VIB2021 : MDOF systems

Number of participants: 51

1

The mode shapes and eigenfrequencies of a system are determined by (K and M are the stiffness and mass matrices)

Calculating the eigenvalues of the stiffness matrix K of the system	3%	1 vote
✓ solving a generalized eigenvalue problem of the type (K-w^2M) {Phi} = 0	82%	32 votes
Calculating the eigenvalues of the mass matrix M of the system	10%	4 votes

Calulating w=K/M		5%	2 votes

2

If a system has n degrees of freedom, it has

2n natural frequencies	6%	2 votes
✓ n natural frequencies	85%	28 votes
(n + the number of excitations) natural frequencies	9%	3 votes
it depends on the type of system	0%	0 votes

3

The mode shapes are orthogonal with respect to the

✓ stiffness matrix	89%	33 votes
✓ mass matrix	73%	27 votes
damping matrix	8%	3 votes

4

The interest of projecting the equations of motion in the modal domain is to:

reduce the number of equations to solve	5%	2 votes
✓ decouple the equations of motion and facilitate solving them	68%	28 votes
work with physical quantities for a better understanding of the system's behavior	27%	11 votes

5

Which of these quantities is a global quantity for a given structure

✓ the eigenfrequency	76%	29 votes
the anti-resonance frequency	16%	6 votes
✓ the damping coefficient	34%	13 votes

6

An anti-resonance happens when

The contribution to the response of the two close modes as equal amplitude and equal phase	3%	1 vote
✓ The contribution to the response of the two close modes as equal amplitude and opposite phase phase	95%	37 votes
The displacement is zero for the two closest modes	3%	1 vote

7

What kind of hypothesis can be made on the damping matrix to decouple the equations of motion in the modal domain ?

✓ Rayleigh Damping	76%	29 votes
Lagrange Damping	21%	8 votes
✓ Modal damping	55%	21 votes
Viscous damping	11%	4 votes

8

How many mode shapes and eigenfrequencies does this building simplified model have ?

one	0%	0 votes
three	3%	1 vote
✓ five	97%	35 votes
an infinity	0%	0 votes

9

If this system is excited with an harmonic force applied to the bottom mass whose frequency is close to the first natural frequency, the motion will correspond to

✓ The first mode shape where the two masses move in phase	69%	25 votes
The second mode shape where the two masses move out of phase	19%	7 votes
A combination of the two modeshapes	11%	4 votes

