They are simply a template or a blueprint.
- A major advantage of classes is inheritance; a mechanism of code customization and reuse.
- Classes tend to be used by people doing long-term development (more strategically oriented)

Object-Oriented (OO) Programming

- **Class:** A user-defined prototype for an object that defines any instance of the class. The attributes are data members (class variables and instance variables) and methods, accessed via dot notation. (e.g., a cookie cutter)
- **Instantiation :** The creation of an instance of a class. (e.g., creating a cookie)
- **Instance:** An individual object of a certain class. (e.g., the actual cookie)
- **Instance variable:** A variable that is defined inside a method and belongs only to the current instance of a class.
- **Method :** A special kind of function that is defined in a class definition and accessed through dot notation.

Class Example (class.py in your data)

```
class BankAccount:   # works fine in Python 3.  Parens not required
# class BankAccount(object):  Top tier class (super class) in Python 2 or 3
    def __init__(self, name):   # This method runs during instantiation
        self.balance = 0  # instance variable
        self.acctname = name  # instance variable
    def deposit(self, amount):     # another method
        if amount < 0:
            return 4   # Negative deposits are really withdrawals
        self.balance += amount
        return 0       # Deposit successful

a = BankAccount('Monty Python')  # Create an instance of Bankaccount
b = BankAccount('Guido van Rossum')  # Create another instance
ret_code = a.deposit(100) # Deposit $100 into the account
if ret_code > 0:  print('Deposit failed')
ret_code = b.deposit(500) # Deposit $500 into the account
if ret_code > 0:  print('Deposit failed')
print(a.balance, b.balance)   # This is not good code - we will replace it.
```

The Reason You Need to Use Self

- Python decided to do methods in a way that makes the object to which the method belongs be passed automatically, but not received automatically.
- The first parameter of methods is the instance doing the calling. (e.g., a.deposit(100) will pass the object (a) and 100 to the deposit method in the example above.)
- That makes methods essentially the same as functions.
- It leaves the actual name to use up to you (self is the convention, and people will generally frown at you if you use something else.).
- The name self is not special to the code, it's just another object.

Lab 11 - Add New Methods

We need a new method that will provide the balance for any account. Create that method. Then test it by retrieving the current balances for both accounts and printing them. Replace the current code that reaches inside the instance without using a method. This is not a good coding practice.

Then, create a method for withdrawals. Subtract the withdrawal amount from the balance. This method should not allow a withdrawal that would result in a negative balance. As with deposits, return a code of four for an invalid withdrawal and a zero for a valid withdrawal. Test with valid and invalid amounts for one account. Then print the resulting balances for that account.

Class Example

- Why do we have to use dot notation to reach inside a class instance?
  - Each class and instance of a class has its own namespace.
- As stated previously, reaching "inside" an instance is generally not a good idea. Normally, you depend on a method for access.
- What happens when we print an instance?
  - Add the statement "print(a)" to the end of your code.
  - "print(a)" produces a result, but it is not helpful.
- We could create a method of our own that would print out all useful account information.
- Or we could use the built-in __str__ method that is invoked whenever you try to "stringify" a class instance (e.g., print(a)).

Python Magic Methods

- Python has a large number of methods that operate "behind the scenes" so to speak.
- The names of all of these methods include double underscores
- Usually, these methods are invoked implicitly.
- Several commonly-used of these methods are:

  __init__ called when an instance is created.

  __del__ called when an instance is deleted.

  __str__ called when an instance is printed (for example)

  __eq__, __ne__, __lt__, __gt__, __le__, __ge__
- Python Notes Addendum has a pointer to a complete list of these methods.

Lab 12a - Stringify

Add a method to your code to override the default __str__ hidden method. This method requires that the object returned must be a string. The new method should return, in printable form, the name associated with the account as well as the balance.

* According to Wiktionary, stringify is actually a word. That's good enough for me.

Class Example

- How do I make comparisons?

  if a == b: Does not work. Why not?
  In 3.x the default is to use __eq__ The standard __eq__ will not do the comparison correctly.

  if a.balance == b.balance: # Will do the desired comparison in a non-standard way.

- These are best done in methods, so everyone using the class can take advantage of them.
  - Avoids code replication in main programs
  - Allows you to use more complex criteria in your comparison.

Comparing Instances

- We can create our own method.

```
def compare(self, other):
    if self.balance == other.balance:
        return True
    else:
        return False
```

- if a.compare(b):   self will receive a and other will receive b
  - This will come back either true or false
  - But we could use one of the "magic methods" instead.

Lab 12b - Comparisons

When you compare for equality, the default version of __eq__ is called automatically and it will blindly compare two instances which will never be equal. To override this result, implement one or more of the newer magic methods – in our case __eq__. Use this magic method to compare the balances of the two accounts. Test by using equal and non-equal balances

Pay attention to which instance is passed to self. Change the balances to test both possible outcomes. Also, understand that this is a simple comparison. Most comparisons done this way are much more complex.

* Note: Good programming practice says you should implement all six comparison methods if you implement one of them. It's not necessary to do so in this exercise.

Class Variables

A variable that is shared by all instances of a class. Class variables are defined within a class but outside any of the methods of the class. They are accessed through the class as they exist only in the class namespace.

