Ljud i byggnad och samhälle (VTAF01) – Lab 1

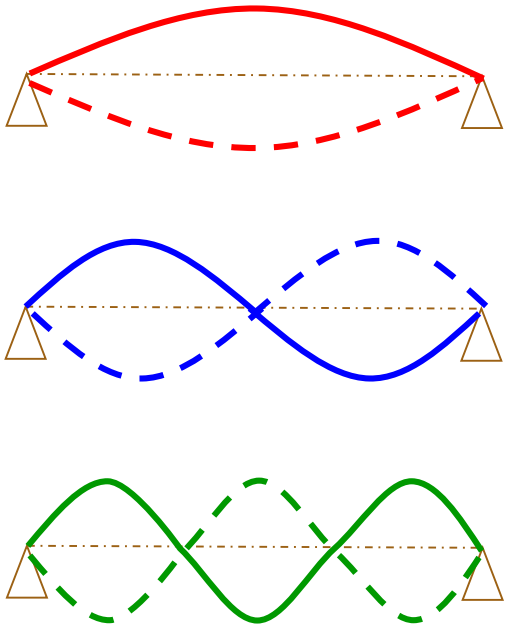
JUAN NEGREIRA
DIVISION OF ENGINEERING ACOUSTICS, LUND UNIVERSITY

Outline

Part 1 – Guitar string

Part 2 – Beam

Part 1 – Eigenfrequencies in a guitar string (I)



In general:

$\lambda = 2L/n$

$f_n = n \cdot v/2L$

$v = (\text{tension}/\text{mass-length})^{1/2}$

Eigenfrequencies in a guitar string

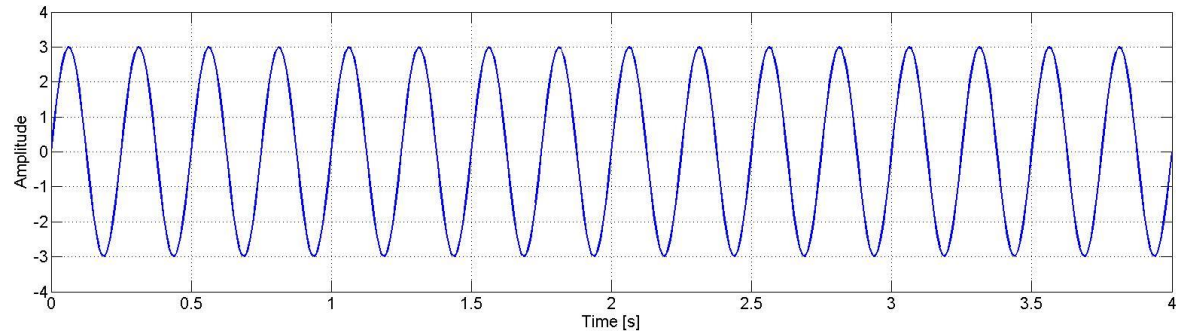
- Wave equation in a string
- Frequency = f(length, density, tension)
- Fourier transform (FFT): time → freq. domain

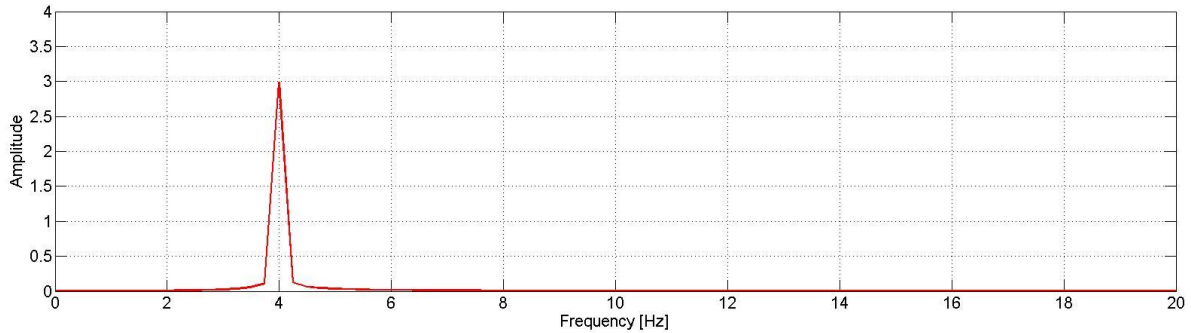
Part 1 – Eigenfrequencies in a guitar string (II)