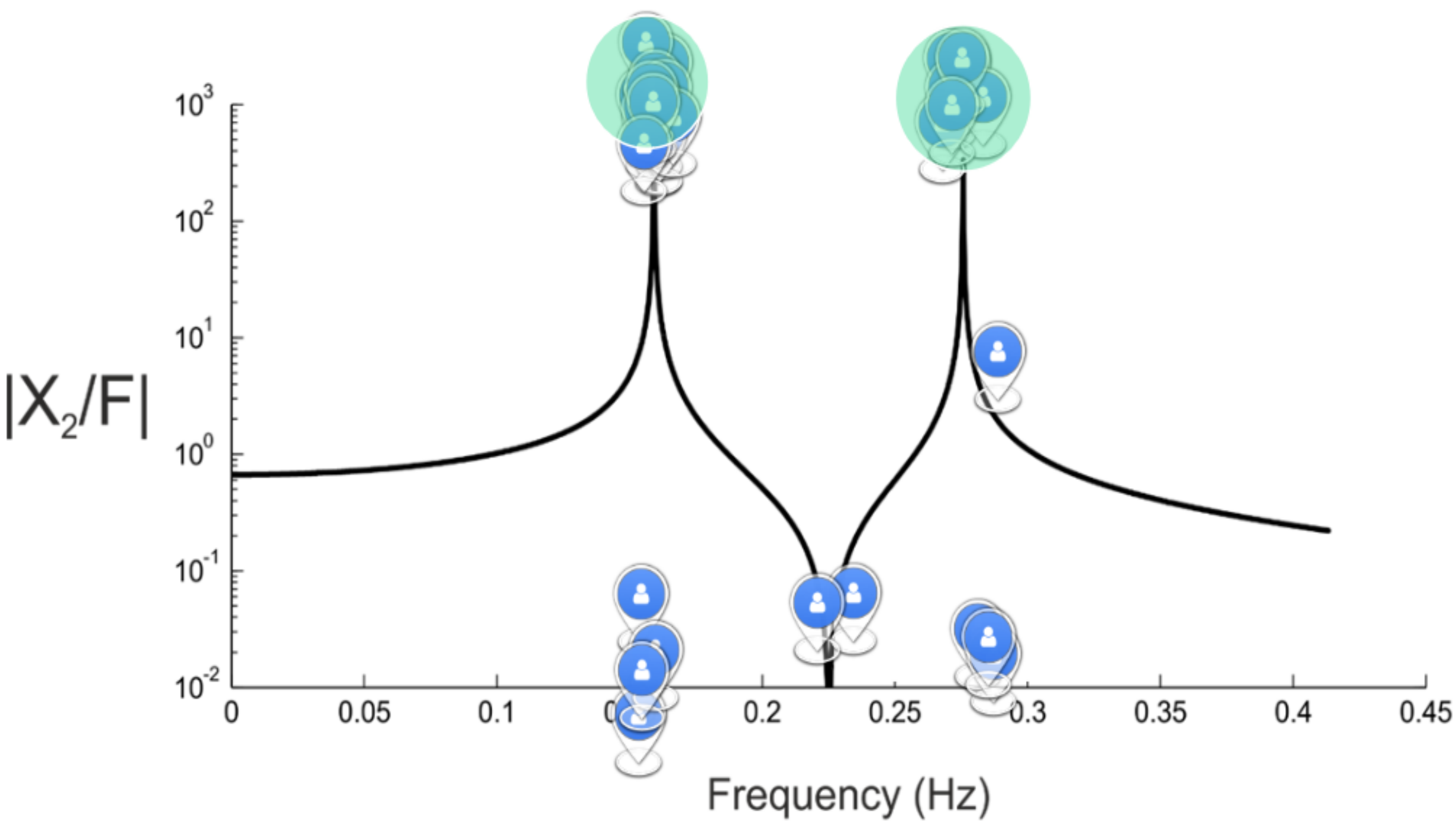
10

If this system is excited with an harmonic force applied to the bottom mass whose frequency is the average of the first and second natural frequencies of the system, the motion will correspond to

The first mode shape where the two masses move in phase	3%	1 vote
The second mode shape where the two masses move out of phase	15%	5 votes
✓ A combination of the two mode shapes	82%	28 votes

