SDLD313 - System masses spring with 2 degrees of freedom with Summarized

hysteretic damping:

This one-way problem consists in carrying out a harmonic analysis of a mechanical structure made up of a set of mass-springs with hysteretic damping and subjected to a sinewave excitation. This test of structural mechanics corresponds to a dynamic analysis of a discrete model having a linear behavior. It understands three modelizations.

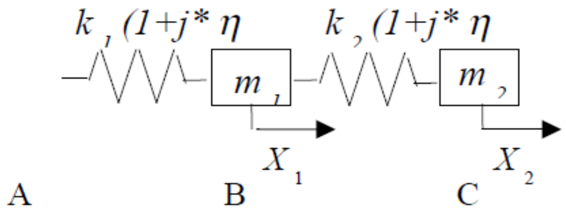
Via the modelization A, one tests the discrete elements in translation (mass, spring), options AMOR_HYST of AFFE_CARA_ELEM.
Via the modelization B, one tests beam elements (POU_D_T), options AMOR_HYST of DEFI_MATERIAU,
Via the modelization C, one tests computation modal (MODE_ITER_SIMULT) complex.

The results got for the first two modelizations (field of displacement for various excitation frequencies) are in concord with the results of guide VPCS. The results got for the third modelization are in concord with the semi-analytical results.

1 Problem of reference

1.1 Geometry

We consider the system represented by the diagram below:



Point masses:	m_1 and m_2
Stiffness of connection:	k_1 and k_2
Hysteretic damping:	η_1 and η_2

1.2 Properties of the material

Comes out from elastic translation linear	$K_1=28000\ N/m$ $K_2=28000\ N/m$
Point mass	$M_1=10\ kg$ $M_2=5\ kg$
Hysteretic damping	$\eta_1=0.1$ $\eta_2=0.0$

1.3 Boundary conditions and loadings

Boundary conditions:
Points A B, C embedded in DY and DZ
Points A : embedded $(DX=0)$.

Loading: Sinusoidal concentrated force of variable frequency at the point C

$$F_{x_4}=F_0 \sin \Omega t$$
$$\Omega=2\pi f \quad 0\ Hz \leq f \leq 21.0543\ Hz$$
$$F_0=constante=100\text{N}$$

1.4 Initial conditions

Without object for the study of the permanent harmonic mode.

2 Reference solution

2.1 Method of calculating

the system of equations differentials of the second order coupled is form:

$$M\ddot{u}+Ku=F$$

with $M=\begin{bmatrix}0 & 0 & 0\\ 0 & 10 & 0\\ 0 & 0 & 5\end{bmatrix}$ and $K=28000\begin{bmatrix}1+0.1j & -1-0.1j & 0\\ -1-0.1j & 2+0.1j & -1\\ 0 & -1 & 1\end{bmatrix}$

the solution with ω a harmonic excitation formulates $\mathbf{F}=\mathbf{F_0}e^{j\omega t}(j^2=-1)$ is form $u=u_0e^{j\omega t}$, which leads to: $(\mathbf{K}-\mathbf{M}\omega^2)u_0=\mathbf{F_0}$

This system is solved for any ω .

2.2 Quantities and results of reference

Displacement according to x point C for certain frequencies.
Reduced eigenfrequencies and damping.

2.3 Uncertainties on the semi-analytical

solution Solution.

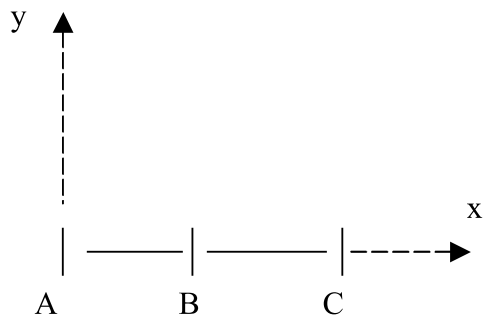
2.4 Bibliographical references

[1] J. PIRANDA: Note of modal use of analysis software MODAN - Version 0.2 (1990). Laboratory of Mechanics Applied - University of Frank County - Besancon (France).

3 Modelization A

3.1 Characteristic of the modelization

Discrete element of stiffness in translation



Characteristics of the DISCRET `elements`: with nodal masses `M_T_D_N` and stiffness matrixes `K_T_D_L`

Boundary conditions:
- in all nodes `DDL_IMPO: (TOUT: "YES" DY: 0. , DZ: 0. )`
- with ending node A `(the GROUP_NO: A DX: 0. )`

Names of the nodes:
- Not $A=N1$
- Not $B=N2$
- Not $C=N3$

3.2 Characteristic of the mesh

Many nodes: 3
Number of meshes and types: 2 SEG2

3.3 Quantities tested and results

Left real and imaginary the component DX of the displacement of the point C .