Class variables aren't used as frequently as instance variables. Class variables are not inherited.

Class Variables

- Change your program to add this code (bold and italicized):

```
class BankAccount:
    acct_cntr = 0        # class variable

    def __init__(self, name):
        .
        .
        BankAccount.acct_cntr += 1   # Accessing a class variable
.
.
.
a = BankAccount('Monty Python')
print('Number of accounts -', BankAccount.acct_cntr)
b = BankAccount('Guido van Rossum')
print('Number of accounts -', BankAccount.acct_cntr)
```

- Note how class variables are accessed either from an instance or the main program. Class variables exist only in the class namespace.

Lab 14

- Add the following statements to the end of your program

```
del a
print('Number of accounts -', BankAccount.acct_cntr)
```

- What is the problem and what has to change?
- Implement the magic method needed to get the correct result. if necessary, go back a few slides to the list of these methods.
- If you use an older version of Python and execute from command line, you may get an error message after the program has run successfully. We will discuss.

Inheritance

- Inheritance describes the transfer of the characteristics of a class to other classes that are derived from it.
- Example:

```
class A:
    def mthd1(self):
        do something
    def mthd2(self):
        do something
class B(A):
```

- Class B has inherited all the methods and instance variables of class A.

Overrides

- Example:

```
class A:
    def mthd1(self):
        do something
    def mthd2(self):
        do something
class B(A):
    def mthd2(self)
        do something different
```

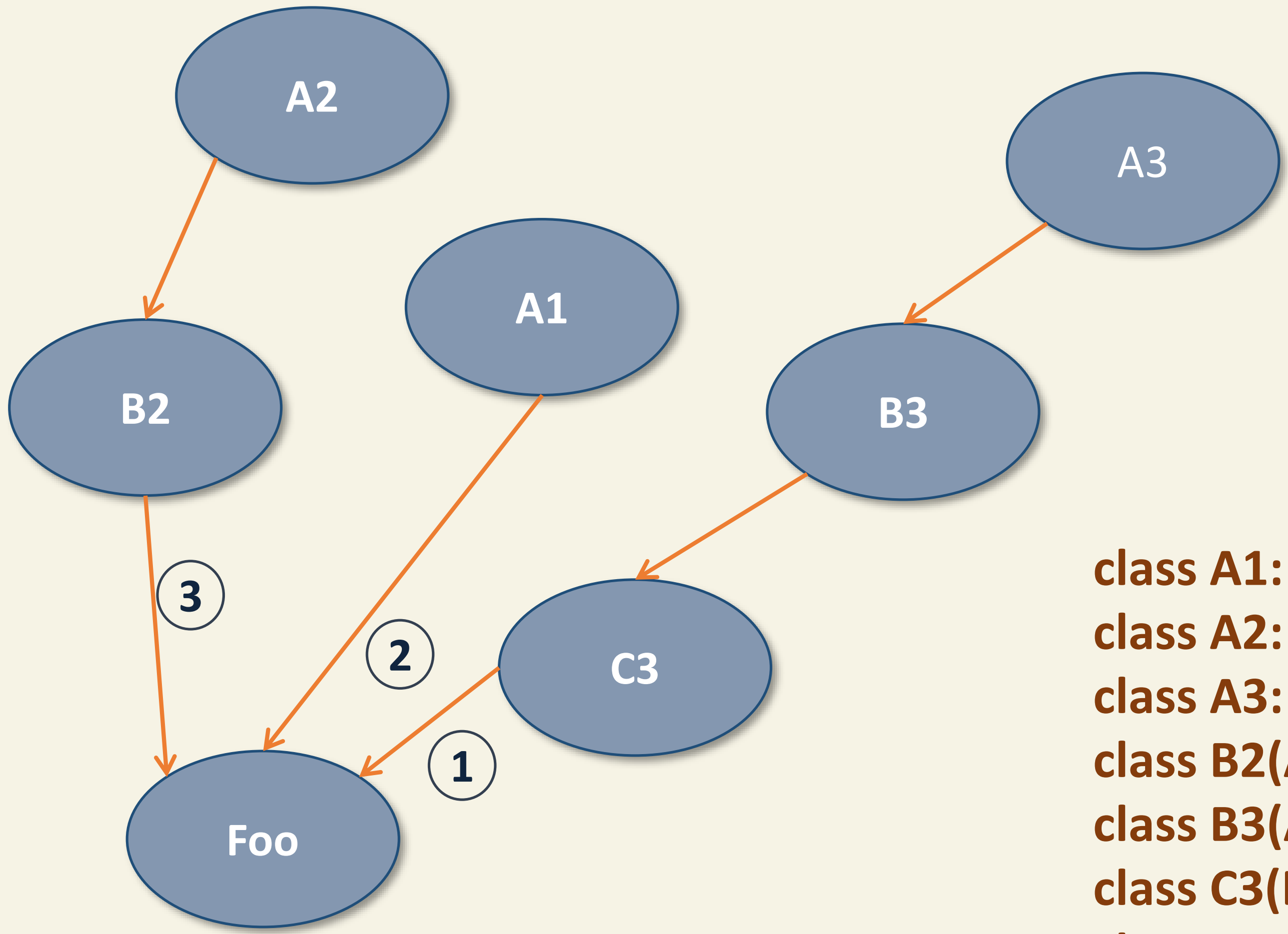
- Class B has inherited all the methods and instance variables of class A. In addition, Class B replaces mthd2 with its own version of that method.