11

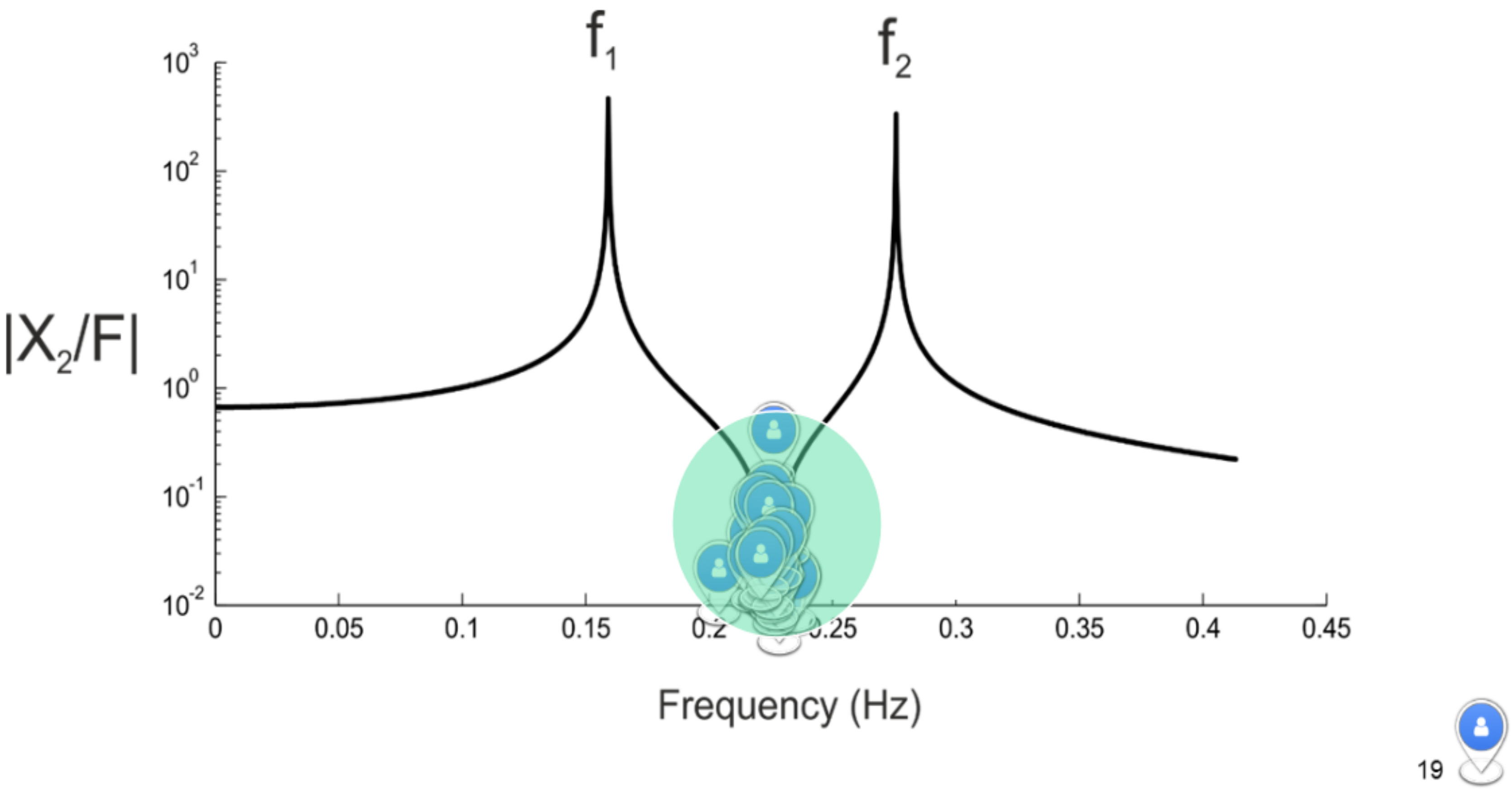
Where are the resonant frequencies of the 2 DOFs system on this graph ?



19

12

Where is the anti-resonance of the 2 DOFs system on this graph ?



13

Why is the damping coefficient higher for the second mode than for the first mode for the damped two dofs system treated in the examples of the course ?

Amk

As two masses move in opposite direction so system damps more than moving in same direction.

high freq

Out of phase modes

🤔

Because in the first mode the spring /damper system between the masses doesn’t compress/extent since the two masses are moving together

Damping coefficient increases with increasing frequency

Dampingcoefficient is dependant of the eigenfrequentie. So if the eigenfrequentie is higher, the dampingcoefficient is higher as well.

Because the frequency is higher, and as such the speed of movement, and damping is a function of speed

Because the masses are out of phase, so the spring between them is more contracted, so more dissipation of energy

Because in the second mode the masses move out of phase and the damper in the middle dissipates energy. In the first mode the damper does not work because masses move in phase

The damper might be much stiffer at the first mode!

Loss of energy

Due to different mode shapes

Because the second mode use two damping and the first just one damping mechanism

the spring in the middle dissipated energy in the second mode

Because the frequency of the second mode is higher, thus the friction factor is higher

Because it has a lower amplitude

Because it’s proportional to the natural frequency

Damping is proportional to velocity, which is higher at the second resonance

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This is the impulse response of a damped two dofs system. Is it possible to extract the information on the first natural frequency and damping from this curve in a simple way ?

✓ Yes	73%	19 votes
No	27%	7 votes

15

How would you extract the first natural frequency from the impulse response ?

Since sweep excitation

FFT 😎

Fourier transform

Fourier

Fourier analysis

Transfer to frequency domain an see the carve

Using them Fourier Integrals

Computing the Fourier transform of the impulse response and pointing out the first peak of the spectrum in the frequency domain

Fourier, looking at the first spike

There are two part in the diagram, one is steady-state and the first one is transient

FFT the transfer function

Fourier transform on transient part.