Frequency	Reference	*Aster*	% Difference
0.00	7.1075E-03 – 3.5360E-04	7.1074964639321E-03 – 3.5360678925035E-04	1.08E-04
3.36870E+00	9.388216E-03 – 7.31196E-04	9.3882649899583E-03 – 7.3120610001073E-04	5.31E-04
6.48480E+00	– 5.0269E-03 – 7.07103E-02	– 5.0349198344062E-03 – 7.0708581052416E-02	0.012
8.00060E+00	– 9.54931E-03 – 2.2154E-03	– 9.5490053525137E-03 – 2.2153458282190E-03	0.003
1.18746E+01	– 4.23259E-05 – 3.57193E-04	– 4.2266734408325E-05 – 3.5719325443817E-04	0.016
1.34747E+01	2.35524E-03 – 5.01765E-04	2.3552527130123E-03 – 5.0176685846530E-04	5.34E-04
1.55802E+01	– 1.6395374E-02 – 6.871471E-02	– 1.6420641488151E-02 – 6.8704047854161E-02	0.039
2.10543E+01	– 1.88977E-03 – 5.53314E-06	– 1.8897660707219E-03 – 5.5328629109043E-06	2.08E-04

3.4 Remarks

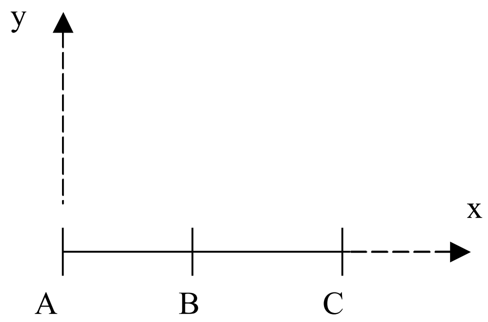
Contained of the file results:

Values of the displacement of the component DX of the point C for all the frequencies of 0 with $2.10543\mathrm{E}+01\mathrm{Hz}$ by step of 3.3687 .

4 Modelization B

4.1 Characteristic of the modelization

continuous Element of standard beam in tension



Characteristics of the DISCRET

`elements`:	nodal masses	`M_T_D_N`
`BEAM`:	stiffness matrixes	`POU_D_T`

Boundary conditions:

in all nodes	`DDL_IMPO`:	`(TOUT: "YES" DY: 0. , DZ: 0. )`
with ending node A		`(the GROUP_NO: A DX: 0. )`

Names of the nodes:
Not $A=N1$
Not $B=N2$
Not $C=N3$

4.2 Characteristic of the mesh

Many nodes: 3
Number of meshes and types: 2 `SEG2`

4.3 Quantities tested and results

Left real and imaginary the component DX of the displacement of the point C.

Frequency	Reference	*Aster*	% Difference
0.00	7.1075E-03 – 3.5360E-04	7.1074964639321E-03 – 3.5360678925035E-04	1.08E-04
3.36870E+00	9.388216E-03 – 7.31196E-04	9.3882649899583E-03 – 7.3120610001073E-04	5.31E-04
6.48480E+00	– 5.0269E-03 – 7.07103E-02	– 5.0349198344064E-03 – 7.0708581052416E-02	0.012
8.00060E+00	– 9.54931E-03 – 2.2154E-03	– 9.5490053525137E-03 – 2.2153458282190E-03	0.003
1.18746E+01	– 4.23259E-05 – 3.57193E-04	– 4.2266734408325E-05 – 3.5719325443817E-04	0.016
1.34747E+01	2.35524E-03 – 5.01765E-04	2.3552527130123E-03 – 5.0176685846530E-04	5.34E-04
1.55802E+01	– 1.6395374E-02 – 6.871471E-02	– 1.6420641488152E-02 – 6.8704047854161E-02	0.039
2.10543E+01	– 1.88977E-03 – 5.53314E-06	– 1.8897660707219E-03 – 5.5328629109043E-06	2.08E-04

4.4 Remarks

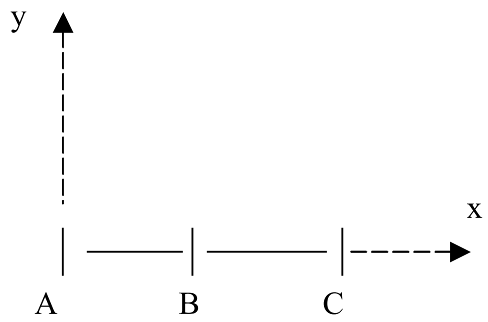
Contained of the file results:

Values of the displacement of the component DX of the point C for all the frequencies of 0 with $2.10543\mathrm{E}+01\mathrm{Hz}$ by step of 3.3687 .

5 Modelization C

5.1 Characteristic of the modelization

Discrete element of stiffness in translation



Characteristics of the DISCRET
`elements`: with nodal masses `M_T_D_N`
and stiffness matrixes `K_T_D_L`

Boundary conditions:
in all nodes `DDL_IMPO: (TOUT: "YES" DY: 0. , DZ: 0. )`
with ending node A `(the GROUP_NO: A DX: 0. )`

Names of the nodes:
$Point\ A=N1$ $A=N1$
$Point\ B=N2$ $B=N2$
$Point\ C=N3$ $C=N3$

5.2 Characteristics of the mesh

Many nodes: 3
Number of meshes and types: 2 `SEG2`

5.3 Quantities tested and Eigenfrequencies

results and reduced dampings.

Eigenfrequencies:

Sequence number	Reference	*Aster*	% Difference
1	6.4537	6.44568	– 0.124
2	15.5806	1.55612	– 0.124

Reduced dampings:

Sequence number	Reference	*Aster*	% Difference
1	0.05	0.05	– 1.39E-14
2	0.05	0.05	2.78E-14

6 Summary of the results

the got results are excellent.