Python basics 2

- **IPython** as replacement for plain Python interpreter
  - IPython is an improved, more interactive version of the plain Python interpreter
  - run `ipython` instead of `python` at the command line
  - does syntax highlighting - pretty colours!
  - numbered input and output lines
    - can access previous output and input lines numbered `n` with `_n` and `_in`
  - use `?` for help, if available, e.g. `range?` gives help on the `range()` function
    - if help is long, scroll up/down with arrow keys, to exit hit `q`
  - command completion: `som + <TAB> -> something`
  - command history with up/down keys
  - attribute exploration via dot notation: `s. + <TAB>` gives a popup menu of attributes/methods
  - view all local variables with `whos`
    - btw, you can delete a variable `v` with `del v`
  - paste multiline code from editor directly into IPython
  - run a script using `run` , e.g. `run hellos.py`
    - if you want your script to be able to access variables in your workspace, run "interactively" with `run -i hellos.py`
  - can call bash command-line commands for folder navigation: `pwd` , `ls` , `cd`
  - exiting **plain Python** in Linux/Mac: `Ctrl+D` ; in Windows: `Ctrl+Z` , then ENTER
  - exiting **IPython** in all OSes: `CTRL+D` , or type `exit` or `quit`
- more **flow control** from last class:
  - `range(start, stop, step)` counts forwards from start (inclusive) to stop (exclusive) in units of step
  - `range()` can also count backwards if step is negative and start > stop
  - `range(10, n, -1)` generates values 10 (start, inclusive) to n+1 (stop, exclusive) in steps of -1
  - `continue`
    - stop whatever the loop is doing and skip to the next iteration
  - `break`
    - stop whatever the loop is doing and exit the loop
  - `while` loops
    - `while i > 1:`
    - same as `for` loops, except:
      - manually initialize the loop variable before you start the loop
      - manually increment the loop variable within the loop, if not, loop runs forever!
      - `CTRL+C` interrupts execution

Flow control exercises from class 01

1. Launch `python` or `ipython` . Do some math. Calulate `2 + 2` and save it to a variable called `i` . Now print out the result in `i` .
2. Use a `for` loop to print out integers 0 to 9.
3. Exit `python` . Use a text editor to save your code in 2. to a script called `basics.py` . Run it by typing `python basics.py` at the command line. Does it work?
4. Now exit `python` , launch `ipython` and run it again using `run basics.py` from within `ipython`

5. Modify the script to print out the square of those integers. Test it!
6. Modify the script to **also** print out the sum of the integers. What do you have to do before starting the loop?
7. Modify the script to print out the square root of those integers. `import math` might help...
8. Restore the script as it was in 2. Modify it to print the word `seven` after printing out the integer `7`
9. Modify it to **also** print out the word `three` after printing out the integer `3`
10. Rewrite the script so that it prints the messages `1 is odd`, `2 is even`, `3 is odd` all the way up to `10 is even`
11. Modify it so that it **doesn't** print the message `7 is odd`
12. Reverse the order of the messages

strings

- string operators:
  - initialize a blank string: `s = ''`
  - combine strings with `+`: `s = 'hello' + ' ' + 'world'`
  - append to an existing string with `+=`: `s += '!'`
  - duplicate strings with `*`: `ss = s * s`
  - whitespace characters: `\n` (new line) and `\t` (tab)
  - `%` string replacement operator
    - format strings act as placeholders:
      - `%s` - replace with a string
      - `%d` - replace with an integer
      - `%f` - replace with a float
        - `%.3f` - keep only the first 3 decimal places
      - `%g` - replace with either integer or float, format appropriately
    - `'hello %s' % name`
    - `'The year %d is here' % 2018`
    - can replace multiple placeholders in a string
    - `'The date is %s %d, %d' % ('April', 17, 2018)`
    - what else does `%` do in Python?
      - how does Python know whether to use it as a string replacement operator or as mod operator?
        - it looks at the type of its inputs
  - check if a string exists within another using `in`: `'h' in s` gives `False`
    - where have we seen the `in` operator before?
  - can iterate over the characters in a string, also using `in`:

```
for c in s:
    print(c)
```

- example string: `s = 'abcdefg'`
  - get length by calling the `len()` function: `len(s)` gives `7`
  - indexing lets you extract a single entry:
    - `s[0]` gives `'a'`, `s[1]` gives `'b'`, etc.
    - this is called "0-based" indexing, similar in behaviour to `range()`
    - see later that 0-based indexing is used throughout, compare with Matlab
    - negative index counts from the end: `s[-1]` gives `'g'`, `s[-2]` gives `'f'`, etc.