- Notes of provided code *readsound.mat*

$$y(t) = 3\sin(2\pi 4t)$$

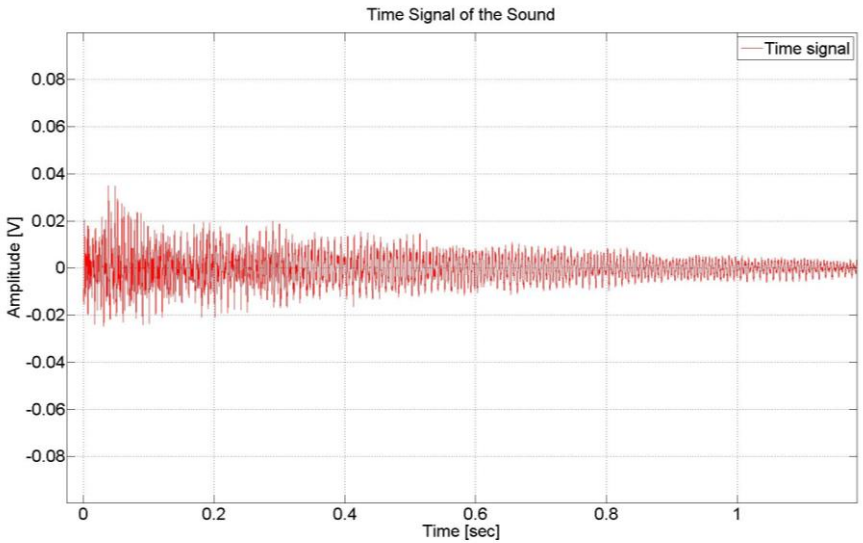
FFT

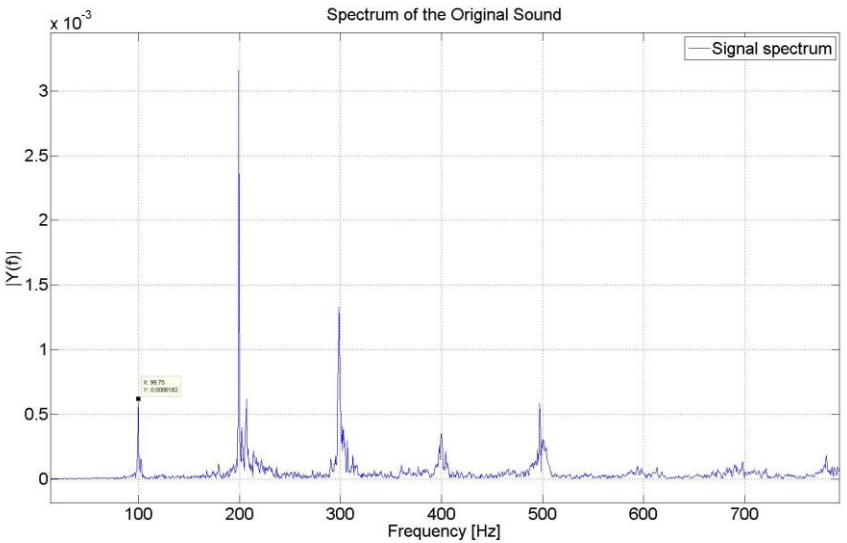




Part 1 – Eigenfrequencies in a guitar string (III)

