Introduction to:
Computers & Programming:
Variables, Functions, Modules & Scripts

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Outline

• More function IO:
  – Assignment of multiple values to variables
  – Keyword parameters
  – Returning multiple values from a function
• Filename – just one more type of Identifier
• Two types of .py files
  – Programs (scripts)
  – Library Files (modules)
• Loading programs
  – To run
    – Into Idle for editing
• Loading and using modules
• Writing a python script
• Writing a python module
Multiple Variable Assignment

• It is possible to use one assignment with multiple variables
  
  chicken, egg, one, two = 'chicken', 'egg', 1 2

• The variables are assigned in order
  – chicken is assigned the value 'chicken'
  – egg is assigned the value 'egg'
  – etc.

• This is equivalent to writing several assignment statements
Parameters of Functions

• Local variables represent input to functions
  – `def print_pattern(char1,char2,len1=1,len2=2,repeat=3):
    for rep in range(repeat):
      print(char1*len1,char2*len2,sep='')
      if len2>1:
        if len1>len2:
          len1 = len1-1
          len2= len2+1
        else:
          len1 = len1+5
      else:
        len1=len1+1
        len2=len2+1
    – `print_pattern('*','+',len1=5,len2=4,repeat=10)

• Normal Parameters are required
• Keyword Parameters include defaults
• Parameter values can be changed because they are local variables
Return Multiple Values

- A function can return multiple values
- `def div_w_remainder(dividend, divisor):
    whole = dividend // divisor
    remainder = dividend % divisor
    return (whole, remainder)
- `cookies_each, xtra_cookies = div_w_remainder(50, 20)`
A Few modules

• Math module
  – import math
    • math.pi, math.e
    • math.floor, math.ceil, math.log, ...

• Random module
  – import random
    • random.random, random.randint, random.seed()
    • Note: in CS random always really means psuedo-random

• OS module
  – Import os
    • os.sep, os.linesep
    • os.chdir, os.getcwd()
Filenames are identifiers

- Files used in python include: program, input and output files
- This lecture only concerns program files (modules and scripts)
  - These should have filetype .py
- When creating program files, it is advisable to follow the same principles as with variables and function names:
  - Use letters, numbers and underscore
  - Begin with a letter
  - Pick filenames that tell you something about the file contents
  - Not abiding by these rules can result in bugs, e.g., when loading files with “import”
Finding Files on Your Computer

• Lets find scripts in the **turtledemo** directory on your computer
  – Apple: /Library/Frameworks/Python framework/Versions/3.4/lib/python3.4/turtledemo
  – Windows: C:\Python34\Lib\turtledemo

• Searching for turtledemo (or any python file)
  – For Apple to find it, you must set “kind” in the search window to include “systems” files
    • Use command F to set this – indicate that “system files are included”
  – For Windows, you must search from C:
    • This worked on my Windows computer, if you have difficulty, you may need to change settings to search for more types of files (and search C:, not a subdirectory)

• Next 2 slides: A quick introduction to file systems on your computer
Computer Files Form a Directed Graph

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CSCI-UA.0002
The Structure of File Systems

- Special Symbol for root of graph and separator
  - Unix-compatible (linux, Apple, …) = /
  - Windows (DOS) only = \n
- The root corresponds to a either a disk drive or all disk drives

- For Windows, C: is usually the “main” disk drive

- The terminal nodes (nodes with no children) of the graph are regular files

- The internal nodes (nodes with children) of the graph are “directories” or “folders”, i.e., they refer to sets of files

- It is possible to have files or directories “shared” by multiple parents
  - These are handled via “file linking” or “short cuts”

- In many operating systems, certain classes of files are hidden from the users: hidden files, system files, etc.
  - This reflects a philosophy that users should be protected from understanding the details of what is going on
  - Computer science professors don't share this philosophy
  - We recommend making all files visible, so you can understand how your computer works and so you can find program files
What is a Script?

• A script is a file that contains a single program
  – Functions defined in other files (modules) are loaded with the keyword `import`
• Scripts can be run in several ways:
  – Double-clicking if the `python3 launcher` is the default program for files of type `.py`
  – By using `open with` and choosing the `python3 launcher`
    • Recommended as python2 is likely to be the current default
  – Typing `python3 filename.py` on a command line (in a shell)
• These can also be loaded, edited and run in IDLE
• For example, we will use the colormixer (`colormixer.py`) script from the `turtledemo` directory
  – We can run it
  – We can open it with Idle, examine the code and run it
The Example colormixer

• When we run it
  – There are 3 sliders corresponding to red, green and blue
    • primary colors for light (magenta, yellow and cyan are primary colors for pigment)
  – Moving the sliders show the result of mixing these colors differently

• When we look at the code
  – This program imports parts of the turtle module
  – It creates some of its own object types (details omitted)
  – The real action is in the main function
The code in colormixer

• By convention, many programmers name their principle function that calls all others *main*.

• The program first defines some variables and creates objects of two types:
  
  – *screen* and *colorturtle* (the programmer's modified version of a type called *turtle*)
  
  – And writes the message “Drag” to label the window

• The method *shift*, part of the definition of *colorturtle*, maps the y position of a turtle to a numerical value

• The function *setbgcolor* sets the red, green and blue components for the background color of the screen at the end of each call to the function *shift*.

  – These component values are based on the y positions of the red, green and blue turtles
What is the turtle module?

- A file called turtle.py
  - `import turtle` loads this in python
  - `help(turtle)` lists the various functions, variables and objects that are part of the turtle module

- History
  - Turtle Graphics was originally implemented as part of the \textit{LOGO} language
  - To this day, there are implementations for teaching young children about programming (e.g., Microworlds)
  - The turtle module is a python implementation of this environment
The Basic Idea behind Turtle Graphics

• Do graphics by creating 'turtles'

• A turtle is an object on a Cartesian Plane
  – The turtle can look like a turtle, but need not
  – A Cartesian Plane is a grid as in High School Geometry
    • Vertical lines are represented as: X = -1, X = 0, X = 1, etc.
    • Horizontal lines are represented as: Y = -1, Y = 0, Y = 1, etc.
    • Points are (X,Y) pairs where X indicates how far to the left or right and
      Y indicates how far up or down, e.g., (1,1) is located diagonally up
      from the middle (0,0)

• Turtles have pens which write when the pen is down, but
  don't when the pen is up

• The ink color of the pen can be changed by setting their
  R,G,B values
Basic Components of Turtle Graphics in Python (and elsewhere)

- **Object types: Turtle and Screen**
  - In effect, this adds to our list of data types
    - integer, string, float, Turtle, Screen, …
  - These are initialized using functions with no arguments
    - turtle.Turtle() and turtle.Screen()
    - Use 'turtle.' prefix for commands from the turtle module
      - Or 'math.' for commands from the math module, etc.
- **Simple commands that are connected to the Turtle object using dot notation**
  - fd(NUM) – moves forward NUM units (i.e., moves forward from the turtles' point of view)
  - left(DEG) and right(DEG) – pivot left/right DEG degrees
  - pd() and pu() – put pen down (to draw) and up (to stop)
A Simple Turtle Graphics Example

• Loading module, creating a screen and a turtle
  
  ```python
  import turtle
  my_screen = turtle.Screen()
  my_turtle = turtle.Turtle()
  ```

• Putting the pen down and drawing a square
  
  ```python
  my_turtle.pd()
  my_turtle.fd(100)
  my_turtle.left(90)
  my_turtle.fd(100)
  my_turtle.left(90)
  my_turtle.fd(100)
  my_turtle.left(90)
  my_turtle.fd(100)
  ```
Drawing a 2\textsuperscript{nd} Square Under the 1\textsuperscript{st} One

```python
my_turtle.pu()
my_turtle.fd(100)
my_turtle.pd()
my_turtle.fd(100)
my_turtle.left(90)
my_turtle.fd(100)
my_turtle.left(90)
my_turtle.fd(100)
my_turtle.left(90)
my_turtle.fd(100)
```
Modules, aka, Library Files?