    - slicing lets you extract multiple entries at one:
        - `s[0:1]` gives `'a'`, `s[0:2]` gives `'ab'`, `s[1:3]` gives `'bc'`, etc.
        - slice indices are like fenceposts, they retrieve fence segments that fall in between
        - normal (non-slice) indices used for normal indexing give you the fence segments directly
        - you can also skip over entries when slicing
        - `s[0:7:2]` -> `aceg` - give me all the entries from fencepost 0 to 7 in steps of 2
        - `s[0:7:3]` -> `adg`
        - if you leave out a slice index, its value is implied:
            - leave out the first slice index -> start from beginning of string - `s[:7:2]`
            - leave out the 2nd slice index: go to end of string - `s[0::2]`
            - leave out the 3rd slice index: go in steps of 1 - `s[0:7]` or `s[0:7:]`
            - leave out multiple slice indices: `s[::2]` - start to end, steps of 2

- string methods
    - everything in Python is an "object", `type()` tells you what kind of object it is
    - objects can have "attributes", which are like adjectives `class Dog(object): pass fido = Dog()` fido.color = 'brown' `# set Fido's color` fido.weight = 10` # set Fido's weight
    - objects can also have "methods", which are functions that only apply to that object; methods are like verbs
    - like other functions (e.g. `print()`), methods take inputs and return outputs
    - `s.count(a)` - find number of occurences of `a` in `s`
    - `s.index(a)` - find 0-based index (position) of first instance of string `a` in `s`
    - `s.split(a)` - split `s` everywhere that string `a` is found
    - `s.replace(old, new)` - find all instances of string `old`, replace with `new`
    - `s.strip(a)` - strip characters in `a` from start and end of `s`, defaults to stripping spaces
        - what might `s.lstrip()` and `s.rstrip()` do?
    - `s.upper()` - uppercase!
    - `s.lower()` - lowercase!
    - what would `s.upper().lower()` do?
        - can chain multiple methods together iff the method1 returns an object with a method2

- are there other string methods? how to discover them without doing a web search?
    - `dir(s)`, or even easier in IPython, `s. + <TAB>`

string exercises

1. Store the alphabet `abcdefghijklmnopqrstuvwxyz` in a string `s`. Use a `for` loop to print out the alphabet backwards. Now do the same thing in a single line of code, in a single line of output
2. Collect every 2nd letter in the alphabet, and store them in all together in a single string
3. Make a new string that takes the above string and replaces `'a'` with `'4'`, `'e'` with `'3'`, and `'i'` with `'1'`

defining your own functions

- function: takes inputs, returns output(s)
- function inputs are called "arguments"

```
def add(x, y):
     """Return x + y"""
     result = x + y
     return result
```

- body is indented, like a `for` or `while` loop
- good practice: first line(s) are a documentation string, usually with triple-quotes
- if you forget what your function does, `add?` prints out your docstring!
- `return` a value, or multiple values separated by comma
- arguments can be purely positional, swapping `x` and `y` in `add()` does nothing, but...

```
def subtract(x, y):
     """Return x - y"""
     result = x - y
     return result
```

- `subtract(x, y) != subtract(y, x)`
- can also have keyword arguments with default values:

```
def add3(x, y, z=0):
     """Return x + y + z"""
     result = x + y + z
     return result
```

- variable scope/namespaces:
  - variables defined within a function are not visible from outside the function
  - Las Vegas: what happens inside a function, stays inside a function, except for the returned result(s)
  - this is called "encapsulation", is very useful to prevent variable name clashes in your code

coding style

- good style is easier to read, understand, debug
- try reading a book without sentences or paragraphs
- a few tips from coding style guide
  - variable assignment: usually leave a space on either side of an operator
    - `a = 5, 2 + 2, 'The year %d is here' % 2018`
  - use only spaces for indentation, not tabs - set text editor to insert spaces on `<TAB>`
  - keep lines less than 100 characters long, 80 is preferred
    - forces you to break up excessively long lines of code into shorter pieces
    - good text editors have visual guide option that you can set at say 95 characters
  - leave a space between neighbouring function arguments
  - all the style tips: PEP 8: https://www.python.org/dev/peps/pep-0008
- comments, docstrings
  - single line: `#`
  - multiline: `"""..."""` or `'''...'''`
  - why comment? what makes a good comment?

        - mostly a message from past self to future self about what the code is, or should be, doing
        - also very nice for other people that have to read your code
        - if you change code without updating comment - confusion!
        - another form of commenting: choose descriptive variable names, use them consistently

Homework 1 due next class!

extra stuff

- errors and debugging
    - `assert` allows you to quickly check assumptions that might not always hold
    - typical errors: `SyntaxError, NameError, TypeError, ValueError, IndexError, KeyError, RuntimeError, AttributeError, ZeroDivisionError`
    - set a breakpoint and "drop into debugger" with: `import pdb; pdb.set_trace()`
        - debugger commands: `l, w, s, n`
    - `try, except` blocks to catch specific types of errors and deal with them
    - `raise` your own errors to stop execution and inform the user of something
- plain text editors
    - key features:
        - plain text format: `.txt` , `.py` , etc.
        - fixed-width font
        - syntax highlighting
        - line numbering
    - linux: geany, gedit, mousepad
    - windows: geany, notepad++, ultraedit, textpad
    - mac: geany, atom, sublime, xcode
    - command line editor: nano, even cat
    - cross-platform Python IDEs: pycharm, spyder, soon: JupyterLab
        - downside: bigger, slower, more complicated than simple text editor