Homework - Serie 10

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Python 3

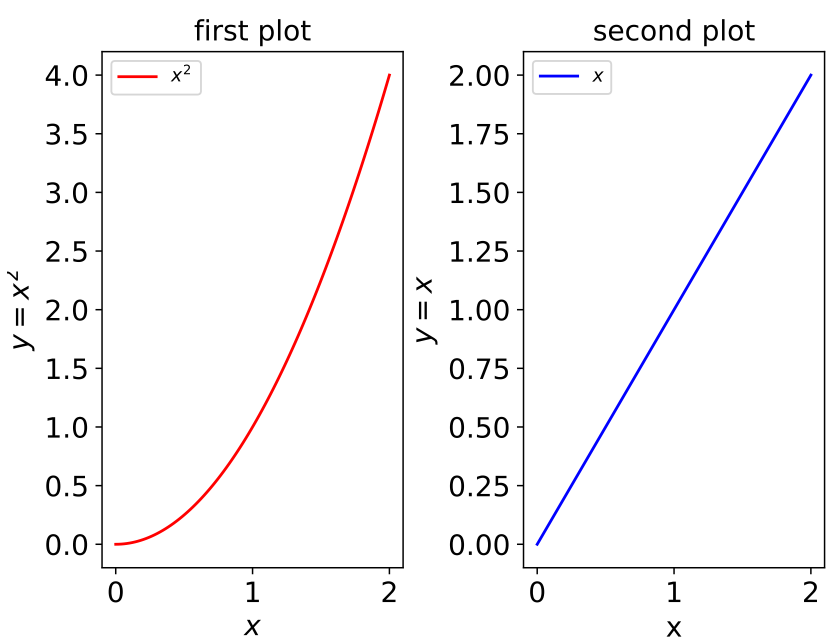
Test your code with examples!

Problem 1.

(a) Create a figure object called `fig` using `plt.figure`.

(b) Use `add_axes` to add an two axes to the figure canvas at `[0.11, 0.11, 0.35, 0.8]` and the second one at `[0.6, 0.11, 0.35, 0.8]`.

(c) Plot (x, y) on that axes and set the labels and titles to match the plot below:



(d) What do `plt.gca` and `plt.gcf` do?

Problem 2.

(a) Create a figure object and put two axes ax1 and ax2 on it which are located at `[0.1, 0.1 , 0.8, 0.8]` and `[0.2, 0.5, .2, .2]`, respectively.

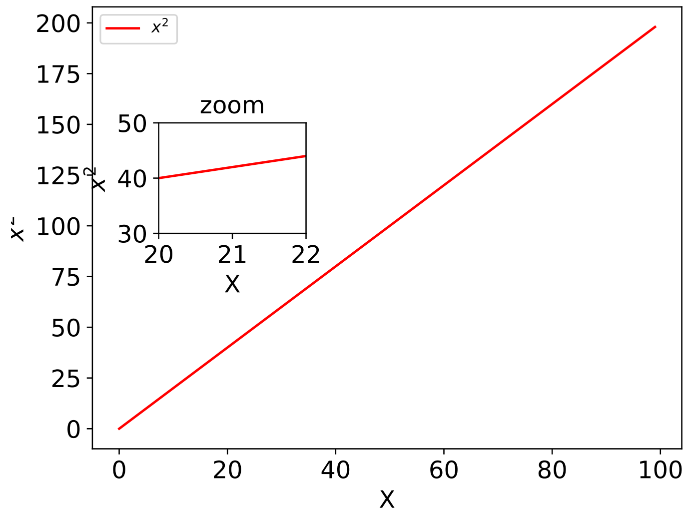


Figure 1: Problem 2

(b) Reproduce Figure 1!

Problem 3.
Use `plt.subplots` to create the following plot. Notice that the columns share the same x range. Also the location of the legends should be identical to the one in Figure 2.

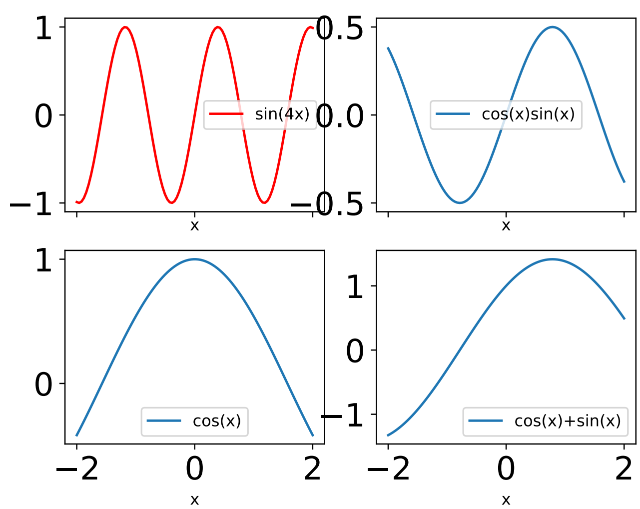


Figure 2: Problem 3

Problem 4. We want to implement *Newton's method* for the calculation of a root of a function $f : [a, b] \to \mathbf{R}$. Given an initial value x_0 one inductively defines the sequence (x_n): For given x_k let

