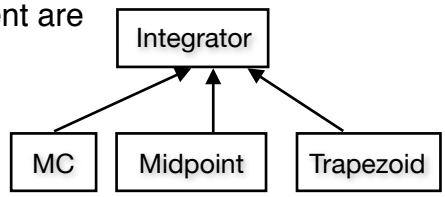
Computing Methods for Physics
24 June 2019

The exam must be sent as a zip file via email by **Wednesday June 26 at 13:00** .

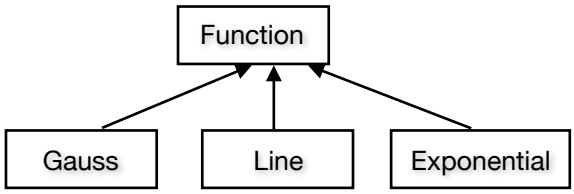
Integration with Strategy Pattern

Use the strategy pattern (lecture 15 of the course) to implement three polymorphic methods of numerical integration (inheriting from a base `Integrator` class) for polymorphic functions in C++. The integration methods to implement are



1. Monte Carlo
2. Midpoint or rectangle method
3. trapezoidal method

For the functions, you have to define a base Function class and implement three polymorphic functions



1. Gauss
2. Line (1st degree polynomial)
3. Exponential

Choice of data members, interface, arguments and return types, and correct mathematical integration will be elements of evaluation.

In order to test the correct implementation of the algorithms, write a simple application in C++ to produce an output file with following information

1. Choose an interval `[a,b]` for each function to evaluate the integral with all 3 methods. Choose the interval so that you can easily compute the exact analytical integral.

2. For each function repeat the evaluation of the integral with increasing number of points, e.g. from `10` to 10^6 points.

3. Store the numerical result for each algorithm and the number of integration points in a text file. You can use plain file or CSV format.

Use python (also jupyter is fine) to read the data from file and plot for each function the difference between the numerical integral and the exact integral (analytical solution) as a function of number of integration points. Evaluation will be based on use of python features and data structures, comprehensions (instead of C-style for loops), NumPy objects (if applicable), labels, units, and clarity of plots.

Please include one pdf file for each function (3 pdf files in total) showing simultaneously the residual (numerical-analytical) as a function of number of integration points. Use different colors, and possibly a legend, for each integration method to help the reader.