Method Resolution Order (MRO)

For simple class structures, MRO can be summarized as left to right and depth first but common ancestor classes are only checked after all of their children have been checked. Given these new style classes:

```
class A1: pass
class A2: pass
class A3: pass
class B2(A2): pass
class B3(A3): pass
class C3(B3): pass
class Foo(C3, A1, B2): pass
```

MRO



```
class A1: pass
class A2: pass
class A3: pass
class B2(A2): pass
class B3(A3): pass
class C3(B3): pass
class Foo(C3, A1, B2): pass
```

Lab 15

- Change the previous program to allow, in addition to the normal account, an account with a minimum balance. Do this through a new class that inherits from the original. Make sure the new class does the following:
  - Provides for an initial deposit and a specified minimum balance as well as a name on account creation. For now, don't check to see that the initial deposit meets the minimum requirement.
  - Does not permit a withdrawal that takes the balance below the minimum. Return zero for valid withdrawals. Otherwise return 4.
  - When an instance is printed, print the balance and the minimum required for minimum-balance accounts.
  - Confirm that the original methods work for the new class.
- Note – class variables are referenced through the original class

Class Review

- Classes are simply prototypes or models to be used in the creation of an instance object.
- The act of creating an instance is called instantiation because we like five-syllable words. (e. g.; polymorphism, encapsulation)
- Each instance of a class has its own instance variables that are preserved in the latest state.
- A class and all of its instances have their own independent namespaces.
- One class can inherent instance variables and methods from another class. Class variables are never inherited.
- An inherited method can be overridden to get a different result.
- The "magic methods" are simply built-in methods that are called automatically in given circumstances, and they can be overridden. (e.g.; __str__(), __le__(), and so on)

raise Statement

- The raise statement is used when code wants some attention because of an event. The attention-getting device is an Exception object
- Below is a generic raise statement:
  - raise [Exception [(0 or more args)]] – where args is usually one string
- In the Shell enter the following and note all results:

  ```
  raise
  raise ValueError
  raise ValueError('An error occurred')
  raise ValueError('An error occurred', 1000)
  ```
- If a problem is discovered during an instantiation (__init__), you can cancel the instantiation by raising an exception.
- See raise1.py and raise2.py in DemoProgs

Lab 16

Change the previous program to prevent a minimum balance account from being created without an initial deposit that meets the required minimum. Capture the error in the main program and print an appropriate message indicating the problem. The message should contain a description of the problem, the attempted deposit amount and the minimum requirement.

Namespaces and Scoping

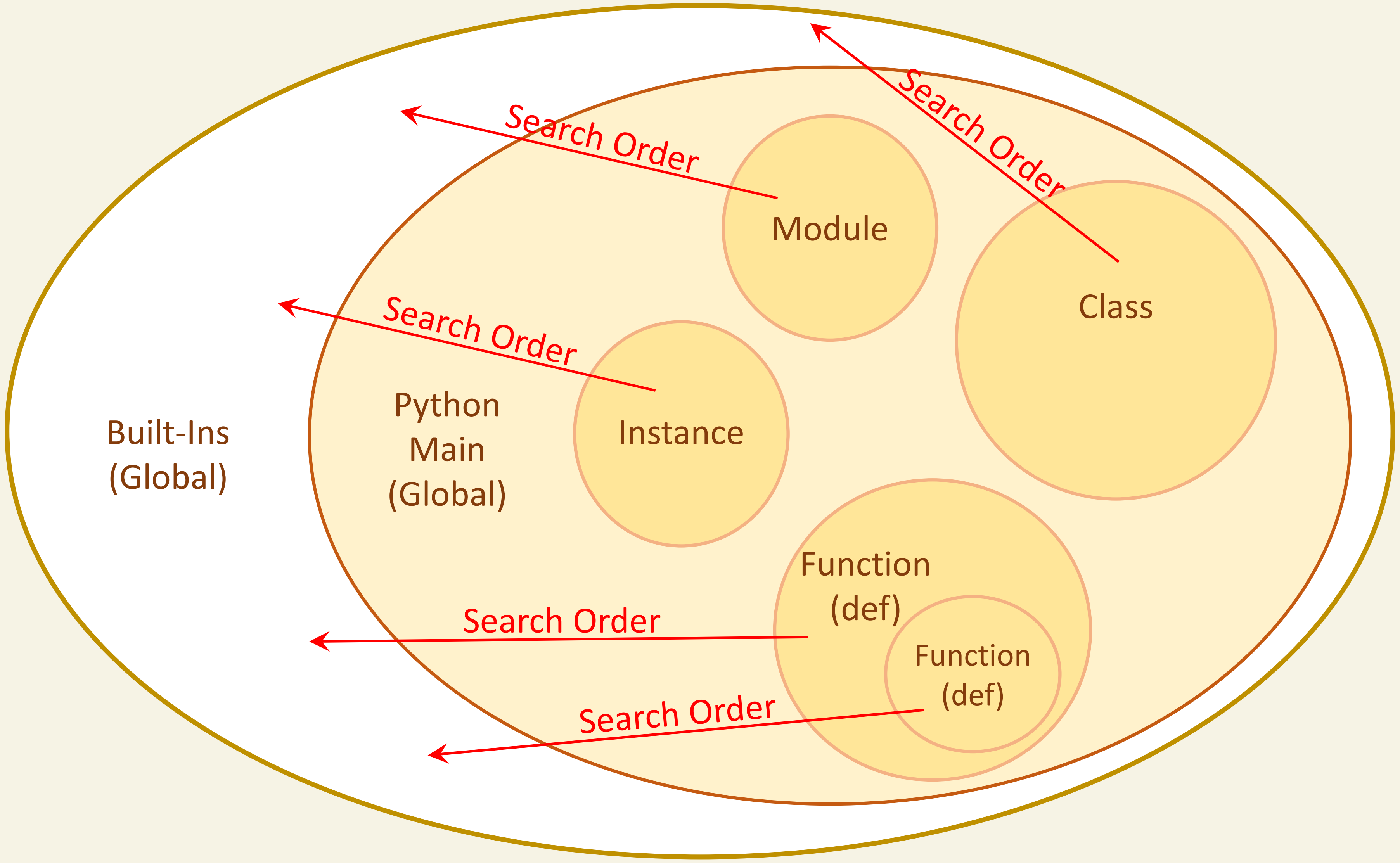
- Everything in a Python program is an “object”.
- Objects have state and behavior.
  - Python stores an object's state in a variable. (x = 'abcde' : a string)
  - It exposes an objects behavior through methods. (x.isalpha() = True)
- **Block**: any Python code executed as a unit e.g. a module, a function, a class or a script.
- Every block of code has its own namespace where all the variables (objects) for that block are defined and tracked.
  - The structure used for this information is a dictionary.
  - The dir(), locals() and globals() functions can be used to examine a namespace dictionary.
- It is possible to use the same variable name in different blocks.
  - But is not a good idea.

