Objective

- More for loop
- Designing for Change
- Using Functions

Review

- Which lab did you submit today?
  - How many have you completed?
- What statement do we use to repeat something?
- What are the possible ways to use the `range` function?
  - What do they mean?

Practicing for Loops

What is getting repeated? How many times?

- A)
  1
  2
  3
  4
  Tell me that you love me more
- B)
  I had the time of my life
  And I never felt this way before
  And I swear this is true
  And I owe it all to you

  } 3 times, followed by Dirty bit
- C)
  10
  9
  8
  7
  …
  1
  Blast off!

Programming Practice

- Add 5 numbers, inputted by the user
  - After implementing, simulate running on computer
- How would have implemented this last week?
  - How can we improve that based on our new knowledge?

`sum5.py`

Generalizing Solution: Accumulator Design Pattern

1. Initialize accumulator variable
2. Loop until done
   - Update the value of the accumulator
3. Display result

DESIGNING FOR CHANGE

Designing for Change

- What are we likely to change in the program?
- How can we make the program easier to change?

Constants

- Special variables whose values are defined once and never changed
  - By convention, not enforced by interpreter
- By convention
  - A constant's name is all caps
  - Typically defined at top of program → easy to find, change
- Examples:

```
NUM_INPUTS = 5
MIN_VALUE = 0
```

Never assigned values in remainder of program

Programming Practice

- Sum **x** numbers inputted by the user

sum_with_constant.py

Parts of an Algorithm

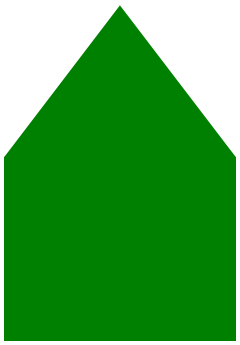
- Input, Output
- Primitive operations
  - What data you have, what you can do to the data
- Naming
  - Identify things we're using
- Sequence of operations
- Conditionals
  - Handle special cases
- Repetition/Loops
- Subroutines
  - **Call**, reuse similar techniques

Motivating Functions

- PB&J: spreading PB, spreading jelly
  - Similar processes
  - Want to do many times
  - Simplify by saying "spread" rather than saying "move the knife back and forth, condiment side down, against the bread until you get X inches of …"
- Benefits
  - Reuse, reduce code
  - Easier to read, write

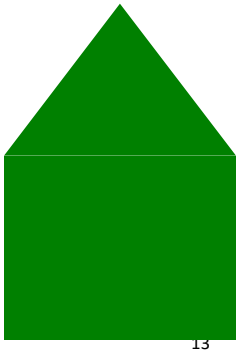
Example

- How would you find the area of this shape?



Example

- How would you find the area of this shape?
- Algorithm Possibilities:
  - Total Area = ½ b_t h_t + w_r*h_r
  - Total Area = Area of triangle + Area of rectangle



Which algorithm is easier to understand?

For (most) humans,
words and abstraction of ideas
are easier to understand

Functions

- Functions perform some task
  - May take **arguments/parameters**
  - May **return** a value that can be used in assignment

What does it do?
How does it do it?

We don't know ***how*** it does it,
but it's okay because it doesn't matter
→as long as it **works**!

Functions

- Syntax:
  - `func_name(arg0, arg1, …, argn)`

Argument list (input)

- Depending on the function, arguments may or may not be required
  - [ ] indicate an optional argument
- Semantics: depend on the function

Built-in Functions

- Python provides some built-in functions for common tasks

Known as function's ***signature***

Template for how to "**call**" function

Optional argument

- `input([prompt])`
  - If prompt is given as an argument, prints the prompt without a newline/carriage return
  - If no prompt, just waits for user's input
  - **Returns** user's input (up to "enter") as a **string**

Description of `print`

- `print(value, …, sep=' ', end='\n', file=sys.stdout)` Important later

  Meaning: default values for `sep` and `end` are `' '` and `'\n'`, respectively

  - Print *object*(s) to the stream *`file`*, separated by *`sep`* and followed by *`end`*.
  - Both *`sep`* and *`end`* must be strings; they can also be `None`, which means to use the default values. If no *object* is given, *`print`*() will just write *`end`*.

