MAS212 Scientific Computing and Simulation

#1: Getting Started with Jupyter Notebook

`https://jupyter.org/about.html`

`http://sam-dolan.staff.shef.ac.uk/mas212`

1. Getting started. Start Jupyter (`Start` →`Anaconda3 (64-bit)` →`Jupyter Notebook`). A terminal window will appear; ignore this. A new tab should appear in a web browser, showing the directory structure. Create a new folder `MAS212` under `ManWin/Documents`, in which to save your work. On the right-hand side, press the `New` button, and choose `Python 3`. When the notebook opens, click on `Untitled` (next to the jupyter logo), and change the notebook title to `Lab_Class_1` or similar. Save via the menu: `File` →`Save and Checkpoint`.

- **Code cells**. Enter Python code in the first cell, e.g. `print("Hello")`. Press `Shift-Enter` to execute the code snippet. The output appears below. Add new cells from the menu: `Insert` →`Insert Cell Below`.
- **Cell types**. There are different types of cells: code, markdown, heading, etc. To toggle the cell type, use the drop-down box situated below the menu. Try the following:
  - Add some HTML to a markdown cell and press `Shift-Enter` e.g. `<h1>Heading!</h1>`.
  - Add some LaTeX to a markdown cell and press `Shift-Enter` e.g. `$ x = \frac34 $`
  - Add another code cell and calculate the first 10 square numbers using list comprehension, e.g. `[x**2 for x in range(1,11)]`
- **Keyboard shortcuts**. For a list see `Help -> Keyboard Shortcuts`. Example: to insert a new cell, press `Esc` to go into command mode, and then press `a` or `b` (to insert cell above or below). To change the cell type press `y` (code) or `m` (markdown). You may wish to take the `User Interface Tour`.

2. Sample notebooks. Go to 'Notebooks' section of course homepage. Right-click on a `.ipynb` link in the right column, and download (`Save Link As ...`). Under `Save as type`, change from Text Document to All Files. Save the file in the directory `Documents/MAS212`. **N.B.** You cannot open the file by double-clicking. Instead open the notebook through the Jupyter tab in the browser. Now, starting at the top, try executing the cells with `Shift-Enter`. Try editing the cells. Try improving any plots by (e.g.) adding titles and axis labels.

3. Mock class test. Go to 'Class Tests' section of course homepage. Right-click the `.ipynb` link next to (Mock) Class Test 1. Save in `My Documents/MAS212`. Open the notebook. Read the rubric. Try taking the class test, by adding a new cell below each question.

4. Revision of Python. There are lots of code snippets in these slides: `https://sam-dolan.staff.shef.ac.uk/mas212/docs/python_basics.pdf` Work through these slides, by entering the snippets in code cells, and executing with `Shift-Enter`. Add markdown cells (or Python comments) to explain what the code does.
Videos of the lecturer working through these slides can be found on MOLE (Week 0 folder).

5. Coding exercises.

(a) **Iteration**. Compute $\sqrt{2}$ using the recurrence relation

$$x \to \frac{1}{2}(x + 2/x)$$

starting from $x = 1$. Now use the `decimal` module to compute $\sqrt{2}$ to 100 decimal places (`https://docs.python.org/3.5/library/decimal.html`). How many iterations are needed?

(b) **Pisano periods**. Write a function to compute the Fibonacci sequence. Now modify the function to compute the Fibonacci sequence modulo N. For example, modulo $N = 4$ the sequence $0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, \ldots$ becomes $0, 1, 1, 2, 3, 1, 0, 1, 1, 2, 3, 1, \ldots$ Can you see a repeating sequence here? Write a function to compute the Pisano period $\pi(N)$: the length of the repeating sequence for a given N. What is $\pi(N = 144)$? Read more at `http://en.wikipedia.org/wiki/Pisano_period`

(c) Using the `cmath` module for complex numbers, and the Newton–Raphson method

$$z_{n+1} = z_n - \frac{f(z_n)}{f'(z_n)},$$

find the three complex roots of the cubic $f(z) = z^3 - 1$. Try choosing the initial guess close to $z = 0$ in the complex plane. Which root does the method converge upon? Read more at `http://en.wikipedia.org/wiki/Newton%27s_method#Complex_functions`