# Exercises 2nd week

Tuesday, 05 March 2024

# Learning outcomes

We hope that at the end of this session you will:

- Understand how to use Python's vectorization tools
- Be able to create and edit rudimentary functions
- Be able to use basic plotting tools
- Be able to see how iterative non-linear solvers can depend on the starting  etc.
- Be able to load a *.py* file and use it

# Exercise 2

The aim of this exercise is to get you familiar with the bisection method.

1.

a) Write a function *bisection_method.py* that takes in as input
- a function *f :* The function of which root is to be calculated
- a tolerance *tol* : Desired error/tolerance in the root
- a range *r :* Guess range on which root is located

and returns the value *x,* which is a root of the function *f(x)=0* using the bisection method shown in class (Consider only the situation where *f(x)* does not have more than one root)

b) Use this function to find *x* such as $f(x) = 3 \sin(2x+ \pi) + 1/3 = 0$ and use the following ranges

[-1,0]

[-1,1]

[-π/2, π/2]

c) What can you tell about these ranges? Did you get satisfying outputs?

Plot f(x) between –π and π and make observation on the outputs you got.

**Bonus:** add a functionality that makes the function display an error message if both range values are negative or both positive.

Hint: Python computes sin and cos using radians

# Exercise 2

2.

a) Write a function called *secant_method.py* that takes two functions (*f* & *g*), two starting points ($x_0$ and $x_1$) and outputs the exact value *x* where *f* and *g* intersect using the secant method

b) Use the same function f as in part 1 and $g(x) = 3\cos(2x-\pi) - 2/3$ and use the following starting points

[0.30 , 0.35]

[1.60 , 1.65]

[0.75 , 0.85]

c) What can you tell about these ranges? Did you get satisfying outputs? Plot f(x) and g(x) between 0 and π and make observation on the outputs you got.

# Exercise 2 (Handwritten)

Consider the following nonlinear equation :

$$g(x) = e^x - x - 2$$

a) Using the Newton-Raphson method, find numerically the root of this equation with a precision better than $10^{-3}$ . Take as initially guess $x_0 = 1$; the exact solution is $x^* = 1.146193$.

b) Do three steps of Newton-Raphson iteration starting from $x_0 = 10$. Discuss shortly the convergence properties of the iterative scheme around this initial point.

c) How many iterations would be needed to obtain the accuracy of $10^{-9}$ if we use the bisection method on the interval (0,5).