MECH2700 Engineering Analysis I, 2015
Exercise Sheet 4

Programming python functions and solving a single non-linear equation

1. Derive an iterative square root algorithm based on Newton's method for solving $f(x) = 0$. Implement your algorithm as a Python function called "squareRoot1". which accepts the number N, the initial guess and the tolerance as parameters and returns the square root of N as a double value. On entry to your function, you should check for valid parameter values and take appropriate action. Try your function for the values $N = 0.6,\ 6.0,\ 0.0,\ -1.0$ and a tolerance of 1.0×10^{-6}.

2. Write a Python program to compute the mean and standard-deviation of a list of numbers. Package the computations in a function called "stats" which accepts a list of floating-point numbers and returns the mean and standard deviation. A prototype for your function might look like

```
def stats(number_list):
    # ...
    # --- guts of your function here ---
    # ...
    return mean, std_dev
```

   Remember to document your program and function adequately.

3. A vertical mast of length L has Young's modulus E and a weight w per unit length. Its second moment of area is I. The mast will just begin to buckle under its own weight when $\beta = \frac{4wL^3}{9EI}$ is the smallest root of

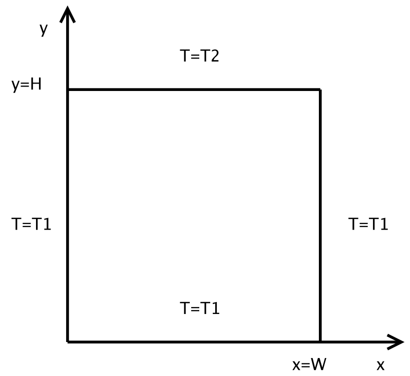
$$f(\beta) = 1 + \sum_{n=1}^{\infty} c_n \beta^n = 0$$

   The first coefficient is $c_1 = -\frac{3}{8}$ and the subsequent ones are given by the recursive relation

$$c_n = \frac{-3c_{n-1}}{4n(3n-1)}$$

Write a Python program that finds the smallest value of β which satisfies $f(\beta) = 0$. Note that you will need to truncate the infinite sum to N terms and that you have to select N to be "large enough". Plot the function $f(\beta)$ over the range $0.0 \le \beta \le 5.0$.

4. A square plate of steel has fixed temperatures at its boundaries as shown in the figure.



Considering heat flow in the (x,y)-plane only, it can be shown that the temperature distribution throughout the plate can be described as the summation of an infinite series, specifically

$$\phi(x,y) = \frac{T - T_1}{T_2 - T_1} = \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n+1} + 1}{n} \left[\sin \frac{n\pi x}{W} \right] \frac{\sinh(n\pi y/W)}{\sinh(n\pi H/W)}$$

Write a Python function to compute an approximation to the temperature at any point in the plate and use that function to generate a mesh of sample points to reproduce the plot of normalised temperature ϕ as shown below. The left-hand plot was produced with the dedicated plotting package "Gnuplot" and the right-hand plot was produced with the Matplotlib contour function. It is probably easiest to write the sample data to a file and then plot the data from with the Gnuplot program with the command "splot". Use the Gnuplot "help" system to read about the required format for the data file. You will also need to decide how many sample points to create and how many terms of the infinite series to sum.