SDLD29 - Transient masses spring with 8 degrees of freedom and viscous damping nonproportional

Summary:

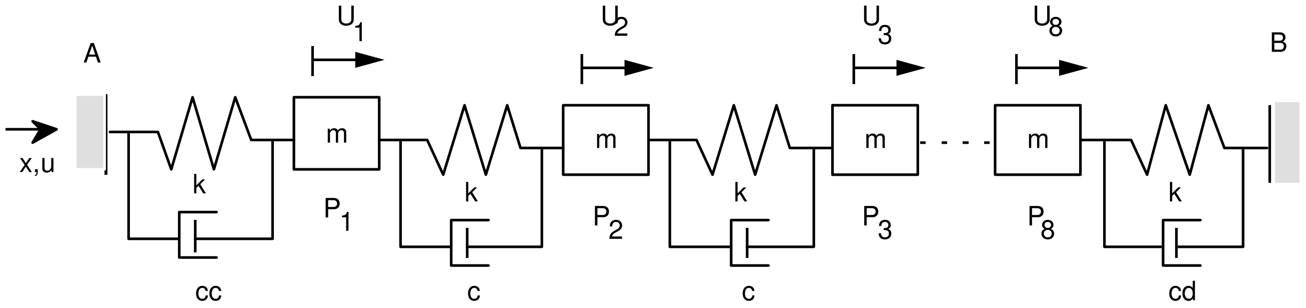
This problem corresponds to a transitory analysis by modal recombination of a linear discrete system made up by 8 degrees of freedom. This system has a damping not - proportional. A transitory force of standard crenel is applied into 1 degree of freedom.

In this problem the elements are tested `DISCRETE` with modal masses (`M_T_D_N`), matrices of rigidity (`K_T_D_L`) and matrices of damping (`A_T_D_L`) in a modeling.

The problem has a reference solution suggested by commission VPCS. Variations with *Code_Aster* do not exceed 1.8%.

1 Problem of reference

1.1 Geometry



Specific masses: $m_{P_1} = m_{P_2} = m_{P_3} = \ldots \ldots = m_{P_8} = m$

Stiffnesses of connection: $k_{AP1} = k_{P1P2} = k_{P2P3} = \ldots \ldots = k_{P8B} = k$

Viscous damping:
$C_{P1P2} = c_{P2P3} = \ldots \ldots = C_{P7P8} = c$
$C_{AP1} = cc$
$C_{P8B} = cd$

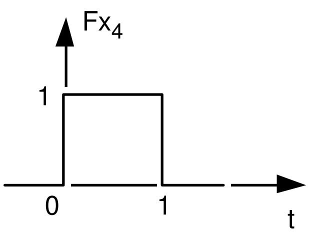
1.2 Material properties

Spring of elastic translation linear	$k = 10^5 N/m$
Specific mass	$m = 10 kg$
Damping of connection	$c = 50 N/(m/s)$
	$cc = 250 N/(m/s)$
	$cd = 25 N/(m/s)$

1.3 Boundary conditions and loadings

Points A and B embedded: $u = 0$

Loading: Concentrated force not periodical at the point $P4$



Not $P4$ $F_{x_4} = F(t) 0 \le t \le 1 \mathrm{s}$ $F(t) = 1\mathrm{N} = constante$
$t > 1 \mathrm{s}$ $F(t) = 0$

1.4 Initial conditions

For $t = 0$, in any point P_i : $u = 0$, $\frac{du}{dt} = 0$.

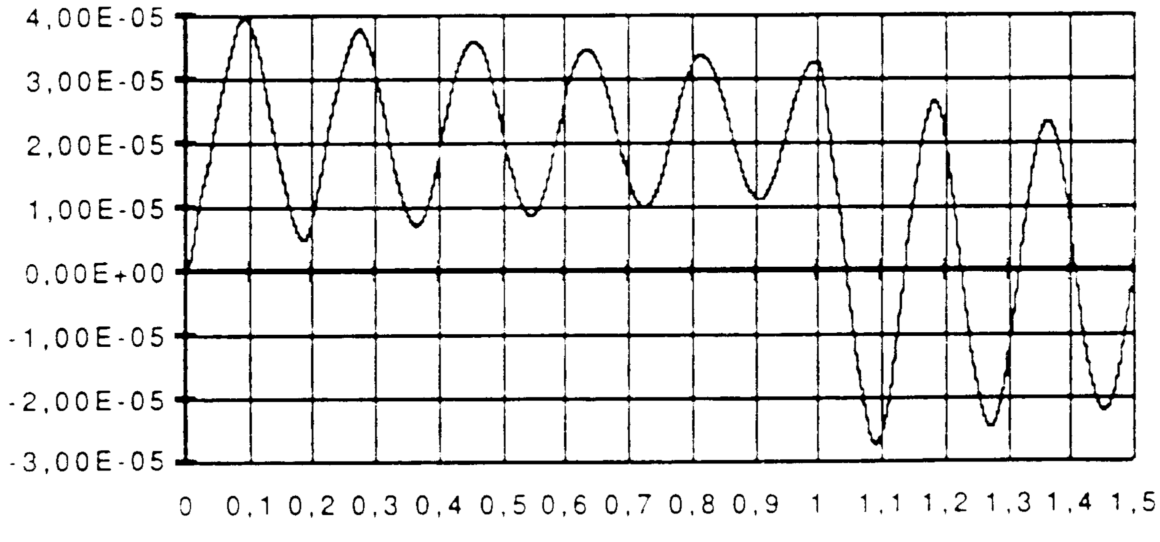
2 Reference solution

2.1 Method of calculating used for the reference solution

Digital integration (approximate) by the direct method using a digital diagram of integration by finished differences, the step of time used must be sufficiently small to obtain a sufficiently precise solution. With one of the diagrams used (Newmark method improved), the step of appointed time was of $0.001\mathrm{s}$.
Method of Newmark improved (NEWMARK NR. Mr., "with method of computation for structural dynamics" proceeding ASCE J. Eng. Mech. Div E-3, July 1959, pp 67-94) use the diagram of integration according to:

$$\left[\frac{1}{\Delta t^2}[M]+\frac{1}{2\Delta t}[C]+\frac{1}{3}[K]\right](u_{n+2})$$
$$=\frac{1}{3}([P_{n+2}]+[P_{n+1}]+[P_n])+\left[\frac{2}{\Delta t^2}[M]-\frac{1}{3}[K]\right](u_{n+1})+\left[\frac{1}{\Delta t^2}[M]+\frac{1}{2\Delta t}[C]-\frac{1}{3}[K]\right](u_n)$$

Indices n , $n+1$, $n+2$ the calculations carried out at time indicate respectively t_n , $t_{n+1}=t_n+\Delta t$ and $t_{n+2}=t_n+2\Delta t$, where Δt is the increment of appointed time. $[M]$, $[C]$ and $[K]$ are respectively the matrices masses, damping and stiffness, (u) is the vector displacement and (P) the vector forces associated.



Point 4: displacement according to time

2.2 Results of reference

Displacement at the point $P4$ according to time, confer graph above.

2.3 Uncertainty on the solution

- position of the extremas: $\Delta t<0.015$
- maximum amplitude: $\Delta u/u<0.5\%$

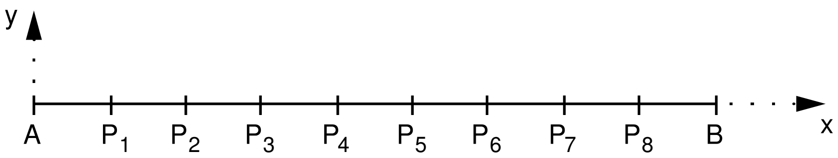
2.4 Bibliographical references

1. Card SDLD29/90 of commission VPCS

3 Modeling A

3.1 Characteristics of modeling

Discrete element of rigidity in translation



Characteristics of the elements

`DISCRETE:`	with nodal masses	`M_T_D_N`
	and matrices of rigidity	`K_T_D_L`
	and matrices of damping	`A_T_D_L`

Limiting conditions:

in all the nodes	`DDL_IMPO=_F`	`(TOUT=' OUI'    DY= 0. , DZ= 0. )`
with the nodes ends		`(GROUP_NO= AB  DX= 0. )`

Names of the nodes:

Not A = $N1$ $P_1 = N2$

Not B = $N10$ $P_2 = N3$

$P_8 = N9$

Modal recombination with all the modes (8) pas de time used $dt = 1.\text{E}-3\ s$

diagram of EULER

3.2 Characteristics of the grid

Many nodes: 10

Many meshs and types: 9 SEG2

3.3 Sizes tested and results

Time (s)	Reference
0.09	3.97 E-5
0.18	5.10 E-6
0.27	3.77 E-5
0.36	7.30 E-6
0.45	3.59 E-5
0.54	8.81 E-6
0.63	3.47 E-5
0.72	1.01 E-5
0.81	3.36 E-5
0.91	1.11 E-5
0.99	3.27 E-5

3.4 Remarks

Contents of the file results: displacements.

4 Summary of the results

One obtains a relatively good agreement between the calculated solution and solution VPCS (<0.7%) except at moment 0.91 (2.4%). The differences are primarily due to the fact that the moments of test are given only with 2 significant figures, which does not make it possible to seize sufficiently well the moment of the extremum.