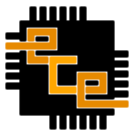
ECE 364
Software Engineering Tools Lab

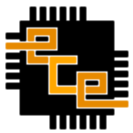
Lecture 3

Python: Introduction



Lecture Summary

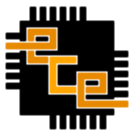
- Introduction to Python
- Common Data Types
- If Statements
- For and While Loops
- Basic I/O



What is Python?

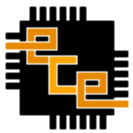
- Python is a flexible programming language
  - Procedural like C
  - Object-oriented like C++, Java and C#
  - Functional like LISP, Haskell, Scheme, Scala

- Python is a high-level language
  - Has a rich set of high-level data types and functions (standard library)
  - Runs on many platforms and operating systems
    - Windows, Linux/Unix, Mac OS and much more…



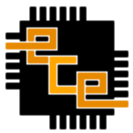
What is Python?

- Python is designed to be simplistic
  - Very simple and consistent syntax
  - Easy to read and write
  - Interactive like a shell



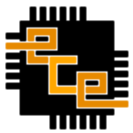
What is Python?

- Most Python implementations have an interactive mode
  - Some implementations provide more interactive features than others
  - Examples: IDLE, IPython



Syntax and Features

- No braces `{ }`
  - Indentation is used to indicate code blocks
- No semicolon at the end of a statement
  - Unless needed to separate multiple statements on one line
- No `$` preceding variable names



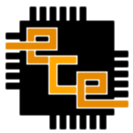
Making a Python Script

- Put the Shebang: `#!` on the first line

```
#! /usr/bin/env python3.4
```

- This line invokes the `env` program to get the path to python

- Comments are indicated using a `#` mark.



The Traceback

- When Python crashes, you will see a message like

```
Traceback (most recent call last):
  File "./tables.py", line 12, in <module>
    x_start = float(sys.argv[3])
  ValueError: invalid literal for float(): c
```

- Read it carefully, starting from the bottom and working upwards.
  - It is usually very accurate in pinpointing errors
  - It can save you a lot of time debugging
  - Debugging Python is easy compared to Bash

Interactive Mode

- Interactive Python:
  - Useful for testing out things you're not sure about
  - Useful for prototyping algorithms
  - Invoke at the command line with:

```
python
ipython
idle                    (graphical version)
```

Comes with a built in help function:

```
>>> help(list)
>>> import sys
>>> help(sys)
```

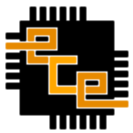
Data Types and Dynamic Typing

- Unlike C, variables are not declared with types
  - The C language uses "static typing"
  - All variables must be given an explicit type during before you can compile your program

- Semantics are defined by the set of functions and properties of the object
  - No need to define variable, nor define their type.
  - "If it looks like a duck and quacks like a duck, it must be a duck"[1]

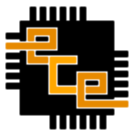
- Check the data-type of any variable using the `type()` function

1. Source: http://docs.python.org/glossary.html#term-duck-typing



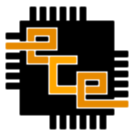
Built-in Constants

- Python defines several constants
  - `True` – true value
  - `False` – false value
  - `None` – indicates the absence of value, like NULL
- Do NOT mistake with strings:
  - `'True', 'False', 'None'`



Built-in Numeric Data Types

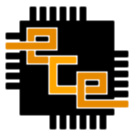
- `int` – Unlimited magnitude integer
  - `12345678901234567890123456789012345678901234567`
  - Size only limited by available memory (and your time)
- `float` - Floating point number
  - 64-bit double precision numbers
- `complex` – Complex numbers
  - Represented as two floating point values
  - `Z = 1.2 + 7.5j`



Truthiness

- Python will evaluate any object for truth in the context of a conditional or Boolean operation

- The following values will *evaluate* to `False`
  - `False`
  - `None`
  - `0, 0.0, 0j`
  - `(), [], ''`



Truthiness (2)

- Anything that does not evaluate to `False` evaluates to `True`

- Just because it evaluates to `False` does not mean it is `False`
  - An empty tuple `()` is not an empty list `[]`
  - `None` evaluates to `False` but `False != None`
  - But `0.0` is `0`

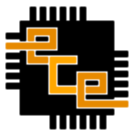
Comparison Operators

Operator	Function
`A == B`	`True` if A **is equal to** B
`A != B`	`True` if A **is not equal to** B
`A < B`	`True` if A **is less than** B
`A <= B`	`True` if A **is less than or equal to** B
`A > B`	`True` if A **is greater than** B
`A >= B`	`True` if A **is greater than or equal to** B
`A in B`	`True` if A **is an element in** B
`A not in B`	`True` if A **is not an element in** B
`A is B`	`True` if A **has the object identity** B