- Example of postprocessed data with *readsound.mat*





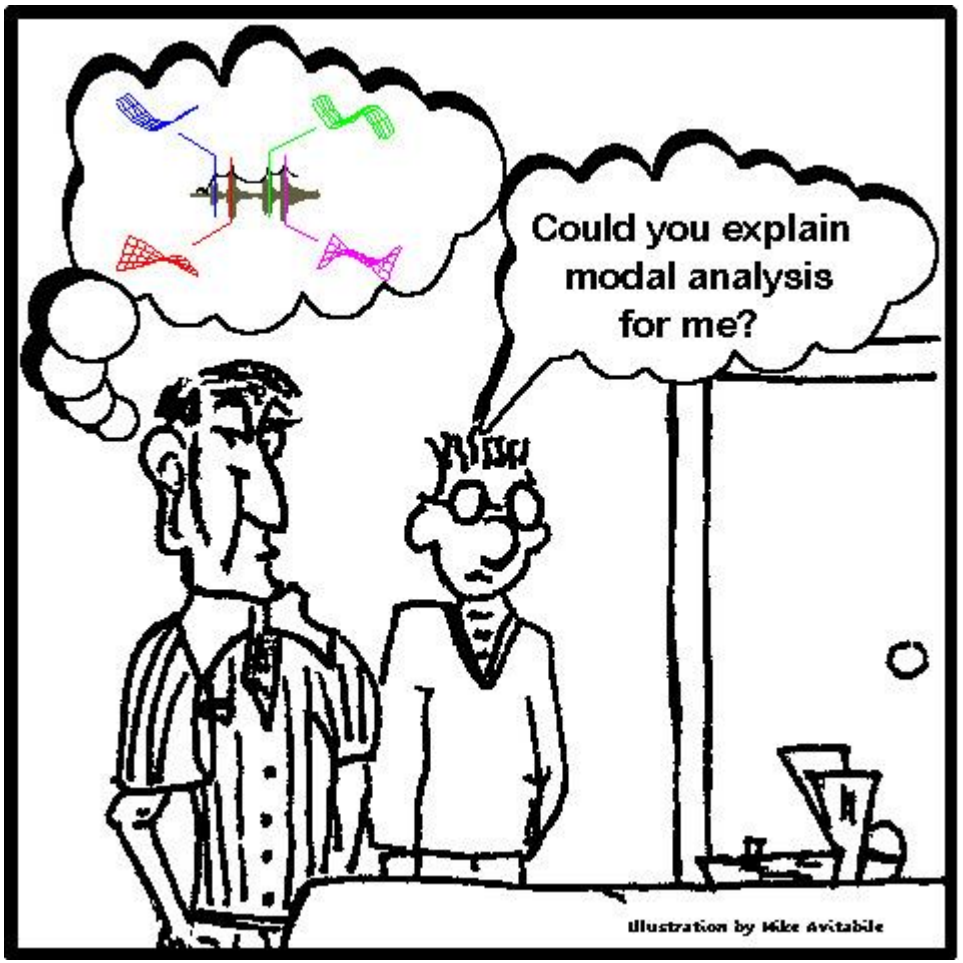
Outline

Part 1 – Guitar string

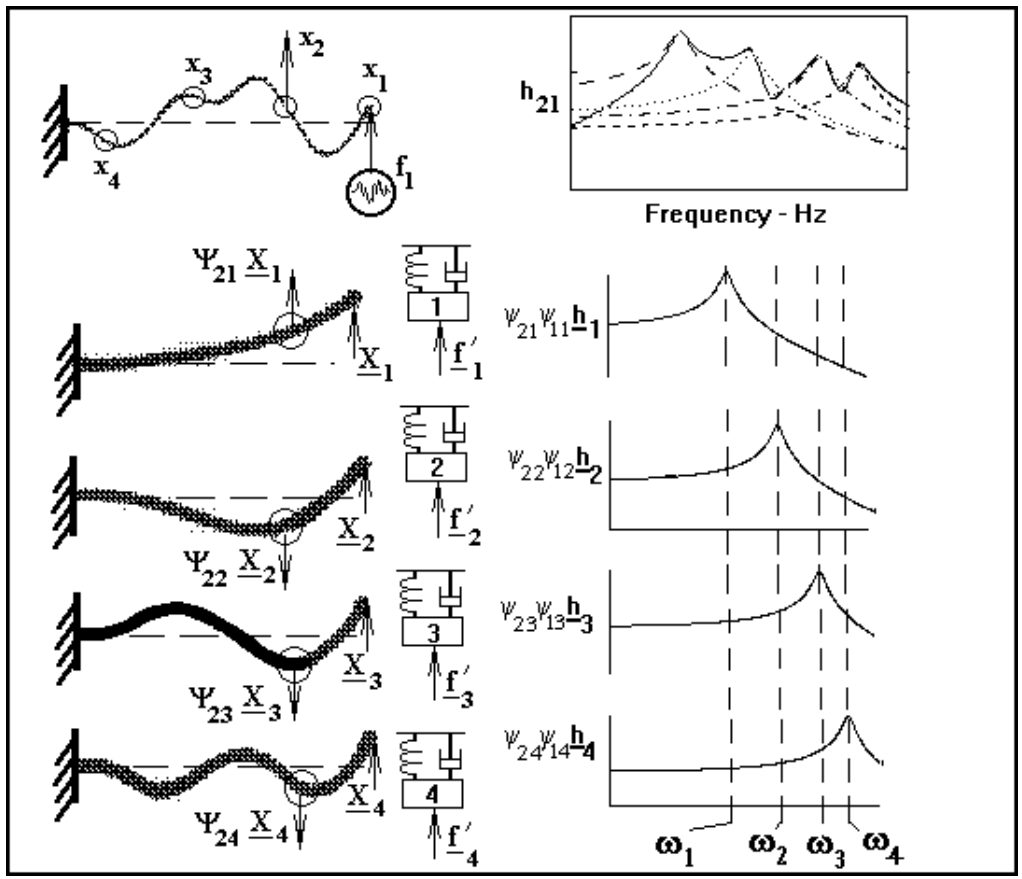
Part 2 – Beam

Modal analysis – Intro

Modal analysis is the field of measuring and analysing the dynamic response of structures and or fluids during excitation

