CSC 108H: Introduction to Computer Programming

Summer 2012

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Administration

- Office hours
  - Held in BA 2270 at M4-6, F2-4
- The second ramp-up session hasn't happened yet.
  - Saturday 10am - 4pm
  - In BA 3185
  - Register on the CSC 148 website.
- Help centre is now open.
  - BA 2270 M-R 2-4

Administration

- Exercise 1 is up, premarking will go live tomorrow.
- If you don't have a cdf account/can't login yet, talk to the cdf support staff.
  - Try to login to Markus tonight or tomorrow, and let me know if you can't.
- Anonymous Feedback.
- Some people have asked for more detailed python installation instructions.
  - I will do them tomorrow post pre-marking setup.

Last Week

- Variables.
  - a name that refers to some value.
  - assigned with:

    ```
    name = expression
    ```

  - The expression is any legal python statement that can evaluate to one value.
  - variable names can consist of digits, letters and underscores.
  - convention in python is to use pothole_case.

Variable exercises

- Write code to swap the values of x and y given the following:

  x = 10

  y = 11

What values do x and y refer to here?

x = 10

y = x

x = y+11

y = y+5

- What assignment statement has incorrect syntax?

  x = (12 -12)*y

  y + x + y

  x+x = 20

  x = x + x + x*y

Variable exercises

- Write code to swap the values of x and y given the following:

  x = 10

  y = 11

  tmp = x

  x = y

  y = tmp

- What values do x and y refer to here?

  x = 10

  y = x

  x = y+11

  y = y+5

- x refers to 21
- y refers to 15

- What assignment statement has incorrect syntax?

  x = (12 -12)*y

  y + x + y

  x+x = 20

  x = x + x + x*y

Last Week

- Functions.
  - A way to reuse code.
  - created by:

```
def name(parameters):
    block
```

  - called by:

```
name(expressions)
```

  - Will evaluate to `None` or the return value if one exists.

Basic Function Exercises

- One of the following will cause a crash.
- Which one, why?

```
def f(x):
    return x + 4
x = f(1)
y = 12
print x + y
```

```
def f(x):
    print x + 4
x = f(11)
y = 12
z = 13 + y
x = x + z
```

Basic Function Exercises

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Basic Function Exercises

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```

```
def f(x):
    print x + 4
x = f(11)
y = 12
z = 13 + y
x = x + z
```

Why functions?

- Allow us to reuse bits of code, which makes updating and testing much easier.
  - Only need to test and update the function, rather than every place that we use it.
- Chunking! Allows us to parse information much better.
  - Human mind is pretty limited in what it can do.
  - Function names allow us to have a shorthand for what a function does.

Functions in detail

- We missed or didn't cover a lot of stuff in the first lecture.
  - print vs. return.
  - variable scope.
  - nesting function calls.
  - designing functions
  - function documentation.

Aside: Command Line Python

- Python can be run from the command line.
  - Usually referred to as a terminal in OS X/Linux
  - Start -> run -> cmd.exe in Windows.
- Can run python files with
  - python file_name.py
  - python will just run the shell.
- Command line python allows one to use python in scripts, and is faster.

Print vs. Return

- Recall that functions end if they see a return statement, and return the value of the expression after the keyword return.
  - If there is no return statement, the function returns None.
- We've also seen snippets of the print statement.
  - Print takes one or more expressions separated by a comma, and prints them to the screen.
- This is different than a return statement, but looks identical in the shell.

Variable scope

- Scope refers to the area in which a variable is defined.
  - If there is an undefined variable the code will crash.
  - Knowing scope is key to being able to trace code.
- There are two types of variables:
  - Local variables defined in functions
  - Global variables defined in the body of the program.

Local Variables.

```
def name(parameters):
    block
```

- Defined within a function.
  - They exist only during a function call.
  - They stop existing one the function call is resolved, and are recreated if the function is called again.
  - The parameters are viewed as local variables.

Local Variables.

```
def name(parameters):
    block
```

- Defined within a function.
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  - The parameters are viewed as local variables.

Global variables

- Defined outside of a function.
- Exist between function calls.
- Cannot be changed by a function call!

```
def name(parameters):
    block1

block2
```

Global variables

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def name(parameters):
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Local Scope

Global Scope

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```

- Cannot be changed by a function call!

Local Scope

Global Scope

Variable name overlap

- It is possible for local and global variables to have the same name.
- If this occurs, python will use the local variable.
- In general, if python sees a variable name, it will try and use as local a variable name as possible.

Local variable question

- ```
  def f(x):
      return x + 4
  z = 4
  z = f(12)
  f(33)
  z = f(z)
  ```

- If we execute the code on the left, what values does x refer to over the course of the execution?
  ```

Local variable question

```
def f(x):
    return x + 4
z = 4
z = f(12)
f(33)
z = f(z)
```

- If we execute the code on the left, what values does x refer to over the course of the execution?

12

33

16

Nesting Function calls

- Sometimes we want to have functions calling other functions.
  - f(g(4))
- In this case, we use the 'inside out' rule, that is we apply g first, and then we apply f to the result.
- If the functions can have local variables, this can get complicated.

Variable Lookup

- First, check local variables defined in a function.
- Then check local variables in an enclosing function.
  - That is for f(g(4)) it will check g's local variables first, and then f's local variables.
- Then check global variables.

How to think about scope.

- We use namespaces.
- A name space is an area in which a variable is defined.
- Each time we call a function, we create a local namespace.
- We refer to that first, and go down to the enclosing functions name space or global namespace as necessary.

Namespaces

```
def f(x):
    return x + 4
def g(y):
    return f(y) + 10
z = 14
z = z + g(z)
```

Global namespace

Namespaces

```
def f(x):
    return x + 4
def g(y):
    return f(y) + 10
z = 14
z = z + g(z)
```

G local namespace
Global namespace

Namespaces

```
def f(x):
    return x + 4
def g(y):
    return f(y) + 10
z = 14
z = z + g(z)
```

F local namespace
G local namespace
Global namespace

Call Stack

- The mechanism through which python does lookups.
- Python starts with a lookup table for global variables.

Lookup Table

- Variables on one side, memory addresses on the other.
- Useful to write something that indicates what namespace the look up table refers to.

Global
y: 0x2
x: 0x3

Call Stack

- The mechanism through which python does lookups.
- Python starts with a lookup table for global variables.
- Each time a function call is evaluated a new lookup table for local variables is created.
- This table is put 'on top' of the currently extant tables.

Call Stack

- To look up a variable one tries to find it in a lookup table.
- Start at the top, and go down until one finds a lookup table that contains the variable one is looking for.
- If one can't find it, the program crashes.
- Note: A variable can only exist at most once in a given lookup table.

Call Stack example.

```
def f(x):
    return x + 4
def g(y):
    return f(y) + 10
z = 14
z = z + g(z)
```

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def f(x):
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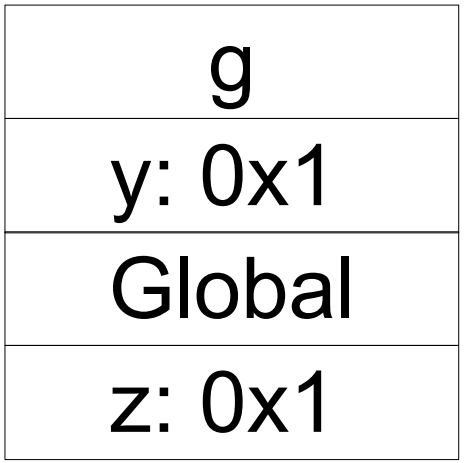
Global
z: 0x1

Call Stack example.