Namespaces and Scoping

- **Scope**: the space where an identifier is visible. Contained blocks can see identifiers of outer blocks
- You start your script and it begins to execute.
  - The portion of your script/program where execution begins is the main portion of your program. As you have seen, the internal name for this block of code is "__main__".
  - Everything defined in __main__ is global. That is, all of variables defined in __main__ are known (visible) everywhere; in all functions, classes and modules.
  - That does NOT mean you can effectively modify that data from another block (e.g., a function)
- The objects <u>**imported from**</u> any module are known globally also.
  - You need to be aware of potential conflicts.
- The objects in functions, classes/instances and modules are not known globally

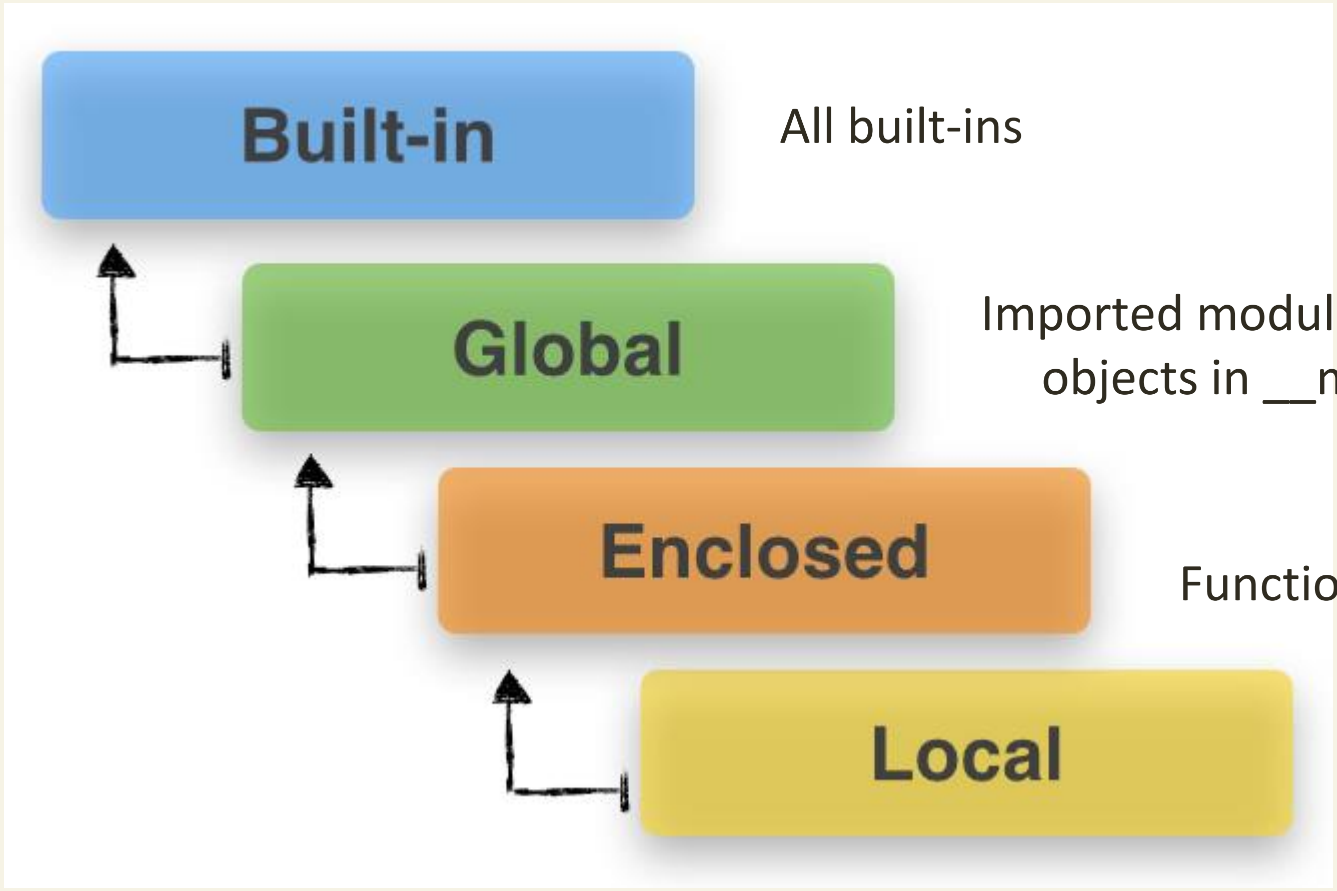
Namespace Diagram

There is a local namespace for each code block.



Namespace Hierarchy

Another way of looking at it



All built-ins

Imported modules and all objects in __main__

Higher Level Functions/Methods/Classes

Lowest Level Functions/Methods

In DemoProgs, run lcl_glbl.py and lcl_glbl_legb.py

Namespaces and Scoping Summary

- Variables are names (identifiers) that map to objects. A *namespace* is a dictionary of variable names (keys) and their corresponding objects (values).
- A Python statement can access variables in its *local namespace* and in the *global namespace*. If a local and a global variable have the same name, the local variable is shown over the global variable.
- In the main program, global equals local.
- Each function has its own local namespace. Class methods follow the same scoping rule as ordinary functions. All classes and class instances also have their own namespaces as do imported modules.
- Python assumes that any immutable variable assigned a value in a function is local. Therefore, in order to assign a value to a global immutable variable within a function, you must first use the global statement. (not recommended)
- The statement *global VarName* tells Python that VarName is a global variable. Python stops searching the local namespace for the variable.

System Modules

- The sys module provides a number of functions and variables that can be used to manipulate different parts of the Python runtime environment.
- The os module in Python provides a way of using operating system dependent functionality. The functions that the OS module provides allows you to interface with the underlying operating system that Python is running on – be that Windows, MacOS or Linux.