x_{k+1} be the root of the tangent on the graph of f in the point $(x_k, f(x_k))$, i.e. $x = x_{k+1}$ satisfies $0 = f(x_k) + f'(x_k)(x - x_k)$. Solving for x shows

$$x_{k+1} = x_k - f(x_k)/f'(x_k).$$

Implement the Newton-method in a function `newton(f,fprime,x0,tau)` where the iteration is stopped if

$$|f'(x_n)| \leq \tau$$

or

$$|f(x_n)| \leq \tau \quad \text{and} \quad |x_n - x_{n-1}| \leq \begin{cases} \tau & \text{for } |x_n| \leq \tau, \\ \tau |x_n| & \text{else} \end{cases}$$

In each case, return x_n as approximation of the root, where in the first case, additionally give a warning. Beside x_n, return the sequence $(x_0, \dots, x_n)$ of the approximative roots and the corresponding function values. Test your implementation with the function $f(x) = x^2 + e^x - 2$.

Problem 5. Study the documentation of `mlab.quiver3d(ux,uy,uz,vx,vy,vz)` of the mayavi module. In this exercise we want to plot the (outward pointing) unit normal vector field along an ellipsoid

$$E^2 := \{(x, y, z) : \; ax^2 + by^2 + cz^2 = 1\}.$$

In order to plot this vector field consider the parametrisation of the ellipsoid:

$$\varphi : (u, v) \to (a \sin(u) \cos(v), b \sin(u) \sin(v), c \cos(v)) : [0, \pi) \times [0, 2\pi) :\to E^2 \subset \mathbf{R}^3,$$

The functions `(ux,uy,uz)` are the component functions of φ and the functions `(vx,vy,vz)` are

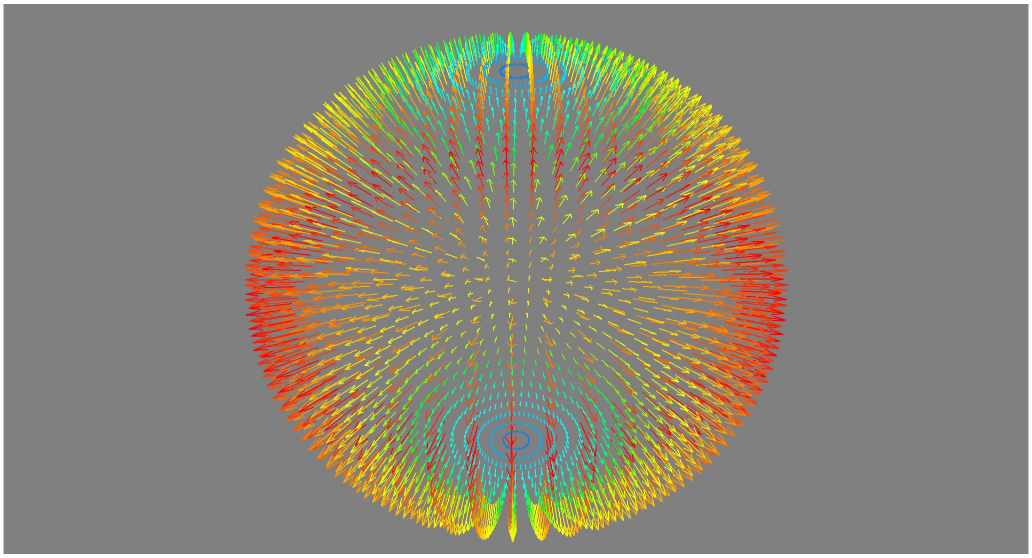


Figure 3: Problem 5

the component functions of $\partial_u \varphi \times \partial_v \varphi / \|\partial_u \varphi \times \partial_v \varphi\|_2$. Also put a nice coordinate system into the plot. The output in case of $a = b = c = 1$ should look like Figure 3.

Problem 6. Write a function `saveMatrix` which takes a matrix $A \in \mathbf{R}^{d \times d}$ and writes it into a file `matrix.dat` via `open`. Write another function `loadMatrix`, which takes a string `'matrix.dat'` and reads the file with `open` and stores the data into numpy array. Compare your result with `numpy.savetxt` and `numpy.loadtxt`.

Problem 7. Use the matplotlib function `plt.quiver` to visualise the vector field $F : \mathbf{R}^2 \to \mathbf{R}^2$ given by

$$F(x, y) := \begin{cases} (1,1) + (-y, x) & \text{if } x > 0 \\ -(1,1) + (y, -x) & \text{if } x < 0 \end{cases}.$$

Plot the vector field on $[-1, 1] \times [-2, 1]$ and make nice captions and legends. Make sure the font size of your plot is not too small.

Problem 8. Use the matplotlib function `plt.scatter` to produce the following plots.