```
def f(x):
    return x + 4
def g(y):
    return f(y) + 10
z = 14
z = z + g(z)
```



Call Stack example.

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def f(x):
    return x + 4
def g(y):
    return f(y) + 10
z = 14
z = z + g(z)
```

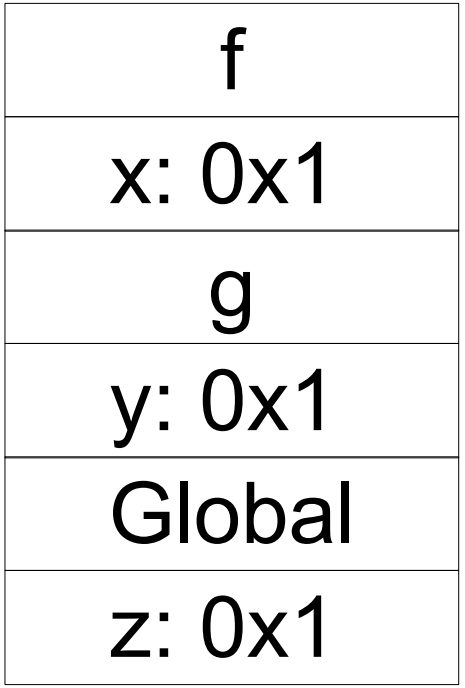

Why do we care about Namespaces and Call Stacks?

- Understanding this will make tracing easier.
  - The better this can be internalised, the more one can trace code without needing to explicitly write things down.
  - Useful for debugging.
  - Common stumbling block for beginners.

Break, the first

Break, the first.

```
def f(x):
    return x + 4
def g(x):
    return x + f(4)
z = 3
g(z)
y = 5
```

- Draw the call stack at the indicated points in the execution.

Break, the first.

```
def f(x):
    return x + 4
def g(x):
    return x + f(4)
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```

- Draw the call stack at the indicated points in the execution.

Global
z: 0x1

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def f(x):
    return x + 4
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    return x + f(4)
z = 3
g(z)
y = 5
```

- Draw the call stack at the indicated points in the execution.

g
x: 0x1
Global
z: 0x1

Break, the first.

```
def f(x):
    return x + 4
def g(x):
    return x + f(4)
z = 3
g(z)
y = 5
```

- Draw the call stack at the indicated points in the execution.

f
x: 0x2
g
x: 0x1
Global
z: 0x1

Break, the first.

```
def f(x):
    return x + 4
def g(x):
    return x + f(4)
z = 3
g(z)
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```

- Draw the call stack at the indicated points in the execution.

Global
z: 0x1

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z = 3
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- Draw the call stack at the indicated points in the execution.

Global
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Global or Local Variables?

- Functions can reference global variables.
- Global variables can also be passed to functions.

Global or Local Variables?

- Functions can reference global variables.
- Global variables can also be passed to functions.
- The latter is strongly preferred.
  - The former tends to make code hard to read and prone to errors.
- Global variables tend to be used only for constants that will never change.

Designing Functions

- Need to choose parameters.
  - Ask “what does the function need to know”.
  - Everything it needs to know should be passed as a parameter.
  - Do not rely on global parameters.
- Need to choose whether to return or not to return.
  - Functions that return information to code should return, those that show something to the user shouldn't (print, media.show(), etc).

Function Documentation

- Recall that we can use the built-in function help() to get information on functions or modules.
- We can do this on functions that we've defined as well, but it doesn't give much information.
- We can add useful documentation with docstrings.
  - A docstring is surrounded by ''' and must be the first line of a module or function.

Docstrings

- If the first line of a function or module is a string, we call it a docstring.
  - Short for documentation string.
- Python saves the string to return if the help function is called.
- Convention: Leave a blank line after but not before a docstring.
- The first line of a docstring should contain information about the parameter and output types.

Docstrings

- The first line of a docstring should contain information about the parameter and output types.

```
(int, float) -> int
picture -> NoneType
NoneType -> float
```

First line of docstrings.

- Write a plausible first line docstring for the following function headers:

  def f(x, z):

  def f():

  def f(x, y, z)

First line of docstrings.

- Write a plausible first line docstring for the following function headers:

