Topic 7: Lists, Dictionaries and Strings

The human animal differs from the lesser primates in his passion for lists of "Ten Best"

– H. Allen Smith

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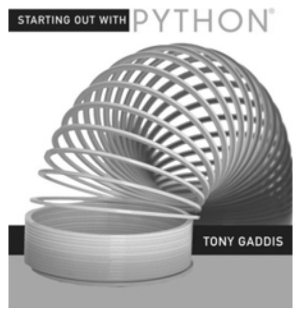
Recommended Readings



- Chapter 8

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Lists

- Consider the following problem
  - Write a program that reads the high temperature of each day for the past year
  - Once the data is read, compute
    - Hottest day, Coldest day
    - Identify heat waves, extended cold periods
    - Determine last day of frost in spring, first day of frost in fall
    - Compute average and median temperature
    - Graph the data

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What is a List?

- A collection of values
  - All values may have the same type, or
  - Values may have different types
  - Each item is referred to as an <u>element</u>
  - Each element has an <u>index</u>
    - Unique integer identifying its position in the list
  - A list is one type of <u>data structure</u>
    - A mechanism for organizing related data

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Creating a List

- Created like other variables
  - Values are comma separated inside square brackets
  - Examples:

```
low_temps = [1.4, -1.8, 0.7, 0.9, 1.2, -2.2, -0.3]
names = [“Ben”]
stuff = [1, “ICT”, 3.14]
empty = []
```

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Accessing Elements

- Each list element has a unique index
  - Values range from 0 to length of the list - 1
- To access one element, use the name of the list, followed by the index of that element in square brackets
  - Use this one element just like any other variable

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Changing Elements

- Individual elements in a list can be changed without impacting the rest of the list

```
aList = [1, “ICT”, 3.14]
aList[1] = “Hello”
print aList
aList[2] = “World”
print aList
```

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Loops and Lists

- A for loop iterates over the values in a list
  - List can be created by the range function
  - List can be created by any other means
- Consider the following loop:

```
for item in [1, “ICT”, 3.14]:
  print item
```

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Length of a List

- When a list is initially created, we know its length
  - Adding / removing elements from the list will change its length
  - New length can be determined using the `len` function in the standard library
  - Examples:
    - `len([0.69, 3.14, -16.0])` returns 3
    - `len([])` returns 0

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Loops and Lists

- Sometimes we need a loop where the control variable varies over the indices rather than the values

```
list = [1, “ICT”, 3.14]
for i in range(0, len(list))
  print list[i]
```

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Adding Elements

- Several methods are defined on lists
  - Use the name of the list you want to work with
  - Follow it by a dot
  - Use the name of the method
  - Provide any required parameters
- Elements are added with append

```
aList = [1,”ICT”]
aList.append(3.14)
print aList
```

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Inserting New Elements

- Append allowed us to add an element to the end of a list
  - What if we want to insert an item in the middle of the list?

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Searching

- Use `in` to check if an item is present in a list
  - `2 in [1,2,3,4,5]` evaluates to `True`
  - `8 in [1,2,3,4,5]` evaluates to `False`
- Use `index` to determine where it is in the list
  - `[11,12,13,14].index(12)` evaluates to `1`
  - `[11,12,13,14].index(8)` results in a Value Error

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Removing

- How can we remove an item from a list?
  - Use the remove method
    - Removes the first occurrence of the item
    - Subsequent identical items remain in the list
    - Item must exist or a Value Error will occur

```
x = [1,2,1,3,4,2,1]
x.remove(1)
print x
```

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Removing

- What if we want to remove all occurrences of an item from a list?

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Removing

- What if we know the index of the item we want to remove?
  - Use pop
  - With no parameters: Removes last item
  - With one parameter: Removes item at the index specified
  - Returns the item that is removed

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Example

- Compute the median of a list of values entered by the user
  - User will enter an unknown number of values
  - A negative number will be used to indicate that no additional values will be entered
  - If the list has an odd number of elements
    - Median is the middle value
  - If the list has an even number of elements
    - Median is average of the two middle values

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Design

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Sorting

- How do we put things into order?

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Selection Sort

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Insertion Sort

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Bubble Sort

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Sorting

- Sorting is an important task
  - Needed when working with large data sets
  - Frequently occurs as part of other algorithms
- Sorting has been studied extensively
  - Many algorithms, some of which are quite complex
  - Selection Sort, Insertion Sort and Bubble Sort
    - Relatively easy algorithms
    - Poor performance for large data sets

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Sorting in Python

- Python makes sorting a list easy
  - Use the sorted function
    - Takes one parameter which is an unsorted list
    - Returns a new list sorted into increasing order
  - Use the sort method
    - Invoked on a list using dot notation
    - Does not require any parameters
    - Modifies the list, sorting it into ascending order

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Example

- Compute the median of a list of values entered by the user

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Other List Operations

- Concatenation
  - Joins two lists
  - Performed using the + operator
- Slicing
  - Extracts a portion of a list
  - Performed using : operator
  - Forms
    - `ListName[first:last]`
    - `ListName[first:last:increment]`

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More Dimensions

- All of the lists we have used so far have been one-dimensional
- We can add a second dimension by making each element in a list another list

```
myList = []
myList.append([1,2])
myList.append([3,4])
```

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Images

- Lists provide a natural representation for images
  - Two dimensional list
  - Outer list is a list of columns (x coordinate)
  - Each column is a list of colors (one for each y coordinate)
  - Each color must be represented
    - Could be packed into a integer
    - Could be a list of the red, green and blue components

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Create a New Image

- Create a new image that is 600 pixels wide by 400 pixels high
- Fill the image so that it is a smooth gradient from solid black at the top, to color 255 192 64 at the bottom
- Write a function that displays an image in this format using QuickDraw