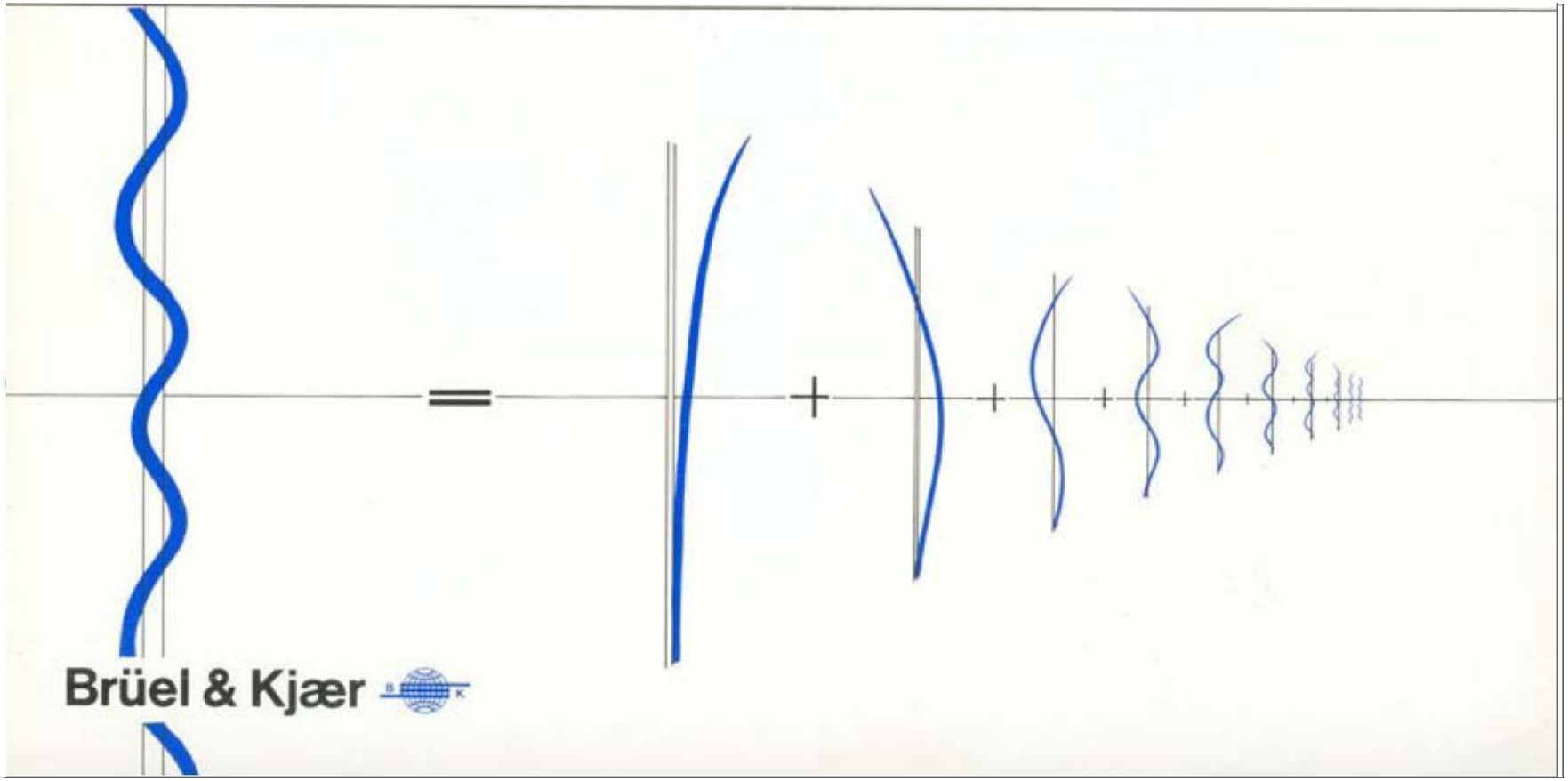


Note on modal superposition (I)