Note: the `in` operator only works with collections

Boolean Operators

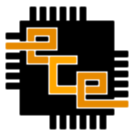
Operator	Function
`A and B`	`True` if **A and B are both** `True`
`A or B`	`True` if **either A or B is** `True`
`not A`	`True` if **A is** `False`



Operator Precedence

- Precedence is listed from highest to lowest
  - `*, /, %`
  - `+, -`
  - `<, <=, >, >=, !=, ==`
  - `in, not in`
  - `not`
  - `and`
  - `or`

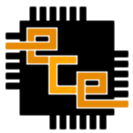
- Parenthesis are used to change the evaluation order, or improve readability.



Strings

- Single quotes in pairs allow `"` without escaping
- Double quotes in pairs allow `'` without escaping
- Triple quotes (single or double) in pairs allow either single or double quotes and newlines with escaping
- There are no other differences in quote types.

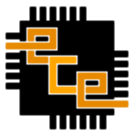
```
X = "This isn't \"funny\" -- \\' not needed"
X = 'This isn\'t "funny" -- \\\' needed'
Y = "Don't quote \"me\" -- \\\" needed"
Y = 'Don\'t quote "me" -- \\" not needed'
Z = """Don't quote "me""""
Z = '''Don't quote "me"'''
```



Strings (1)

- `str` – A string of characters
  - `My_string = "Hello World!"`
  - `Name = "Goldfarb"`

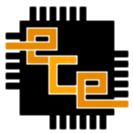
- Use the `len()` function to get the length of any string
  - `len(My_String)` `# 12`
  - `len(Name)` `# 8`



Strings (2)

- Strings can be easily concatenated using the addition (+) operator

  - `Var1 = "Hello" + " World"`
  - `Var2 = Var1 + ", how is the weather?"`



Strings (3)

- `StrVar.rstrip()`

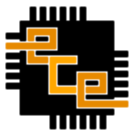
  returns a new copy of the string with whitespace removed from the right side.

- `StrVar.lstrip()`

  returns a new copy of the string with whitespace removed from the left side.

- `StrVar.strip()`

  returns a new copy of the string with whitespace removed from both sides.



Strings (4)

- `StrVar.split()`

  splits `StrVar` into a list on whitespace

  Q: What is the difference between:
  `StrVar.split()` *and* `StrVar.split(" ")` ?

- `StrVar.split(delim)`

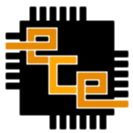
  splits `StrVar` into a list on the string `delim`

- `StrVar.split(delim, n)`

  splits `StrVar` into a list on the first `n` occurrences of the string `delim`

Strings (5)

```
Data = "    mgoldfar,ee364a01,10.6    "

# Clean off any extra whitespace
Data = Data.strip()

# Split into list of strings
Cols = Data.split(",")

# Cols[0] is 'mgoldfar'
# Cols[1] is 'ee364a01'
# Cols[2] is the string '10.6'
```

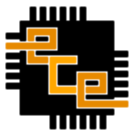


Strings (6)

- `delim.join(StrList)`

returns a string with each string in `StrList` separated by the string `delim`

```
Sep = "?"
Items = ["Baz", "Foo", "Bar"]
ItemsStr = Sep.join(Items)

# ItemsStr is "Baz?Foo?Bar"

# You can inline the separator string also!
ItemsStr = ",".join(Items)

# ItemsStr is "Baz,Foo,Bar"
```



Lists

- `list` is a built-in Python data type
  - Much more powerful than plain old arrays
  - Can also be used to implement stacks and queues

- Lists are containers of things (objects)
  - Items need not be of the same data type

```
A = [1, 2, 3, 4]
B = [1, "Big Deal", [1, 2], 6.7J]
```

Lists (2)

- Lists are mutable, elements can be reassigned:

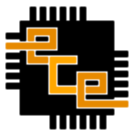
```
A = [1, 2, 3]
A[0] = "First"
```

- Use the `len(X)` function to return the length of a list

```
len(A)              # Returns 3
```

- Lists are **not** sparse – an index must exist

```
A[9] = "foo" # Illegal - causes a runtime error
```



Indexing

Negative indices are allowed in Python

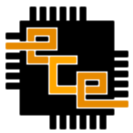
```
X = ["1st", "2nd", "3rd"]
X[0] = X[-3] = "1st"
X[1] = X[-2] = "2nd"
X[2] = X[-1] = "3rd"
```

- 0 is the index of the leftmost item
- -1 is the index of the rightmost item

Slicing

- Slicing is a way to extract multiple elements from lists, tuples and strings.