```
def f(x, z):
'''(int, float) -> float'''
def f():
'''NoneType -> int '''
def f(x, y, z)
'''(float, float, int) -> NoneType'''
```

Why Docstrings?

- If you write the docstring first, you have an instant sanity check.
- Makes portability and updating easier.
  - Allows other people to know what your functions do and how to use them, without having get into the code.
  - Allows for good chunking.
- Every Function should have a docstring!

Writing Good Docstrings.

- '''A sunset module.'''
- '''Changes into a sunset.'''
- These are terrible docstrings.
  - They are vague and ambiguous. The don't tell us what the function expects or what it does.
- How can we make it better?

Writing Good Docstrings.

- Describes what a function does.
- '''Changes into a sunset.'''
- '''Makes a picture look like it was taken at sunset.'''
- '''Makes a picture look like it was taken at sunset by decreasing the green and blue by 70%.'''

Writing Good Docstrings.

- Describes what a function does.
- '''Changes into a sunset.'''
- **'''Makes a picture look like it was taken at sunset.'''**
- **'''Makes a picture look like it was taken at sunset by decreasing the green and blue by 70%.'''**

Writing Good Docstrings.

- Does not describe how a function works.
  - More useful for chunking, and it's unnecessary information if we're using the function.
- '"Makes a picture look like it was taken at sunset."'
- '"Makes a picture look like it was taken at sunset by decreasing the green and blue by 70%."'

Writing Good Docstrings.

- Does not describe how a function works.
  - More useful for chunking, and it's unnecessary information if we're using the function.
- **'''Makes a picture look like it was taken at sunset.'''**
- '''Makes a picture look like it was taken at sunset by decreasing the green and blue by 70%.'''

Writing Good Docstrings.

- Makes the purpose of every parameter clear and refers to the parameter by name.
- '''Makes a picture look like it was taken at sunset.'''
- '''Takes a given picture and makes it look like it was taken at sunset.'''
- '''Takes a picture pic and makes it look like it was taken at sunset.'''

Writing Good Docstrings.

- Makes the purpose of every parameter clear and refers to the parameter by name.
- '''Makes a picture look like it was taken at sunset.'''
- '''Takes a given picture and makes it look like it was taken at sunset.'''
- **'''Takes a picture pic and makes it look like it was taken at sunset.'''**

Writing Good Docstrings.

- Be clear if a function returns a value, and if so, what.

  Consider average_red(pic)
- '''Computer the average amount of red in a picture.'''
- '''Returns the average amount of red (a float) in a picture pic.'''

Writing Good Docstrings.

- Make sure to explicitly state any assumptions the function has.

  def decrease_red(pic,percent)

- '''Decreases the amount of red per pixel in picture pic by int percent. percent must be between 0 and 100.'''

Writing Good Docstrings.

- Be concise and grammatically correct.
- Use commands rather than descriptions.
- '''Takes a picture pic and makes it appear as it if was taken at sunset.'''
- '''Take picture pic and make it appear to have been taken at sunset.'''

Writing Good Docstrings.

- Docstrings do not include definitions or hints.
- The docstring for sqrt is not:

  '''Return the sqrt of (x). The sqrt of x is a number, that when multiplied by itself evaluates to x'.

- Is it simply:
  - Return the square root of x.

Writing Good Docstrings.

- Describes what a function does.
- Does not describe how a function works.
- Makes the purpose of every parameter clear and refers to the parameter by name.
- Be clear if a function returns a value, and if so, what.
- Make sure to explicitly state any assumptions the function has.
- Be concise and grammatically correct.
- Use commands rather than descriptions.

Break, the second.

Break, the second.

- What's the better docstring?

```
def f(x,y):
    '''int -> int
Adds two numbers'''
```

```
def g(x,y):
    '''multiplies two
    numbers'''
```

```
def max(x,y):
    '''(int, int) -> int
    returns the maximum
    of two numbers.'''
```

```
def f(x,y):
    '''Adds two
    numbers'''
```

```
def g(x,y):
    '''(int, int) -> int
    multiplies two
    numbers'''
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```
def max(x,y):
    '''(int, int) -> int
    takes two numbers
    and returns the
    maximum.'''
```

Break, the second.

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    numbers'''
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def g(x,y):
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    multiplies two
    numbers'''
```

```
def max(x,y):
    '''(int, int) -> int
    takes two numbers
    and returns the
    maximum.'''
```

Adaptive Programs

- We've seen programs that are executed line by line.
  - Even if they had function calls, we could expand these to something that was line by line.
- This is very limited.
  - Can't make choices, adapt to information.

Booleans: A new type.

- Can have two values `True`, `False`.
- Have three operations: `not`, `and`, `or`.
- `not` changes a `True` to a `False` and vice versa.
- `and` returns `False` unless all the arguments are `True`.
- `or` returns `True` unless all the arguments are `False`.

Truth Tables

- A way of representing boolean expressions.

x	y	not x	not y	x and y	x or y
True	True	False	False	True	True
True	False	False	True	False	True
False	True	True	False	False	True
False	False	True	True	False	False

What if we want to adapatively assign Boolean values.

- We can use relational operators.
  - <,>,<=,>=,!=, ==
- These are all comparison operators that return True or False.
- == is the equality operator.
- != is not equals.

Boolean Expressions and Representation

- Can combine boolean operators (and, or, not) and relational operators (<,>,etc) and arithmetic operators (+,-,*, etc).
  - 5+7<4*3 or 1-2 >2-4 and 15==4 is a legal expression.
  - Arithmetic goes before relational goes before boolean.
- False is represented as 0, and True is represented as 1.
  - Can lead to weirdness. Best to avoid exploiting this.

Boolean Exercises

What do these expressions evaluate to?

not (True and False)

(True or False) and (True and not False)

(not(True or False)) or (not(True and False))

True and (10 > 11)

(4*3) == 12

((4*3) == 12) and (5>11)

not ((4*3) != 12)

Boolean Exercises

What do these expressions evaluate to?

not (True and False)

True

(True or False) and (True and not False)

True

(not(True or False)) or (not(True and False))

True

True and (10 > 11)

False

(4*3) == 12

True

((4*3) == 12) and (5>11)

False

not ((4*3) != 12)

True

Short Circuit Evaluation

- Python only evaluates a boolean expression as long as the answer is not clear.
  - It will stop as soon as the answer is clear.
- This, combined with the nature of boolean representation can lead to strange behaviour.
- Exploiting these behaviours is bad style.

How to use boolean variables

- Recall that we want to make our code adaptive.
- To use boolean variables to selectively execute blocks of code, we use if statements.

If statement

- The general form of an if statement is:

```
if condition:
    block
```

- Example:

```
if grade >=50:
    print “pass”
```

If statement

- The general form of an if statement is:

```
if condition:
    block
```

- The *condition* is a boolean expression.
- Recall that a block is a series of python statements.
- If the *condition* evaluates to true the block is executed.

Other Forms of if statement

- If we want to execute different lines of code based on the outcome of the boolean expression we can use:

```
if condition:
    block
else:
    block
```

- The block under the else is executed if the condition evaluates to false.

More general if statement.

```
if condition1:
    block
elif condition2:
    block
elif condition3:
    block
else:
    block
```

- Python evaluates the conditions in order.
- It executes the block of the first (and only the first) condition that is true.
- The final else is optional.

Style advice for booleans.

- If you are unsure of precedence, use parentheses.
  - Will make it easier for a reader.
  - Also use parentheses for complicated expressions.
- Simplify your Boolean expressions.
  - Get rid of double negatives, etc.

Boolean Docstrings.

- def: is_odd(x):

  return (x%2)==1

- The docstring for this might look like
  '''int -> bool
  Return True if int x is odd, and False otherwise.'''
- Written part is commonly shortened to:
  - '''Return True iff int x is odd.

IFF

- iff stands for if and only if.
- So in fact we wrote:
- '"Return True if int x is odd and only iff int x is odd."'
- We didn't specify what to do if x is not odd.
- But for boolean functions, it is understood that we are to return False if we're not returning True.

If statement questions.

```
z = 50
if z < 10:
    print '10'
elif z < 25:
    print '25'
elif z < 100:
    print '100'
else:
    print '1000'
```

```
z = 50
if z > 10:
    print '10'
elif z > 25:
    print '25'
elif z > 100:
    print '100'
else:
    print '1000'
```

- What gets printed?

If statement questions.

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z = 50
if z < 10:
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elif z < 25:
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z = 50
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- What gets printed?

If statement questions.

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else:
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```

```
z = 50
if z > 10:
    print '10'
elif z > 25:
    print '25'
elif z > 100:
    print '100'
else:
    print '1000'
```

- What gets printed?