PHYS416- Computer Applications in Physics

Homework 3 - Vibrations of Atoms in a Solid

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I pledge that I worked entirely alone on this homework and will not share information about any aspect of this homework with any other persons.

Signature: _____

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd

# Parameters
N = 26          # Number of masses
m = 1.0         # Mass of each object
k = 6.0         # Spring constant
C = 1.0         # External force
omega = 2.0     # Angular frequency

# Calculating alpha (main diagonal element)
alpha = 2 * k - m * omega**2

# Constructing the main diagonal (alpha) and the off-diagonals (-k)
main_diagonal = [alpha] * N
main_diagonal[0] = alpha - k     # Adjusting the first element
main_diagonal[-1] = alpha - k    # Adjusting the last element
off_diagonal = [-k] * (N - 1)

# Creating the tridiagonal matrix
matrix = np.diag(main_diagonal) + np.diag(off_diagonal, k=1) +
np.diag(off_diagonal, k=-1)

# Convert matrix to DataFrame for better display
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```
matrix_df = pd.DataFrame(matrix)

print("26x26 Matrix:")

print(matrix_df)


# Constructing the right-hand side vector with external force applied to the first mass

rhs = np.zeros(N)

rhs[0] = C  # External force applied to the first mass


# Solving for the displacement amplitudes Ui

U = np.linalg.solve(matrix, rhs)


# Calculating the amplitudes of each mass

amplitudes = np.abs(U)


# Plotting the amplitudes of the vibrations for each mass

plt.figure(figsize=(12, 8))

plt.plot(range(1, N + 1), amplitudes, marker='o', color='b', linestyle='-', markersize=6)

plt.xlabel("Mass index (i)")

plt.ylabel("Amplitude |U$_i$|")

plt.title("Amplitudes of Vibrations of Masses")

plt.xticks(range(1, N + 1))  # Ensures all mass indices are visible on the x-axis

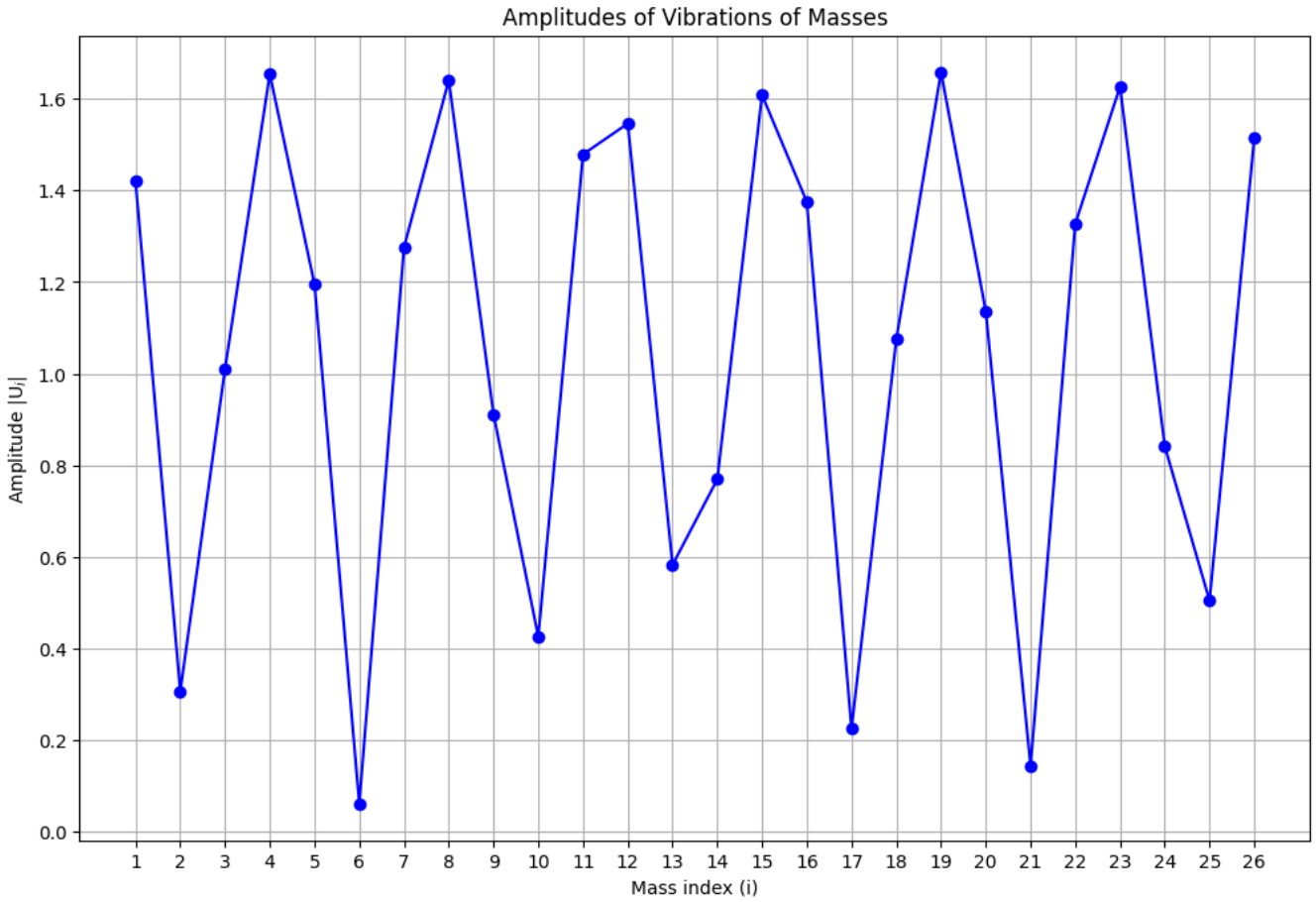
plt.grid(True)

plt.show()
```

```
26x26 Matrix:
```

	0	1	2	3	4	5	6	7	8	9	...	16	17	18	19 \
0	2.0	-6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
1	-6.0	8.0	-6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
2	0.0	-6.0	8.0	-6.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
3	0.0	0.0	-6.0	8.0	-6.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	-6.0	8.0	-6.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	-6.0	8.0	-6.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	-6.0	8.0	-6.0	0.0	0.0	...	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	-6.0	8.0	-6.0	0.0	...	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-6.0	8.0	-6.0	...	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-6.0	8.0	...	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-6.0	...	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	-6.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	8.0	-6.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	-6.0	8.0	-6.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	-6.0	8.0	-6.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	-6.0	8.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	-6.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0

	20	21	22	23	24	25
0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0
19	-6.0	0.0	0.0	0.0	0.0	0.0
20	8.0	-6.0	0.0	0.0	0.0	0.0
21	-6.0	8.0	-6.0	0.0	0.0	0.0
22	0.0	-6.0	8.0	-6.0	0.0	0.0
23	0.0	0.0	-6.0	8.0	-6.0	0.0
24	0.0	0.0	0.0	-6.0	8.0	-6.0
25	0.0	0.0	0.0	0.0	-6.0	2.0


Amplitudes of Vibrations of Masses
Amplitude |Uᵢ|
Mass index (i)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26