- We have access to other system-level information through the getpass, platform and multiprocessing modules.

Lab 17 - System Modules

- Some of these are extremely large modules containing many diverse functions and/or classes.
- We will look at just a few of the capabilities.
- Click on these links to get the formal documentation for the following modules:
  - os
  - sys
  - platform
  - getpass
  - mutiprocessing
- sys.path is a list. Import it and try to print it neatly so you clearly see what it contains.
- We will review a completed program that uses all of these modules.
- Also, in DemoProgs, see systeminfo.py

Importing

- You can create your own modules to import
  - Makes the code available to others
  - Unclutters your display
  - Name your module anyname.py and import anyname
- Set the search path for imports
  - Permanently in system settings
  - Temporarily in the shell
  - Temporarily in the Python program

```
import sys
sys.path.append('/home/student/imports')
print(sys.path)
```

Lab 18

Using the program you created for Lab 16, separate the code for the classes from the main program. Place the code for the classes in a new directory. Give this code module a short name as directed in PEP 8. Import the code for the classes from that directory. Keep in mind whether you want to access the classes through dot notation or not. That will govern how you do the import.

Use the code on the previous slide to add the new directory to your path temporarily. Also, add a statement to your main program to import your class code. Get your program working paying special attention to the naming requirements. Also, examine the code in your new directory. Note the module ending with .pyc. We will discuss this when you are done.

Collections / Counter

- The collections module has a number of useful classes.
- We will use one of them as an example: Counter
- Counter is a dictionary subclass that has many of the attributes of a dictionary with a number of useful enhancements.
- As the name implies, it is built to aid counting.
- As with any class, it has to be instantiated.
- Normal dictionary rules/methods apply except:
    - fromkeys does not work
    - most_common(n) produces the n highest occurring keys
    - Incrementing nonexistent keys defines and initializes the key.
    - There are more details here.

