

# Computing Methods for Physics – 5 July 2022

**Your exam material (code files, plots, datafiles, etc.) must be submitted via google classroom by 13:30 as a single zip file.**

**C++ evaluation will be based on:** correct syntax, proper return types, proper arguments of functions, data members and class interfaces, comments throughout the code, separation of class implementations and interfaces.

**Python evaluation will be based on:** correct syntax, avoiding C-style loops, using Python features in general, comments throughout the notebook/scripts, labels, legends and plot styling and clarity in general.

## Part 1 – Classes, inheritance, and polymorphism in C++

Implement a C++ class `DataSet` to represent and manipulate  $N$  positive, real numbers. As private data members, your class must have at least  $N$  and the values  $\{x_i > 0, i = 1, \dots, N\}$ . The class must also provide the following.

- A constructor that takes as arguments  $N$  and the path to a text file that stores  $N$  values  $\{x_i\}$  (this constructor must read in the data stored in the file).
- A copy constructor.
- A method to add a new data point to an existing `DataSet` instance, and a method to remove a data point from an existing `DataSet` instance.
- An overload of the plus (+) operator to shift all  $x_i$ 's by a given quantity (e.g., if the instance `D1` of `DataSet` is storing  $\{1, 5, 1, 2\}$ , then `D1 + 3` must be an instance of `DataSet` that stores  $\{4, 8, 4, 5\}$ ).

Finally, provide three classes `Arithmetic`, `Geometric` and `Harmonic` that have `DataSet` as parent class and implement the method `mean()`. As a reminder these means are defined as

$$A = \frac{1}{N} \sum_{i=1}^N x_i$$
$$G = \left( \prod_{i=1}^N x_i \right)^{1/N}$$
$$H = \frac{N}{\sum_{i=1}^N x_i^{-1}}.$$

**Your submitted material must include a file `app.cpp` that showcases the classes you implemented.**

## Part 2 – Classes, inheritance, and polymorphism in Python

Use a Python notebook or Python scripts to complete the following tasks. Aim for clean, well commented and efficient code.

1. Draw  $N = 10^4$  random values from a Gaussian distribution with centre  $\mu$  and width  $\sigma$  of your choice. Store these values to a text file, so that you can use them to test your C++ code.
2. Design a class to process an array of integers in order to find pairs of its elements (identified by their indices) such that their sum is equal to a specific number  $s$ . [The array and  $s$  are arguments of the class constructor.] Test your class with  $10^2$  randomly drawn integers.
3. Design a class to find triplets of elements in an array of random integers such that their sum is zero. [The array is an argument of the class constructor, and the triplets are identified by their indices within the array.] Test your class with  $10^3$  random integers.
4. Design a class that inherits from the two classes described above and is able to handle either problem, given the user's request that must be provided interactively [i.e., ask the user a question and process the answer appropriately].