Source: http://signalysis.com

Note on modal superposition (II)

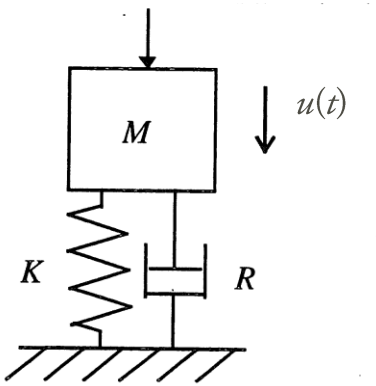


Vibration Response = 1st Mode + 2nd Mode + 3rd Mode + - - - - - - - - -

SDOF – Complex representation (Freq. domain)

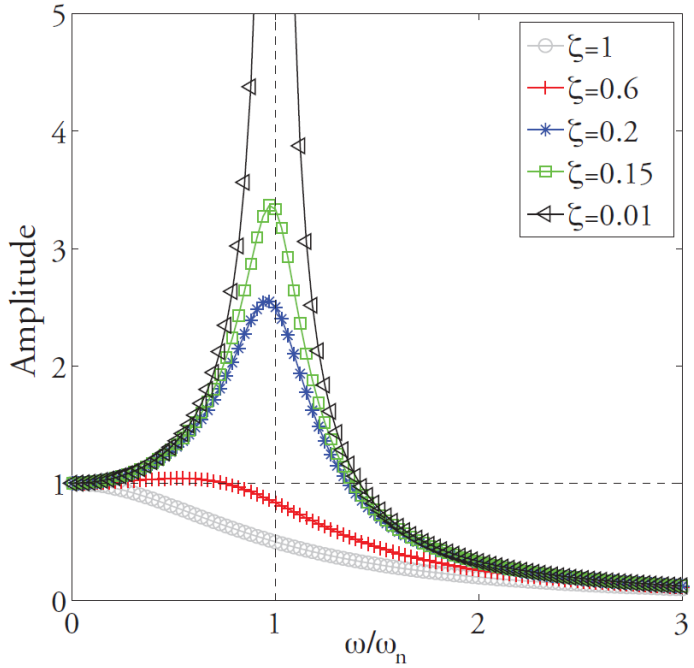
- Complex representation of a damped SDOF

$$F(t) = F_{driv} \cdot \cos(\omega t)$$



$$M\ddot{u}(t) + R\dot{u}(t) + Ku(t) = F(t)$$

$$\tilde{u}(\omega) = \frac{F_{driv}}{(K - M\omega^2) + Ri\omega}$$



SDOF – Frequency response functions (FRF)

- In general, FRF = transfer function, i.e.:
  - Contains system information
  - Independent of outer conditions

$$H_{ij}(\omega) = \frac{\widetilde{s_i}(\omega)}{\widetilde{s_j}(\omega)} = \frac{\text{output}}{\text{input}}$$

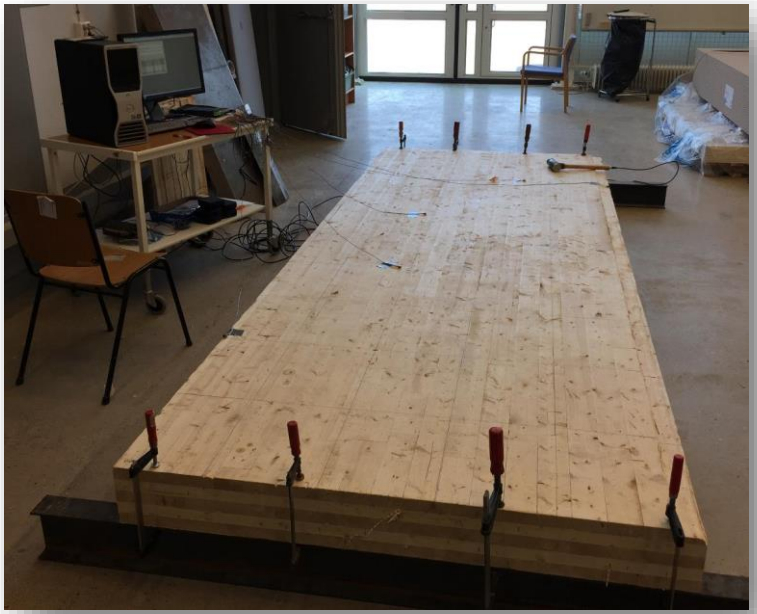
- Different FRFs can be obtained depending on the measured quantity
  - Excitation measured with a force transducer in the hammer
  - Response measured with accelerometers