- Modules are files of functions and variables
  - Designed to be incorporated in other programs
  - Typically on a single theme (math, graphics, astronomy, ...)
  - Some modules are built in, i.e., installed with Python
  - You can download or write others yourself

- To load a module
  - 'import module_name'
    - You can use functions, global variables and objects
      - Use dot notation, e.g., module_name.function()
  - 'from module import functionX' (or objectX)
    - Use functionX without dot notation
    - Overwrite function and global variable definitions if they have the same name
  - 'from module import *' – same as above, except import everything
Modules

• Example (the math module)
  import math
  help(math)
  math.ceil(5.1)
  help(math.ceil)

• The 'help' function
  – Lists variables, functions, methods, etc. for a module
  – Also gives function definitions

• Use 'dot' notation for module variables/functions

• Alternatively: from module_name import *
  – Let's you drop the dot notation
  – Can cause problems (name conflicts)
four-squares.py Script

• Uses 2 modules: *turtle* and *time*

• Encapsulates square drawing as a single function which we call 4 times

• The square drawing function puts down the pen; moves forward and turns left three times each; and then puts down the pen

• The main function draws four squares, (redundantly) puts down the pen in between squares and sleeps for 15 seconds at the end
  – Note that the redundancy insures that the function works properly in all environments
four-squares.py Script 2

• The comments suggest ways to modify the program

• Turtles come in several different shapes
  – (turtle.getshapes() will list them)
  – 'turtle' is in fact one of the possible shapes
  – This is being called with a keyword argument shape='turtle'

• Args identified by name, rather than order

• colormode(255) allows colors to be set in combinations of Green, Yellow and Blue on a scale from 0 (no color) to 255 (saturated)

• The package is very detailed. It has its own manual: http://docs.python.org/py3k/library/turtle.html

Is there a way to improve the code?

• Do you notice any redundancy in the `draw_turtle_square` function?
  – Is there any way that a loop could be used to simplify the code?

• Is there any way we could generalize this function so that we could use one function for drawing, not just squares, but other shapes as well?
Revisit For Loop Checkerboard Program

• Re-examine Code from loop-examples lecture
Summary

- Identifiers in Python include:
  - variables
    - local variable names apply inside of functions
    - global variable names apply whenever they are not clobbered by a local variable name
  - functions – encapsulate sets of commands
  - program files
    - Scripts – special purpose
    - Modules (aka library files) – reusable code
- Intro to Graphics:
  - typically use X,Y coordinates for points on a plane
  - use some sort of RGB encoding for color
Summary

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Homework Part 1
(Due Oct 18)

• Read Chapters 7 and 8
  • (Note: We will Read Chapter 6 later in the term)
• Do Module 7
  • http://cs.nyu.edu/elearning/CSCI_UA_0002/module07.php
• Do Quiz 7 in NYUClasses
Homework 2: Part 2 (Due Oct 18)
Write a program

• Use the turtle module to draw a picture.
  – Several turtle programs are on the class website
  – See: http://docs.python.org/release/3.4.3/library/turtle.html

• Include at least a stick figure in your picture.
  – If you want the figure to have a round head use
    `my_turtle.circle(NUMBER)`
    where NUMBER is the radius of the circle (e.g., 50)

• Include functions that encapsulate code for reuse
  – Examples: `draw_left_arm`, `draw_left_leg`, `draw_stick_figure`
  – This makes it easy to draw multiple stick figures and different types
    of stick figures. It also makes your code easier to understand
Grading Criterion

• There must be at least one recognizable stick figure
• Higher score for encapsulating code as functions: draw_hand, draw_finger, etc.
• Higher score for calling the same function more than once with different parameters
• Higher scores for creative, interesting or surprising pictures
Part 3 (Due Oct 25)

• Do Module 8
  – http://cs.nyu.edu/elearning/CSCI_UA_0002/module08.php

• Do Quiz 8 in NYUClasses