Applying Fourier transform

Frequency of the underlying sinusoid

Sine sweep and find where resonance occurs

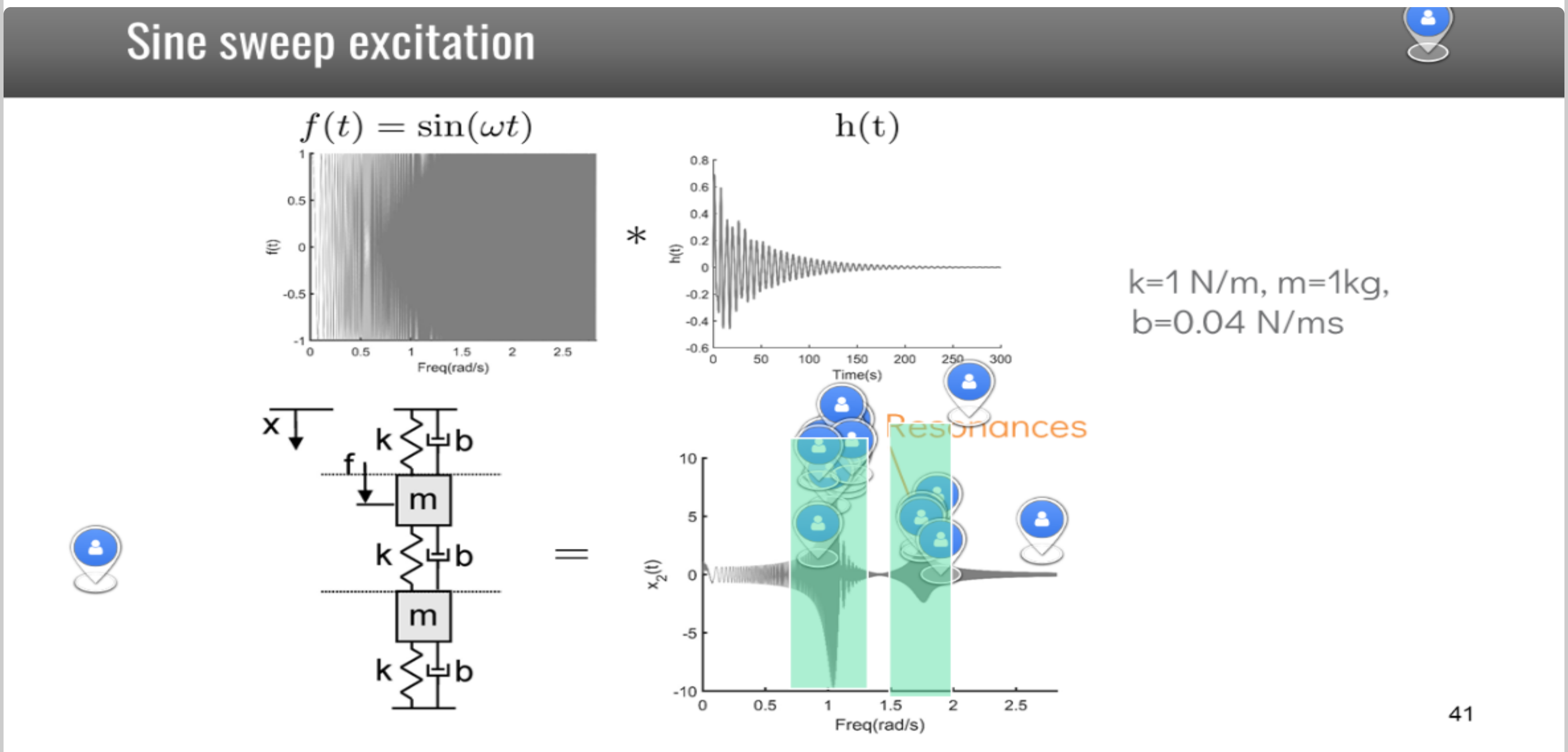
16

This is the impulse response of a damped two dofs system. Is it possible to extract the information on the second natural frequency and damping from this curve in a simple way ?

Yes	42%	10 votes
✓ No	58%	14 votes

17

This is the time domain response of a damped 2 DOFs system under sine sweep excitation. Where do you see the resonances on the time domain response ?



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When a system is excited by its base, it is easier to write the unknown displacements

as relative displacement between the neighbouring DOFS	13%	4 votes
as relative displacement between the base and each DOF.	87%	27 votes
in mm instead of m	0%	0 votes

19

When doing so, the equation of motion is equivalent to an applied force which is

✓ proportional to the applied acceleration	73%	24 votes
inversely proportional to the applied acceleration	12%	4 votes
proportional to the applied displacement	15%	5 votes