Unique Aspects of Counter

x = Counter('himalayas') # Here x becomes:

Counter({'a': 3, 'i': 1, 'h': 1, 'm': 1, 'l': 1, 's': 1, 'y': 1})

y = Counter(list(x)) y contains all keys found in x initialized with a count of 1.

x.subtract(y) reduces all counts in x by 1 and retains all results

x = x – y reduces all counts by 1 and removes all items less than or equal to zero

x.subtract(x) reduces all counts to zero and retains all results.

x = Counter() creates an empty Counter or clears an existing one

- See mCounter.jpg in Samples

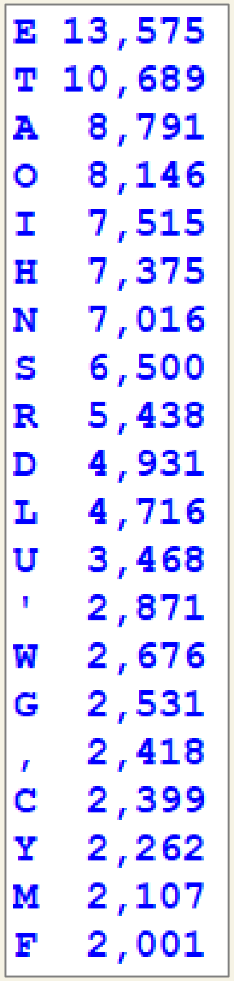
Lab 19

a) Use the file alice_in_wonderland.dat to create a Counter. First, read the entire document into memory, and remove all whitespace using translate/maketrans. Then, use a Counter to determine the 20 most used characters in this document. Print out each character and its number of occurrences in descending order by use count. Be sure to make all cases the same.

b) Alternatively, use translate and split to isolate each word in the book. Then use Counter and other tools such as sets to count the total words in the book, the unique words in the book, the number of words in the book that are not in words.txt and the top 20 words in the book by use counts. (See answers on the next slide)

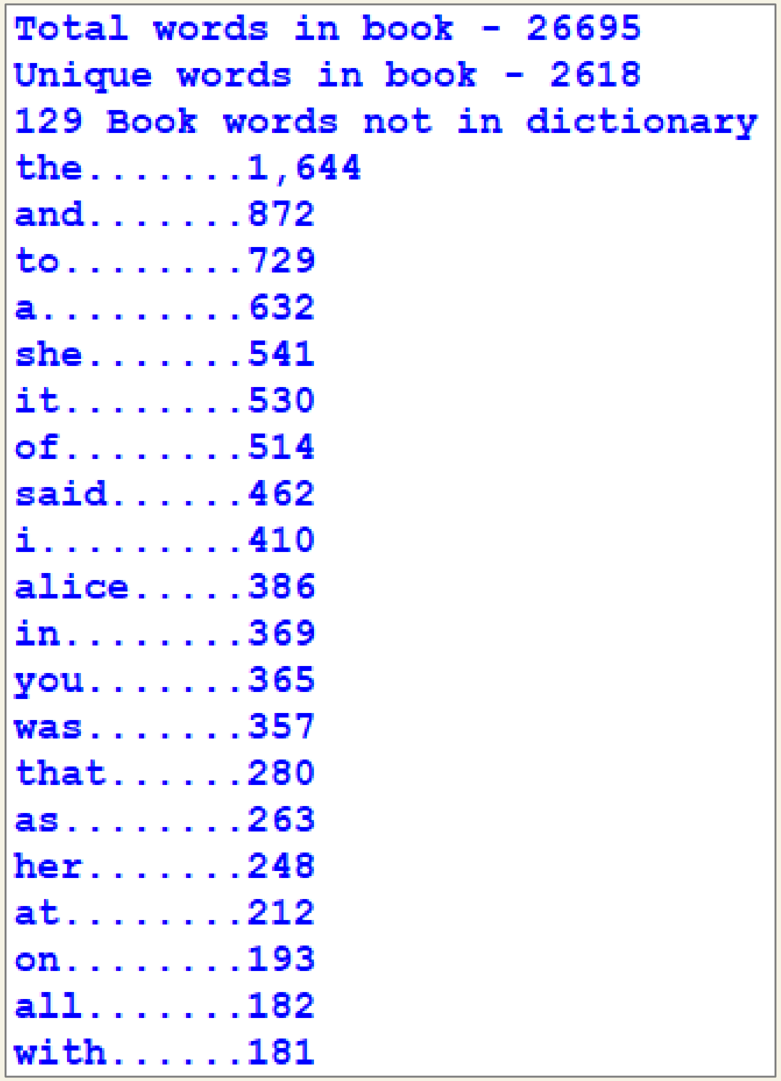
Lab 19 Results

Part A



```
E 13,575
T 10,689
A  8,791
O  8,146
I  7,515
H  7,375
N  7,016
S  6,500
R  5,438
D  4,931
L  4,716
U  3,468
'  2,871
W  2,676
G  2,531
,  2,418
C  2,399
Y  2,262
M  2,107
F  2,001
```