Part 2 – Modal analysis of a beam

Modal analysis of a steel beam

- Bending waves in a beam
- eigenfrequency = f(E, I, density, length)
- Fourier transform (FFT): time → freq. domain

Part 2 – Modal analysis of a ~~beam~~ floor



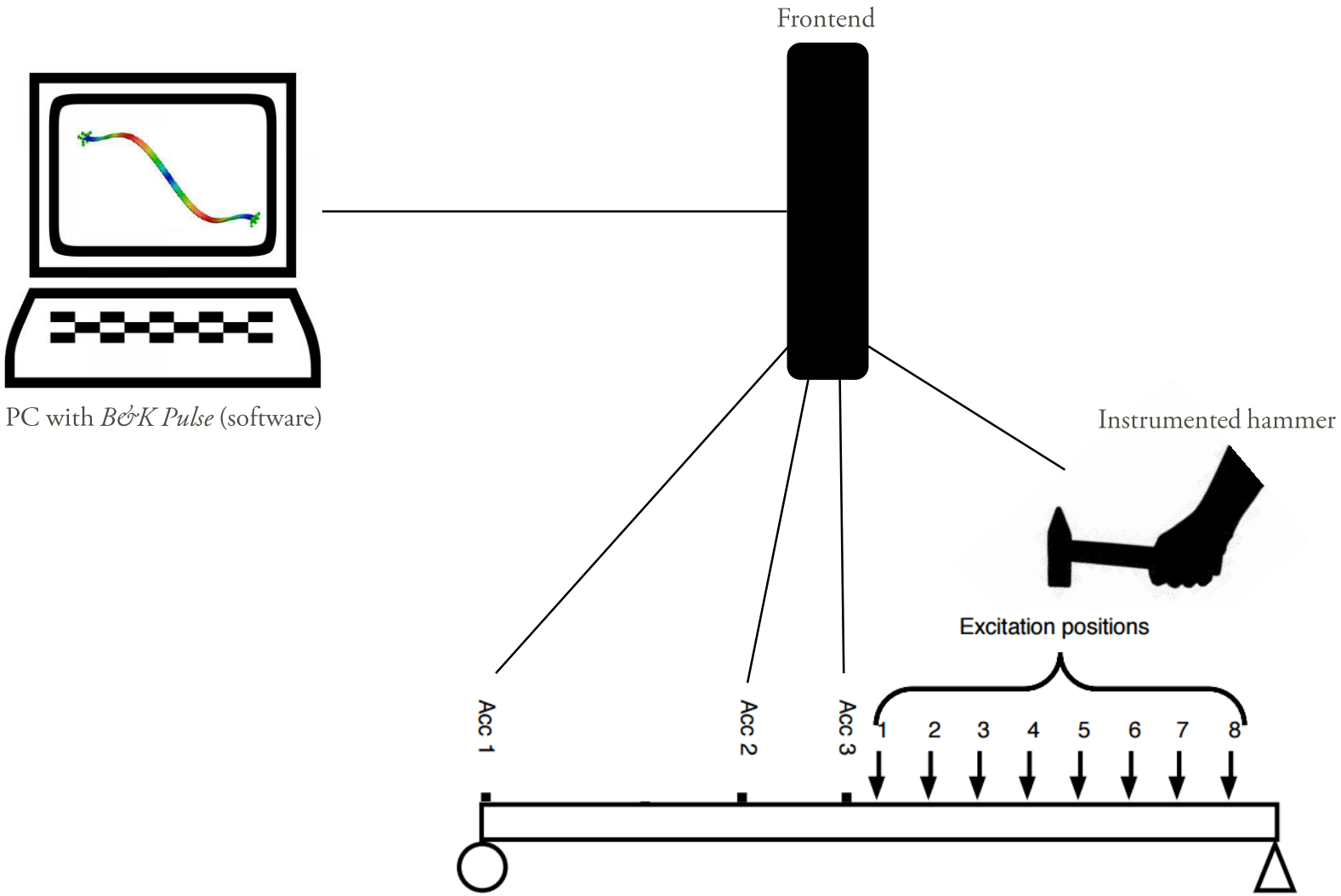
In the Lab report, you will see (for the sake of simplicity) the theoretical background for a beam.