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Create a New Image

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Image Processing

- Common to use loops to process images
  - Nested for loops over indices
  - Apply a transformation to each pixel, possibly using values from nearby pixels as well
  - Examples:
    - Blur / low pass filter
    - Edge detection
    - Grayscale
    - Rotation
    - …

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Image Processing Example

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Tuples

- Similar to lists, but
  - length cannot be changed
  - Items cannot be assigned individually
  - () empty tuple, (3,) length one

```
aTuple = (1,”ICT”,3.14)
aList.append(3.14)
print aList
```


From Lists to Dictionaries

- Consider the following problem
  - Many cities in Alberta
  - Want to have a list that contains the populations
  - Need to be able to look up population by city

Dictionaries

- Dictionary: A collection of values
  - Each element in a list has an index
    - A unique integer, starting from 0
  - Dictionaries allow us to extend this idea
    - Each value in the dictionary has a unique identifier associated to it
      - Referred to as a key
    - Can be a string or a number
    - Items in the dictionary are unordered

Dictionary Example

- Create a dictionary that describes the population of several Alberta cities

Adding to a Dictionary

- What if we want to add more cities to our dictionary later in the program?

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Removing Items

- Remove one item
  - Use a del statement
  - Example: `del cities["calgary"]`
  - Also works on lists
    - `del some_list[3]`
- Remove all items
  - Use clear method
  - Example: `cities.clear()`

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Dictionary Methods

- Want a list of the keys in a dictionary?
  - Use dictionary_name.keys()
  - Example:

```
for i in cities.keys():
  print cities[i],"people live in",i
```

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Dictionary Methods

- Want a list of values in a dictionary?
  - Use dictionary_name.values()

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Dictionaries Example

- Consider the following problem
  - We have a list of values
  - Want to determine the mode for the list
    - Mode is defined to be the most frequently occurring value
    - A list may have more than one mode

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Dictionaries Example

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Dictionaries Summary

- Dictionaries
  - Hold a collection of values
  - Unordered
  - Each element is a key value pair
    - Easy to lookup the value associated with each key

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Strings

- Strings
  - A collection of characters
  - Numerous methods available to manipulating strings
    - upper
    - lower
    - swapcase
    - rjust
    - …

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Strings

- Strings provide additional methods for searching, separating, etc.
  - Processing input from the user is challenging
    - Anything could be entered
    - Generally want our program to handle this nicely
    - Common to expend significant effort processing input before it is passed to the rest of the program

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String Example: Validating a Password

- Write a function that determines if a password is (somewhat!) secure
  - Has at least 7 characters
  - Contains at least one upper case letter
  - Contains at least one lower case letter
  - Contains at least one numeric digit

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Searching

- The find method searches a string for a substring

```
s = “Hello World!”
print s.find(“ll”)
print s.find(“o”)
print s.find(“o”,5)
print s.find(“Wor”,0,6)
```

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Separating

- Use split
  - Returns a list of strings
  - Splits the string at each separator character that is encountered

```
s = “This is a test string”
list = s.split(“ “)
for i in list:
  print i
```

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Extracting Characters

- Characters in a string can be accessed by index
  - Enclose index of single character in square brackets
  - Use : to form a slice

```
s = “Hello World!”
print s[3]
print s[6:]
```

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String Example: Validating a Password

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Functions Involving Strings, Lists and Dictionaries

- Lists, Dictionaries & Strings
  - Can be passed as parameters
  - Can be returned as results
- Care must be taken to avoid inadvertently modifying a list or dictionary inside a function

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Functions Involving Lists and Dictionaries

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Mutable vs. Immutable Types

- In python, every variable is an object
  - Consists of
    - a pointer to some memory
    - value(s) stored in that memory
  - The location that the pointer points to can change
  - For mutable types, the values stored in memory can also change
  - Values stored in memory can not change for immutable types

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Mutable vs. Immutable Types

- What happens when a new value is assigned to a variable storing an immutable type?

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Mutable vs. Immutable Types

- What happens when we change a value in a list (a mutable data type)?

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Mutable vs. Immutable Types

- Examples of Immutable Types
  - Integer, Float
  - String
  - Boolean
  - …
- Examples of Mutable Types
  - Lists
  - Dictionaries
  - …

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Mutable vs. Immutable Types Review

- Which types are immutable?
- Which types are mutable?
- What happens when you change the value of a variable with immutable type?

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Mutable vs. Immutable Types Review

- What happens when you change a variable with mutable type?
- Why are some types immutable and other types mutable?

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Organization of Memory

- The memory for a program is organized into four regions
  - Text
  - Data
  - Heap
  - Stack

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Key Points

- Mutable vs. Immutable Types
  - Memory in the heap doesn't change for immutable types
  - Changing the value of a variable with immutable type causes it to point to a different piece of memory
  - Changing a variable with immutable type in the called scope will not change the value of the variable in the calling scope

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Wrapping Up

- Data structures allow us to organize larger amounts of information
  - Lists hold many values (ordered)
    - May have same type or may have different types
    - Each element has a unique integer index, starting from zero
  - Dictionaries hold many values
    - Each element consists of a key-value pair
    - Items can be looked up by key
    - Unordered data structure

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Wrapping Up

- Strings help us organize character data
  - Provide mechanisms for searching and splitting strings
    - Can be used to validate user input
- Lists, dictionaries and strings can be passed to and returned from functions
  - Strings are immutable
  - Lists and dictionaries are mutable

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Where Are We Going?

- Data structures allow us to manage larger amounts of data in a reasonable way
  - Larger amounts of data typically come from disk
    - Too much to enter by hand
  - How do we load data from files?
  - How do we save data in files?
  - How do we handle errors?

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