

kapitza_pendulum_exercise_0

May 13, 2025

1 Kapitza's Pendel

1.1 Ergänze wo ein XXX steht

1.1.1 Wichtige Module

```
In [17]: import numpy as np
import matplotlib.pyplot as plt
from scipy.integrate import solve_ivp
from matplotlib.animation import FuncAnimation
from IPython.display import HTML
```

1.1.2 Parameter

```
In [18]: # Parameters
g = XXX          # gravity
m = XXX          # mass of pendulum
l = XXX          # length of pendulum arms
A = XXX          # amplitude
Omega = XX       # driving frequency
```

NameError

Traceback (most recent call last)

```
Cell In[18], line 2
      1 # Parameters
----> 2 g = XXX          # gravity
      3 m = XXX          # mass of pendulum
      4 l = XXX          # length of pendulum arms
```

NameError: name 'XXX' is not defined

1.1.3 Bewegungsgleichung in Matrixform

```
In [19]: # Define the equation of motion
def eq_of_motion(t, y):
    phi, omega = y
    domega_dt = XXX
    return [XXX, XXX]
```

1.1.4 Numerische Lösung der Differentialgleichung

```
In [20]: y0 = [XXX, XXX] # initial conditions: [phi, omega]
t_span = (0, XXX)
t_eval = np.linspace(*t_span, 2000)

sol = solve_ivp(eq_of_motion, t_span, y0, t_eval=t_eval)

t = sol.t
phi = sol.y[0]
omega = sol.y[1]
```

NameError

Traceback (most recent call last)

```
Cell In[20], line 1
----> 1 y0 = [XXX, XXX] # initial conditions: [phi, omega]
      2 t_span = (0, XXX)
      3 t_eval = np.linspace(*t_span, 2000)
```

NameError: name 'XXX' is not defined

1.1.5 Zeitlicher Verlauf des Winkels

```
In [21]: plt.figure()
plt.plot(XXX, XXX)
plt.xlabel(r'$t$')
plt.ylabel(r'$\varphi$')
plt.grid(True)
plt.show()
```

<Figure size 640x480 with 0 Axes>

NameError

Traceback (most recent call last)

```
Cell In[21], line 2
      1 plt.figure()
----> 2 plt.plot(XXX, XXX)
      3 plt.xlabel(r'$t$')
      4 plt.ylabel(r'$\varphi$')
```

NameError: name 'XXX' is not defined

1.1.6 Energien als Funktion der Zeit

```
In [22]: K = XXX
        V = XXX
        E = K + V

        plt.figure()
        plt.plot(XXX, XXX, '-r')
        plt.plot(XXX, XXX, ':g')
        plt.plot(XXX, XXX, '--b')
        plt.xlabel(r'$t$')
        plt.ylabel('Energy')
        plt.grid(True)
        plt.show()
```

NameError

Traceback (most recent call last)

```
Cell In[22], line 1
----> 1 K = XXX
      2 V = XXX
      3 E = K + V
```

NameError: name 'XXX' is not defined

1.1.7 Erzeugung einer Animation

```
In [23]: # Convert to Cartesian coordinates
        x = XXX
        y = XXX
```

NameError

Traceback (most recent call last)

```
Cell In[23], line 2
      1 # Convert to Cartesian coordinates
----> 2 x = XXX
      3 y = XXX
```

NameError: name 'XXX' is not defined

```
In [24]: # Animation
fig, ax = plt.subplots(figsize=(5, 5))
ax.set_xlim(-2.1, 2.1)
ax.set_ylim(-2.1, 2.1)
ax.set_aspect('equal')
ax.grid()

line, = ax.plot([], [], 'r-', lw=2)
bob, = ax.plot([], [], 'ro', markersize=8)
origin, = ax.plot([], [], 'ko', markersize=5)

# Initialization function
def init():
    line.set_data([], [])
    bob.set_data([], [])
    origin.set_data([0], [A * np.cos(Omega * t[0])])
    return line, bob, origin

# Update function
def update(i):
    xi = [0, x[i]]
    yi = [A * np.cos(Omega * t[i]), y[i]]
    line.set_data(xi, yi)
    bob.set_data([x[i]], [y[i]])
    origin.set_data([0], [A * np.cos(Omega * t[i])])
    ax.set_title(f't = {t[i]:.2f} s')
    return line, bob, origin

ani = FuncAnimation(fig, update, frames=range(0, len(t), 5), init_func=ini
plt.close(fig)
HTML(ani.to_jshtml())
```

NameError

Traceback (most recent call last)

```
Cell In[24], line 32
    30 ani = FuncAnimation(fig, update, frames=range(0, len(t), 5), init_func=
    31 plt.close(fig)
---> 32 HTML(ani.to_jshtml())

File /lib/python3.12/site-packages/matplotlib/animation.py:1353, in Animation
1349     path = Path(tmpdir, "temp.html")
1350     writer = HTMLWriter(fps=fps,
1351                         embed_frames=embed_frames,
1352                         default_mode=default_mode)
-> 1353     self.save(str(path), writer=writer)
1354     self._html_representation = path.read_text()
1356 return self._html_representation

File /lib/python3.12/site-packages/matplotlib/animation.py:1105, in Animation
1102 for data in zip(*[a.new_saved_frame_seq() for a in all_anim]):
1103     for anim, d in zip(all_anim, data):
1104         # TODO: See if turning off blit is really necessary
-> 1105         anim._draw_next_frame(d, blit=False)
1106         if progress_callback is not None:
1107             progress_callback(frame_number, total_frames)

File /lib/python3.12/site-packages/matplotlib/animation.py:1140, in Animation
1136 def _draw_next_frame(self, framedata, blit):
1137     # Breaks down the drawing of the next frame into steps of pre- and
1138     # post- draw, as well as the drawing of the frame itself.
1139     self._pre_draw(framedata, blit)
-> 1140     self._draw_frame(framedata)
1141     self._post_draw(framedata, blit)

File /lib/python3.12/site-packages/matplotlib/animation.py:1768, in FuncAnimation
1764     self._save_seq = self._save_seq[-self._save_count:]
1766 # Call the func with framedata and args. If blitting is desired,
1767 # func needs to return a sequence of any artists that were modified.
-> 1768 self._drawn_artists = self._func(framedata, *self._args)
1770 if self._blit:
1772     err = RuntimeError('The animation function must return a sequence
1773                        'of Artist objects.')
```

Cell In[24], line 22, in update(i)

```
21 def update(i):
```

```
---> 22     xi = [0, x[i]]
      23     yi = [A * np.cos(Omega * t[i]), y[i]]
      24     line.set_data(xi, yi)
```

NameError: name 'x' is not defined

In []:

In []: