Introduction to computational thinking and programming for CFD (13251)

Dr. rer. nat. Marten Klein

Chair of Numerical Fluid and Gas Dynamics, BTU Cottbus-Senftenberg

Written Module Examination – Summer Semester 2024

---

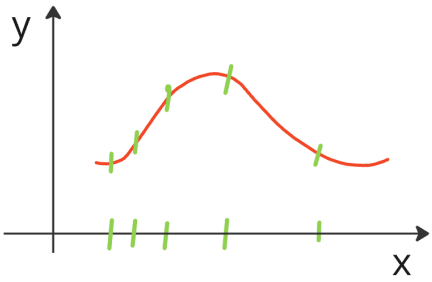
1. **(10 pts.)** Provide a brief answer to each of the following questions. Explain using own words and provide an example.

   (a) What is CFD?

   (b) What is discretization?

   (c) What is gridded data?

2. **(40 pts.)** The function $f(x)$ is unknown except for a few nodal values $y_s = f(x_s)$ at nodal points x_s $(s = 0, 1, \ldots)$. The values x_s and y_s are given as Python lists.




```
1  xs = [ 1, 2, 3, 5, 10]
2  ys = [ 1., 10., 20., 10., 1.]
⋮
11 pl.bar(xLeftEdges, heights, widths, align='edge')
⋮
```

   (a) Compute the integral $\int_1^{10} f(x)\,\mathrm{d}x$ on paper by application of the lower sum approximation using x_s and y_s from lines 1 and 2.

   (b) Develop a small Python program that computes the integral numerically. The program should display the computed result on the screen.

   (c) Sketch the problem graphically. Indicate the analytical integral and the approximation. Comment on the numerical error.

   (d) Add Python commands such that line 11 visualizes the lower sum approximation with a bar plot.

   (e) Add meaningful axis labels and enforce that the x axis ranges from 1 to 10.

   (f) Save the figure to the image file `graph.png`.

3. **(40 pts.)** The following code computes some arithmetic average.

```
1  import numpy as np
2
3  def averageOfNth(vals, nth=1):
4      avg = 0.0
5      num = 0
6      for i in range(0, len(vals), nth):
7          avg  = avg + vals[i]
8          num += 1
9          print(num, avg)
10     return avg/num
11
12 x = np.linspace(-1., 4., 6)
13 print( 'Avg: %1.6f' % averageOfNth(x, 2) )
```

(a) What is the purpose of the keyword `def`?

(b) What is the meaning of `nth=1` in line 3? What is `nth` doing in the code?

(c) What are the data types of the variables `avg` and `num` in lines 4 and 5?

(d) What is the value of `vals[i]` for `i = 1` and `i = 300` when `vals = [1, 20, 300]`?

(e) Assume that `avg = 3.0` and `num = 11` after line 7. What are the values of `avg` and `num` when line 8 has been executed?

(f) What is the output of the script? *Hint:* Note down the values of all variables including arrays. Make a table of values for all those variables that are changing during the for loop. Based on that information, indicate what is printed on screen.

(g) Modify the function such that only negative values are taken into account. What is the result of line 13 in this case?

4. **(10 pts.)** A perfect dice is modeled by a random sequence of integers from $\{1, 2, 3, 4, 5, 6\}$.

(a) How can such a random integer be obtained in Python? Give a Python call.

(b) Does Python provide true or pseudo random numbers? Explain your choice.

(c) How could the histogram look like after $N = 6$ and after $N = 6{,}000{,}000$ dice rolls? Sketch your expectation qualitatively. Give axis labels and ranges, but do not write Python code.