

Exercisesheet 1 - The influence of nonlinearities

Mathematical Pendulum

Given is the mathematical pendulum with string length l . The equation of motion is:

$$\ddot{x}(t) + \frac{g}{l} \sin(x(t)) = 0 \quad (1)$$

where often for simplification, the linearization

$$\ddot{x}(t) + \frac{g}{l} x(t) = 0 \quad (2)$$

is considered.

Task 1

Write a program in Python for the numerical integration of mechanical systems with one degree of freedom. Use the command `solve_ivp` from the `scipy.integrate` library.

Task 2

Use the program from question 1 to generate phase portraits for the mathematical pendulum (1) and its linearization (2). Choose the initial conditions such that:

- a) a good agreement is achieved
- b) a significant quantitative deviation occurs
- c) a qualitative deviation occurs

Task 3

Adapt the program from question 1 so that with the option `events`, the turning points with positive (**event, direction**) displacement are found. The linearization is no longer considered here. Now calculate the frequency of the oscillation from the time between the turning points. Use your program to complete the following table:

Maximum Displacement	0.1	0.2	0.3	0.5	0.8	1.0	1.2	1.5	2.0	5.0	$2\pi - 5.0$
Frequency											