1. task for OOP

deadline: Oct. 11 2011, 10:00 Uhr

The goal of this small project consists in autonomous design an programming. You should take into account the following items:

- include source and header files of a given library into your project and **use the functions** therein,
- program functions for your own library (source and header files) wrt. the given task,
- work with input and output files,
- test your modules/functions carefully,
- document your code, explain the parameter lists in the header files and what the function is doing. I use the documentation style from doxygen, see also the brief introduction (Download).

What's the functionality of your code?

a) Read discrete x-values from the given ASCII-files (use module *file_io*).

b) Calculate function values $f(x)$, discrete derivatives $f'(x)$ and discrete primitives $F(x) = \int\limits_0^x f(x)dx$ numerically for a given function f , $\forall x$.

For this purpose, you should write a module (header and source files) for calculus wherein the function under consideration is appears as function pointer in the parameter lists.

c) The resulting values for all x have to be stored in three separate ASCII-files. (This allows you to read the data into Matlab via `importdata` and to visualize them)

d) The module *file_io* has to be used and to be included in your project.

Mathematical functions:

$$p(x) = 4x^3 + 3x^2 \quad ; \qquad q(x) = \mathrm{e}^{-x}\sin(40x) \quad ; \qquad s(x) = x\sin(40/x)$$

Files with input values x: *input_1_x.txt* and *input_2_x.txt*.

Items a)-d) should be used with 2 different input data and 3 different functions, i.e., it might be of advantage to combine a)-d) into one function.

You will use the following formulas.

Numerical Integration

The numerical integration of $f(x)$ is done approximately, e.g., via the Riemann sums

$$\int_a^b f(x)dx \approx F_n(x) := \sum_{j=1}^{n} f(a + jh) \cdot h \tag{1}$$

with n denoting the number of equidistant subintervals of $[a, b]$ resulting in an subinterval length of $h = \frac{b-a}{n}$.
The accuracy of the numerical integration depends obviously on the number of subintervals n, i.e., **you have to increase** n ***while*** $|F_n(x) - F_{n-1}(x)|$ is larger than a given accuracy ε.
Suggestion for the parameter list: f, a, b, ε.
Validate your function with test data that can be checked easily!

Numerical Differentiation

The numerical differentiation of a function f in x can be approximated by the central difference

$$f'(x) \approx \frac{f(x+h) - f(x-h)}{2h} \quad . \tag{2}$$

The stride h is given and $h = 0.1$ is a good starting guess for our data.
Once again the numerical differentiation have to accurate enough, i.e., you have to **decrease** $h > 0$ ***while*** the difference between the two last approximations of $f'(x)$ is larger than a given accuracy.
Suggestion for the parameter list: f, x, ε.
Validate your function with test data that can be checked easily!
