

Exercise 10: Root finding

Consider the function

$$f(x) = e^{-x} - x \quad (1)$$

- Draw the function in ROOT (Analysis framework by CERN) or another equivalent program.
- Write a program which evaluates the root with precision 10^{-8} using
 - Bisection method,
 - Newton-Raphson method.
- Compare the precision after N steps.

Some tips: Create a function which evaluates the value for you, and another function which gives the derivative (once you have calculated it analytically) for the Newton-Raphson method,

```
double myFunc(double x);
```

```
double myFuncDeriv(double x);
```

10.1 Multiple root finding

We consider the motion of a damped oscillator. We assume that the amplitude of such an oscillator is described by the following function:

$$A(t) = A_0 e^{-\gamma t} (\cos \omega_1 t + \sin \omega_2 t) \quad (2)$$

Let assume the following values for the coefficients:

$$A_0 = 2.0, \gamma = 0.3, \omega_1 = 3./2., \omega_2 = 17./4. \quad (3)$$

- Find all the roots of $A(t)$ in the interval $[0, 5]$ sec with a precision of 10^{-8} sec using both the bisection and the Newton-Raphson method.

Tips: Draw the function and think how to handle this problem. 17/4 (integer) is different from 17./4. (floating point number). The solution is not necessary to be very general.

How to use ROOT

ROOT is a modular scientific software toolkit organized by CERN. It provides all the functionalities needed to deal with big data processing, statistical analysis, visualisation and storage. It is mainly written in C++ but integrated with other languages such as Python and R.

Installation: Visit <https://root.cern.ch/>. Go to "Downloads". Go to the latest release, which is v6.20/04. Files for Linux, MacOS, Windows are available. For Linux, you might need to compile from the source. Follow <https://root.cern.ch/building-root>

Linux:

Download and open the file, for example

```
wget https://root.cern/download/root_v6.20.04.Linux-centos7-x86_64-gcc4.8.tar.gz
gunzip root_v6.20.04.Linux-centos7-x86_64-gcc4.8.tar.gz
tar xf root_v6.20.04.Linux-centos7-x86_64-gcc4.8.tar
```

Setup environment. This is needed to start using root.

```
source root/bin/thisroot.sh
```

Windows:

Download and install with the wizard.

Setup environment. This is needed to start using root.

```
c:\root_v5.34.25\bin\thisroot.bat
```

Usage:

The general documentation is available at <https://root.cern.ch/documentation>. However, it would be too much. The simplest usage for this exercise is as follows.

To launch,

```
> root
```

Draw a plot

```
root [0] TF1 *f1 = new TF1("f1", "2.0*sin(x)", -5, 10)
root [1] f1->Draw()
```

If you want, your script can be saved in a .C file, like in draw_func.C,

```
void draw_func(){
    TF1 *f1 = new TF1("f1", "2.0*sin(x)", -5, 10);
    f1->Draw();
}
```

Listing 1: draw_func.C

The file name and the name of function should be unique. Then, type in your shell as follows,

```
> root draw_func.C
```

ROOT is written with C++. All the objects in ROOT are classes, for example TF1.