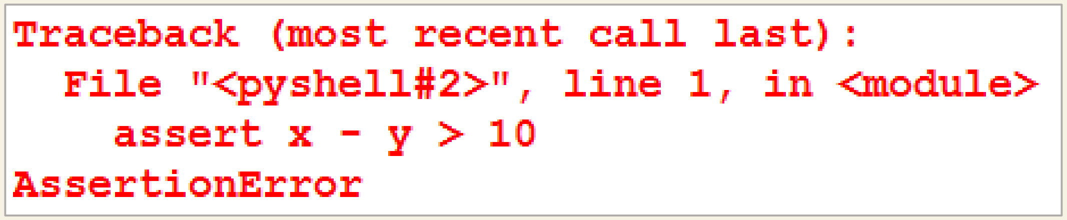
Part B



```
Total words in book - 26695
Unique words in book - 2618
129 Book words not in dictionary
the.......1,644
and.......872
to........729
a.........632
she.......541
it........530
of........514
said......462
i.........410
alice.....386
in........369
you.......365
was.......357
that......280
as........263
her.......248
at........212
on........193
all.......182
with......181
```

assert Statement

- The assert statement is used as a debugging tool.
- At key places in your program, you test a condition.
  - If that condition fails, an AssertionError is raised.
  - Example: assert x – y > 10



```
Traceback (most recent call last):
  File "<pyshell#2>", line 1, in <module>
    assert x - y > 10
AssertionError
```

  - You can bypass assert statements
    - python –O progname – bypasses asserts

Debugging Using PDB

- Some Vocabulary:
  - Single step: run one line of code and stop
  - Step in: trace into a function
  - Step out: return from tracing a function
  - Breakpoint: run normally until here, then stop
  - Watch list: monitored variables

- Set breakpoints in the code
  - import pdb to get the software loaded
  - pdb.set_trace() – insert this code at every desired breakpoint
  - This does not preclude using the commands on the next slide.
- Run program under pdb.
- From command line enter pdb3 modulename and use the commands on the next slide. (Windows – python –m pdb module)
- See full documentation at https://docs.python.org/3/library/pdb.html

Common PDB Commands

• h(elp)	list commands or display doc for a specific command
• b(reak)	set a breakpoint or (no arguments) list all breakpoints
• s(tep)	step into a function. Using n will bypass the function
• n(ext)	execute the next statement.
• r(eturn)	step out of a function
• c(ontinue)	execute normally stopping at any breakpoints
• l(ist)	list the source statements adjacent to current location
• p expression	print this value to the screen. Usually a variable
• q(uit)	get out of pdb altogether
• cl(ear)	clear a specific breakpoint. No argument clears all breaks
• !expr	change the value of any variable while at a breakpoint. The ! is needed to avoid confusion with a command.

Independent Lab

- The programs debug1.py and debug2.py are in DemoProgs
- From command line, execute pdb3 debug1.py
  (in Windows – python –m pdb debug1.py)
  - Note what happened when pdb is imported and set_trace is used.
  - At the break, issue h to get a list of commands.
  - Also, print the value in variable a and then variable b.
  - Why is there a problem with variable b?
  - Change the value of variable a to 'zzz'
  - Enter command n and step through the rest of the program.
- From command line, execute pdb3 debug2.py
  (in Windows – python –m pdb debug2.py)
  - Set breakpoints at lines 8 and 11.
  - Execute (command c) the program until the break. Print variable a and change its value to 'zzz' (!a = 'zzz').
  - Step through the program using command n.
  - Be sure to use the s command to step into the function.
  - Step through the function using command n. Step out using command r
  - Continue to the breakpoint with a c command. Issue a b command, then a clear (respond y) then b again. Note all breakpoints cleared.
  - Print variables s1, s2 and s3 and issue a c command to finish.

Future

- __future__ module allows you to use certain elements of version 3 while still in version 2
- Examples:

```
7/3 = 2
from__future__ import division
7/3 = 2.33333
print 'Why wait for version 3?',
from __future__ import print_function
print('Why wait for version3?', end = ' ')
```

- See future1.py and future2.py in Demo Progs

Converting to Python Version 3

- Using the 2to3 module – use 2to3 as the command as with pdb
  - Ex: 2to3 /home/student/[progname.py]
  - Processes one program or an entire directory
  - Windows must use:
    python c:\python37\tools\scripts\2to3.py file_dir
- Pertinent flags – default produces a report of changes
  - -w - create output files with fixes in the same directory.
    Rename original files and keep as backup.
  - -o - send output to a different directory. Use -n here.
  - -n - suppress the creation of the backups mentioned above
  - -W - write all files even if there are no changes. Implies –w
    Used mostly with -o to ensure entire tree is copied.

Converting to Python Version 3

- A Few Examples of Fixers:
  - **xrange** - Renames xrange() to range() and wraps existing range() calls with list where appropriate.
  - **raw_input** - Converts **raw_input()** to **input()**.
  - **print -** Converts the **print** statement to the **print()** function.
  - **dict -** Fixes dictionary iteration methods. **dict.iteritems()** is converted to **dict.items()**, **dict.iterkeys()** to **dict.keys()**, and **dict.itervalues()** to **dict.values()**.
  - Find a complete list **here**
- Examples of 2to3:
  - 2to3 –w /home/student/progname.py
  - 2to3 /home/student/pyprogs –W –n –o /home/student/newdir

Lab 20

Your LabsData directory contains a program named convert.py

Use 2to3 to update only this program. Allow the backup version to be created. Observe the result. What changed?

Least Squares Linear Regression

- Least squares is the most common method of fitting a straight line to a set of points.
- The general formula for a linear function is $y = mx + b$
- There are two formulas used to determine the least-squares line.
  - one for the slope (m) and
  - one for the y-intercept (b)
- The formulas for deriving these values are shown on the next slide.
- The "goodness of fit and prediction" is estimated by the coefficient of determination which is the correlation coefficient (r) squared.