However, you will be able to compare the analytically calculated bending modes of the floor using the proposed formulas for the beam (considering the floor as 2D beam whose length is the span of the wooden floor)

Modal analysis of a ~~steel~~ ~~beam~~ wooden floor

- Bending waves in a ~~beam~~ floor
- eigenfrequency = f(E, I, density, length, width)
- Fourier transform (FFT): time → freq. domain

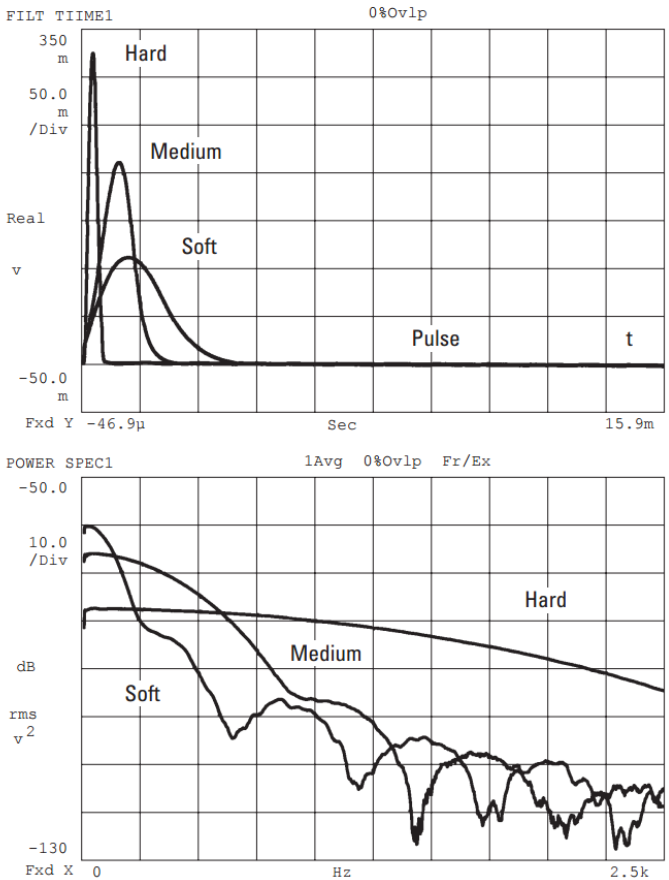
Part 2 – Experimental modal analysis: Lab setup