`A[M:N]`	A slice of elements starting from index `M` and ending at index `N-1`
`A[M:N:S]`	A slice of elements starting from index `M` and ending at index `N-1`, with a step `S`
`A[M:]`	A slice of elements starting from index `M`
`A[:N]`	A slice of elements starting from index `0` and ending at index `N-1`
`A[:]`	A slice containing all elements of A

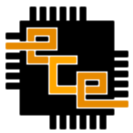


Slicing (2)

- Many things in Python can be sliced.
  - List, tuples and strings just to name a few

```
A = [1, 2, 3, 4, 5]
B = "ECE 364 is only 1 credit hour."
```

```
A[2:4] is [3, 4]        B[4:7] is '364'

A[:3] is [1, 2, 3]
```



List Functions

- `list.append(x):` Add an item to the end of the list.

```
l = [2, 5]
l.append(13)    # l = [2, 5, 13]
```

- `list.extend(L):` Extend the list by appending all the items in the given list.

```
l = [2, 5]
g = [7, -6]
l.extend(g)    # l = [2, 5, 7, -6]
```

- Another way to extend a list is to use the addition operator `(+)`
  - Note: You must use a list on both sides of the operator!

```
T = ["Mike", "Greg"]
T = T + ["Sudhir"]    # Or T += ["Sudhir"]
# T is ['Mike', 'Greg', 'Sudhir']
```

List Functions (2)

- `list.insert(i, x):` Insert an item at a given position.

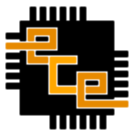
```
l = ['IN', 'MI', 'IL', 'CA']
l.insert(2, 'OH')   # l = ['IN', 'MI', 'OH', 'IL', 'CA']
```

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

```
m = [3, 2, 6, 11, 2, 15, 77]
m.remove(2)     # m = [3, 6, 11, 2, 15, 77]
```

- `list.clear():` Remove all items from the list. Equivalent to `del a[:]`.

```
g = [9, 7]
g.clear()   # g = []
```



List Functions (3)

- `list.index(x):` Return the index in the list of the first item whose value is x. It is an error if there is no such item.

```
m = [3, 2, 6, 11, 2, 15, 77]
e = m.index(2)  # e = 1
```

- You can use the `in` operator to test for membership.

```
m = [3, 2, 6, 11, 2, 15, 77]
9 in m     # Result in False
11 in m    # Result in True
```

- `list.count(x):` Return the number of times x appears in the list.

```
m = [3, 2, 6, 11, 2, 15, 77]
c = m.count(2)  # c = 2
```

List Functions (4)

- `list.sort()`: Sort the items of the list in place.

```
l = [2, 5, 7, -6]
l.sort()    # l = [-6, 2, 5, 7]
```

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

```
m = [3, 6, 11, 2, 15, 77]
m.reverse() # m = [77, 15, 2, 11, 6, 3]
```

- `list.copy()`: Return a copy of the list. Equivalent to `b=a[:]`.

  Note: `copy` creates a shallow copy.

```
l = ['IN', 'MI', 'OH', 'IL', 'CA']
c = l.copy()

# c & l both point to ['IN', 'MI', 'OH', 'IL', 'CA'].
# If you change l, c will also change.
```

List Functions (5)

`del ListVar[n]`

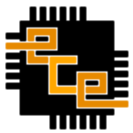
removes the item at index `n` from the list

`del ListVar[i:j]`

removes the items `i` to `j-1` from the list

`del ListVar`

deletes the entire list



File I/O

- The preferred method to open files is using the `with` keyword.
- The `with` keyword is a shorthand for a lot of work in the background to ensure resources are claimed by the system when done.
- Can be used for both reading and writing.

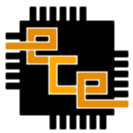
File I/O (2)

Example 1: Reading the file as a list of lines.

```
# This is called a "with-block"
# The "myFile" below is called the file alias.
# 'lines' is a list of strings.

with open('textFile.txt', 'r') as myFile:
    lines = myFile.readlines()
```

Example 2: Reading the file as a single string.

```
# 'content' is a single string of the whole file.

with open('textFile.txt', 'r') as myFile:
    content = myFile.read()
```



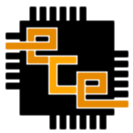
File I/O (3)

Example 3: Writing a list of strings.

```
# The list of strings must already contain the "\n"

with open('textFile.txt', 'w') as myFile:
      myFile.writelines(lines)
```

Example 4: Writing a single string.

