5 Eigenfrequencies of a continuous system - beam

5.1 Tutorial purpose

Throughout the previous laboratory tutorials, the eigenfrequencies and mode shapes were determined by exciting the system using a shaker. During this laboratory tutorial, the system's response will be obtained by impact excitation. In contrast to the previous two tutorials, the excitation force will be unknown.

5.2 Task definition

Determine the first three eigenfrequencies of the in-plane bending oscillations of the free-free supported beam (Fig. 1) using two approaches:

analytically using the Euler-Bernoulli theory [1],

experimentally using frequency analysis of the temporal response of the system to impulse excitation.

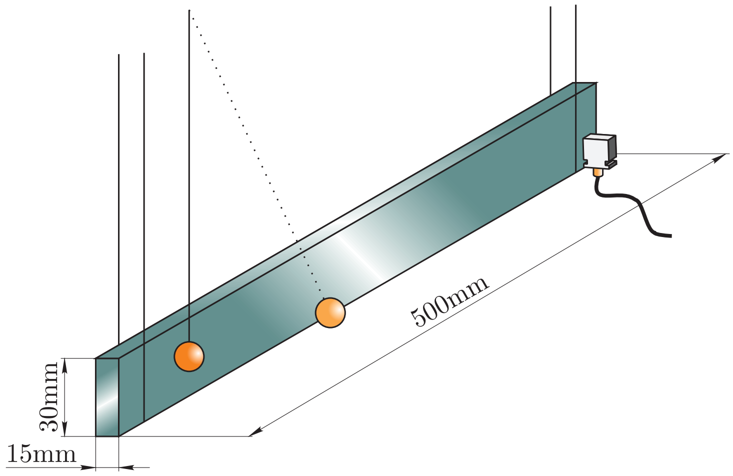

Figure 1: Free-free supported beam with an impact ball and a mounted accelerometer.

5.3 Course of the tutorial

The subject of the analysis is a homogeneous straight beam of length 500 mm and a rectangular cross-section with dimensions 15×30 mm, which allows adding an additional weight with mass 884 g. Six distinct system configurations are considered:

1. beam only,
2. beam with added weight,
3. beam, taking into account the accelerometer and magnet mass (28 g), mounted 10 mm from the left edge of the beam,
4. beam, taking into account the accelerometer and magnet mass, mounted in the center of the beam,,
5. beam with an added weight and taking into account the accelerometer and magnet mass, mounted 10 mm from the left edge of the beam,

6. beam with added weight and taking into account the accelerometer and magnet mass, mounted in the center of the beam.

Calculate the results for configurations 1 and 2 analytically and experimentally obtain the results for configurations 3–6.

5.4 Theoretical questions

1. What determines the eigenfrequencies of a beam?
2. Working principle of a piezo-crystal accelerometer.
3. Working principle of an impact hammer.
4. Derivation of the boundary condition of a beam.
5. Define the following terms, which are essential for data acquisition: sampling frequency, dynamic depth, length of measurement.
6. What is the time and frequency influence of the individual windows?
7. Lenght of the measured signal in Fourier transform.

5.5 Review of measurements and results

Symbol	Value	Unit
1. numerical model		
$f_{0,1}$		Hz
$f_{0,2}$		Hz
$f_{0,3}$		Hz
2. numerical model		
$f_{0,1}$		Hz
$f_{0,2}$		Hz
$f_{0,3}$		Hz
3. experiment		
$f_{0,1}$		Hz
$f_{0,2}$		Hz
$f_{0,3}$		Hz
4. experiment		
$f_{0,1}$		Hz
$f_{0,2}$		Hz
$f_{0,3}$		Hz
5. experiment		
$f_{0,1}$		Hz
$f_{0,2}$		Hz
$f_{0,3}$		Hz
6. experiment		
$f_{0,1}$		Hz
$f_{0,2}$		Hz
$f_{0,3}$		Hz

References

[1] *Mechanical vibrations (multiple editions)* Addison-Wesley Publishing Company