`http://docs.python.org/py3k/library/functions.html#print`

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- Examples

```
print("Hi", "there", "class", sep='; ')
print("Put on same", end='')
print("line")
```

Output:

```
Hi; there; class
Put on sameline
```

`print_examples.py`

More Examples of Built-in Functions

Function Signature	Description
`round(x[,n])`	Return the `float` **x** rounded to **n** digits after the decimal point If no **n**, round to nearest `int`
`abs(x)`	Returns the absolute value of **x**
`type(x)`	Return the type of **x**
`pow(x, y)`	Returns x^y

Interpreter

Using Functions

- Example use: Alternative to exponentiation
  - Objective: compute -3^2
  - Python alternatives:
    - **pow**(-3, 2)
    - (-3) ** 2
- We often use functions in assignment statements
  - Function does something
  - Save the output of function (what is ***returned*** in a variable

```
roundedX = round(x)
```

Python Libraries

- Beyond built-in functions, Python has a rich **library** of functions and definitions available
  - The library is broken into **modules**
  - A ***module*** is a file containing Python definitions and statements
- Example modules
  - `math` — math functions
  - `random` – functions for generating random numbers
  - `os` — operating system functions
  - `network` — networking functions

`math` Module

- Defines constants (variables) for `pi` (i.e., π) and `e`
  - These values never change, i.e., are ***constants***
  - Recall: ***we*** name constants with all caps
- Defines functions such as

Function	What it Does
`ceil(x)`	Return the ceiling of x as a float
`exp(x)`	Return e raised to the power of x
`sqrt(x)`	Return the square root of x

Using Python Libraries

- To use the definitions in a module, you must first **import** the module
  - Example: to use the **math** module's definitions, use the import statement: **import math**
  - Typically import statements are at ***top*** of program
- To find out what a module contains, use the **help** function
  - Example within Python interpreter:

```
>>> import math
>>> help(math)
```


Using Definitions from Modules

- Prepend constant or function with **modulename**.
  - Examples for constants:
    - math.pi
    - math.e
  - Examples for functions:
    - math.sqrt

Alternative Import Statements

```
from <module> import <defn_name>
```

- Examples:
  - `from math import pi`
    - Means "import pi from the math module"
  - `from math import *`
    - Means "import *everything* from the math module"
- With this `import` statement, don't need to prepend module name before using functions
  - Example: `e**(1j*pi) + 1`

Benefits of Using Python Libraries/Modules

- Don't need to rewrite code
- If it's in a module, it is very *efficient* (in terms of computation speed and memory usage)

Finding Modules To Use

- How do I know if functionality that I want already exists?
  - Python Library Reference: `http://docs.python.org/py3k/library/`
- For the most part, in the beginning you will write most of your code from scratch

RANDOM MODULE

random module

- Python provides the random module to generate pseudo-random numbers

- Why "pseudo-random"?
  - Generates a list of random numbers and grabs the next one off the list
  - A ***seed*** is used to initialize the random number generator, which decides which list to use
    - By default, the current time is used as the seed

List of Lists of Random Numbers

Seed	List of Random Numbers				
1	0.1343642441	0.8474337369	0.763774619	0.2550690257	…
2	0.9560342719	0.9478274871	0.0565513677	0.0848719952	…
3	0.2379646271	0.5442292253	0.3699551665	0.6039200386	…
4	0.2360480897	0.1031660342	0.3960582426	0.1549722708	…
…	…				…

Some `random` Functions

- `random()`
  - Returns the next random floating point number in the range [0.0, 1.0)
- `randint(a, b)`
  - Return a random integer N such that a ≤ N ≤ b

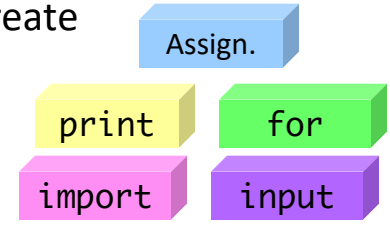
```
import random

#random.seed(1)     # module.function()

for x in range(10):
    print(random.random())
```


VA Lottery: Pick 4

- To play: pick 4 numbers between 0 and 9
- To win: select the numbers that are selected by the magic ping-pong ball machine
- Your job: Simulate the magic ping-pong ball machines
  - Display the number on *one* line

Programming Building Blocks

- Adding to your tool set
- We can combine them to create more complex programs
  - Solutions to problems



Looking Ahead

- Pre Lab 3, Lab 3 next week