Take-Home Lab 1

There are two formulas defined here for calculating a least-squares, linear regression. Using the x and y values supplied in the file ExperimentReadings.csv, determine the slope (m) and intercept (b) values in the linear formula y = mx + b. Also, determine the r^2 for this regression. The data contains what represents 24 hourly-reading values for an experiment. Use the linear formula you calculate to predict what the reading value will be for the 50th reading.

Answers:

```
slope 0.61
intercept 2.51
Reading 50 should give about 33.0
Pearson Correlation Coefficient - 0.958
R Squared (Linear Regression) - 0.917
```

$$m = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2}$$

$$b = \frac{(\sum y) - m(\sum x)}{n}$$

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Take-Home Lab 2

Process the data in AnnualRainTemp.csv. It contains the average high temperature and the total rainfall for every year from 1900 to 2018. Using the instructions included in your data for producing percentiles, create a program that will produce percentiles for the rainfall and temperature data you have read in. Test your program using a simple list such as: [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20]. Then add the number 21 to the end of the list and run it again. Your answers for this list for percentiles of 20% should be [4.5, 8.5, 12.5, 16.5] and [5, 9, 13, 17] respectively. The same percentiles for rainfall and high temperatures should be [20.5, 26.2, 31.4, 38.0] and [78.8, 79.4, 80.4, 81.3] respectively. Be very careful to devise a way to avoid the cumulative effects of adding decimals that are not precisely represented by floating point. It should not be necessary to use the decimal module.

Take-Home Lab 3

Create a class that accepts a list or tuple of numbers. In the case of a list, the methods should make no changes to it. Provide the following methods:

- Produce the median and return it as a number.
- Produce a mode or modes if there are duplicates. Return a tuple containing all results regardless of the number.
- Provide a method that returns a tuple containing the requested percentiles. The percentile should be passed as a float.
- Provide a method that produces a running average for the number of units specified.

Your instantiation method should check for the validity of all data types. If any data type is not as prescribed, raise a condition and halt the instantiation process. (Continued on the next slide)

Take-Home Lab 3 (cont'd)

These are the answers to different sets of data:

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

10.5 - Median
(6, 15) - Modes
(4.5, 8.5, 12.5, 16.5) - Percentiles (20%)
(3.0, 4.0, 4.8, 5.8, 6.8, 7.8, 8.8, 10.0, 11.0, 12.2, 13.2, 14.2, 15.2, 16.2, 17.0, 18.0) - Running average using a period of 5

Using the annual rain data from a previous lab.
29.3 - Median
(28.5,) - Modes
(20.5, 26.2, 31.4, 38.0) - Percentiles (20%)
(27.0 26.1 26.7 26.7 26.7 26.4 25.5 26.0 25.8 25.9 26.6 26.9 27.2 27.8 26.8 26.5 27.3 27.6 28.4 28.1 26.5 27.1 27.0 27.7 27.1 27.5 28.3 29.1 28.8 28.4 29.0 28.9 28.9 28.4 28.4 27.7 26.4 25.5 26.6 27.4 27.7 27.6 27.7 26.9 26.8 26.8 27.1 25.9 26.5 26.8 26.4 26.5 26.9 27.1 28.9 30.0 30.4 31.6 30.7 30.5 31.1 30.8 31.3 31.3 31.7 31.4 31.6 32.7 33.1 32.5 32.1 32.8 33.4 34.1 33.1 33.3 33.2 32.1 32.3 32.6 31.6 32.2 32.2 33.3 33.5 34.4 33.2 32.2 32.6 32.4 32.8 32.8 31.5 31.1 31.1 30.5 31.6 32.9 32.5 32.5) - Running average using a period of 20

Take-Home Lab 4

Modify the program developed to solve the last lab. Add the possibility of a second list or tuple. Do the same data checking as before. If two collections of data are provided, assume the first one defines the dependent variable (Y values) and the second one defines the independent variable (X values).

Add two methods to your class. The first one should calculate the Pearson correlation coefficient (r). In this case it doesn't matter which collection is the dependent and independent variable. This method should return the value of r.

The second method should perform a linear regression on the two sets of numbers. The method should return a tuple containing the slope (m), the Y intercept (b) and the coefficient of determination (r^2).
(Continued on the next slide)

Take-Home Lab 4

Your instantiation method (__init__) must be able to accept a variable number of positional parameters. The existing methods (from the previous lab) should use just the first variable. Only the new methods should use both variables. Both new methods will have to calculate r. You have several options here:

1) You can include that code in both methods. (Not recommended)

2) Observe that most of the work to do a linear regression is accomplished in calculating r. Simply have the user specify which they want and return the desired results from just one method.

3) You can include another method containing the code to do those calculations. Then, both the correlation method and the linear regression method will call it. The question is, how does that work? Examine the demo program methodcall.py for an example of how that works.

Python IV

- Review
- JSON including Pickle and other alternatives
- REST API
- Argparse
- Decorators
- Subprocesses
- Threads
- Multiprocessing
- Test-driven development

The End