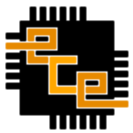
```
# Construct the string before you write it.

with open('textFile.txt', 'w') as myFile:
      myFile.write(content)
```



Type Conversion

- There is no casting from one type to another in Python
  - New values can be created from other values of different types
  - If a new value can not be created python will raise an exception

`int(x)`	Attempts to create a new integer from `x`
`float(x)`	Attempts to create a new float from `x`
`str(x)`	Attempts to create a new string from `x`
`complex (re, im)`	Attempts to create a complex number.



Type Conversion (2)

`str(Var)`

Create a new string from `Var`.

`int(StrVar)`

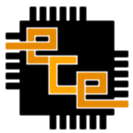
Create a new integer from `StrVar`.

`int(StrVar, base)`

Create a new integer from `StrVar` in base `base`

`float(StrVar)`

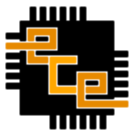
Create a new floating point number from `StrVar`



`if` Statement

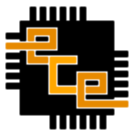
- Behaves just like any other if statement you have encountered
- Colons are required at the end of each conditional expression

```
if <condition1>:
      statements
elif <condition2>:
      statements
else:
      statements
```



while Loops

```
while <condition>:
    statements when condition is true


j = 10
while j > 0:
      print j
      j -= 1
```



`for` Loops

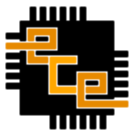
- Python supports only one style of for loop:

```
for <variable> in <sequence>:
  statements
```

- Example:

```
Sum = 0
for Item in [2, 4, -2, 5]:
    Sum = Sum + Item
print Sum
```

- Loop execution can be modified with `break` and `continue`



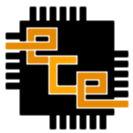
`range` Function

- Range can generate a lists of integers

`range(N)` Generates a list of integers between `0` and `N-1`
`range(6)` → `[0, 1, 2, 3, 4, 5]`

`range(M, N)` Generates a list of integers between `M` and `N-1`
`range(5, 10)` → `[5, 6, 7, 8, 9]`

`range(M,N,S)` Generates a list of integers between `M` and `N-1` with a stride of `S`.
`range(10,50,10)` → `[10, 20, 30, 40]`



`range` Function (2)

- Try your absolute best **NOT** to use the index, and operate on the elements directly.
  - This is the *Pythonic* Style. Works with all collection types:

```
for item in someList:
    # Do Something with the item.
```

  - Works only with lists & tuples. (NOT Recommended):

```
for index in range(10):
    # Get the item from the list.
    # Do Something.
```

Printing

- Use `print(someString)` to write data to `stdout`

```
print("Hello World!")
```

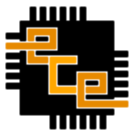
- New way to control printing is by using `format()`
  - Old Style (with `%`) can still be used, but not recommended.

- Examples:
  - Print one or more elements in order.

```
>>> print('I am "{}" and I am "{}".'.format('Smart', 'Happy'))
I am "Smart" and I am "Happy".
```

  - Print one or more elements out of order.

```
>>> print('I am "{1}" and I am "{0}".'.format('Smart', 'Happy'))
I am "Happy" and I am "Smart".
```



Printing (2)

- Examples:
  - Printing with keywords.

```
>>> print('Today is "{day}" and it is "{weather}"!'
          .format(weather='Sunny', day='Monday'))
Today is "Monday" and it is "Sunny".
```

  - Print one or more elements out of order.

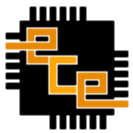
```
>>> print('I am "{1}" and I am "{0}".'.format('Smart', 'Happy'))
I am "Happy" and I am "Smart".
```

  - Print an integer with leading 0s.

```
>>> print("{:05d}".format(23))
'00023'
```

- Check string formatting specs for more details:

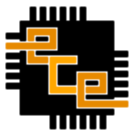
https://docs.python.org/3/library/string.html#formatstrings



Python Modules

- Python has a few built-in functions
- Many more are found in modules
  - A module is like a header file, it provides access to new functions
  - Common modules: `sys`, `string`, `os`, and `math`
- When you want to use a function from a module, you must first import that module

```
import sys
import os, math
from enum import Enum
from pprint import pprint as pp
```



Python Modules (2)

- A common problem is not importing a module when it is used
  - Python will raise an error if you forget to import something

- Example: (Solution: add `import sys`)

```
Traceback (most recent call last):
    File "<stdin>", line 1, in <module>
NameError: name 'sys' is not defined
```