Note on frequency content of excitation

Figure 2.12 Frequency content of various pulses

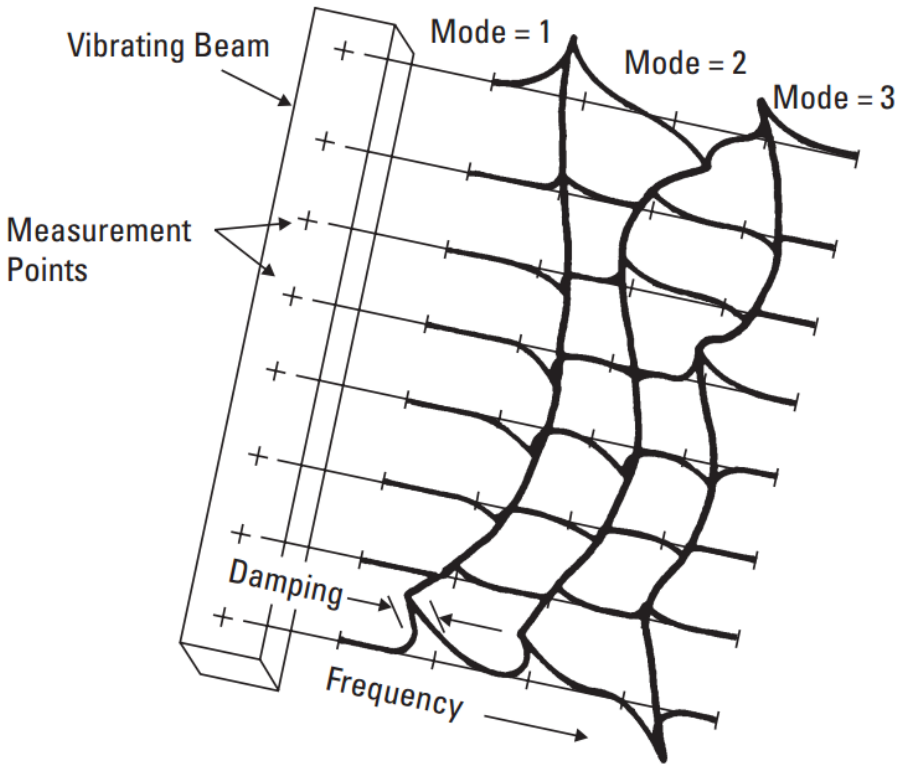
Source: Agilent Technologies



LUND UNIVERSITY

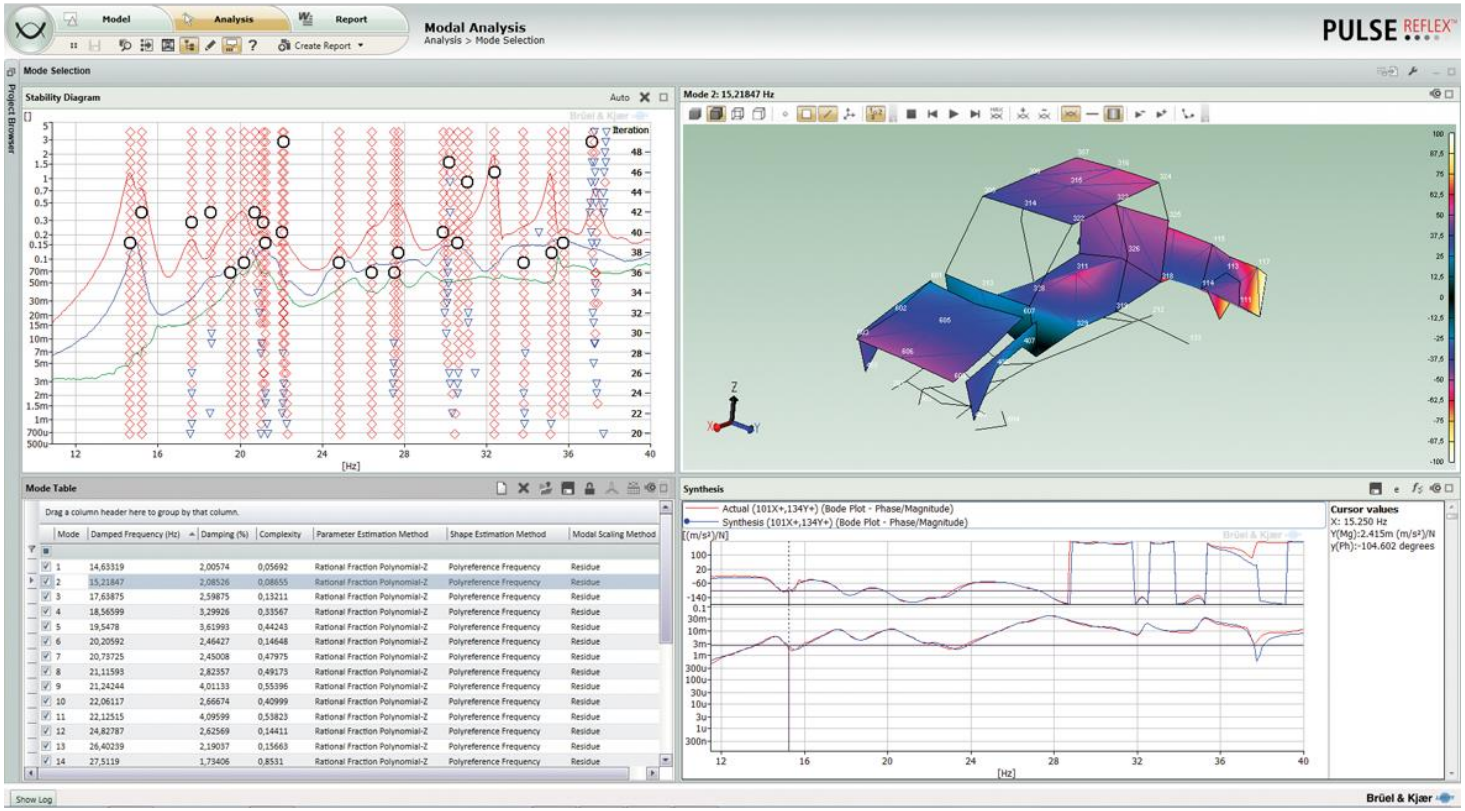
Experimental Modal Analysis (EMA)

Figure 4.2
Concepts of modal parameters
Source: Agilent Technologies



Damping, frequency — same at each measurement point
Mode shape — obtained at same frequency from all measurement points

Experimental Modal Analysis (EMA) – Examples



LUND UNIVERSITY

Thank you for your attention!

juan.negreira@construction.lth.se

LUND
UNIVERSITY