SDLD34 – To release of a simple mass/Summarized

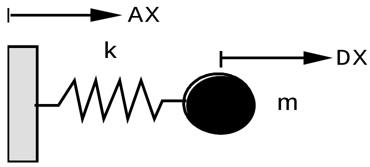
spring:

A simple oscillator, made up of a mass connected to a support by a spring, is subjected to releasing on the basis of tended spring. It is checked that *Code_Aster* calculates well the oscillatory response with the initial conditions without external forces.

One tests the features of linear transient computation on the basis of physical base and modal base operator DYNA_VIBRA.

1 Problem of reference

1.1 Geometry



One is interested in motion of the mass m .

1.2 Material properties

Point mass: $m=1\,kg$
Arises elastic: $k=\pi^2 N/m$

Case 1 : conservative system (without damping)
Case 2 : dissipative system $c=0,2\pi\, N.s/m$

1.3 Boundary conditions and loadings

the problem is unidimensional in the direction x , and with a degree of freedom: the displacement of the mass m .

The mass is left free, without external excitation.

Initially it is except equilibrium: spring is tended with an elongation of 1 meter.

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is analytical. In the absence of damping, it is a simple sinusoid of which the period is equal to the own pulsation of the oscillator $\omega_0=\sqrt{\frac{k}{m}}$, and whose amplitude is the initial lengthening (x_0) of spring. The position $x(t)$ of the mass is given by the equation:

$$x(t)=x_0\cos(\omega_0 t) \quad (1)$$

the velocity of the mass is thus:

$$v(t)=-\omega_0 x_0 \sin(\omega_0 t) \quad (2)$$

In the presence of a viscous damping $(c_{[N.s/m]})$, the oscillations become damped and the position $x(t)$ is written :

$$x(t)=x_0 e^{-\zeta\omega_0 t}[\cos(\omega t)+(\frac{\zeta}{\sqrt{1-\zeta^2}})\sin(\omega t)] \quad (3)$$

where ζ is reduced damping given par. $\zeta=\frac{c}{2\omega_0 m}$ ζ is considered to be lower than 1 to preserve the oscillations. The pulsation is given by the formula $\omega=\omega_0\sqrt{(1-\zeta^2)}$. It is thus different from the own pulsation (ω_0) of the system.

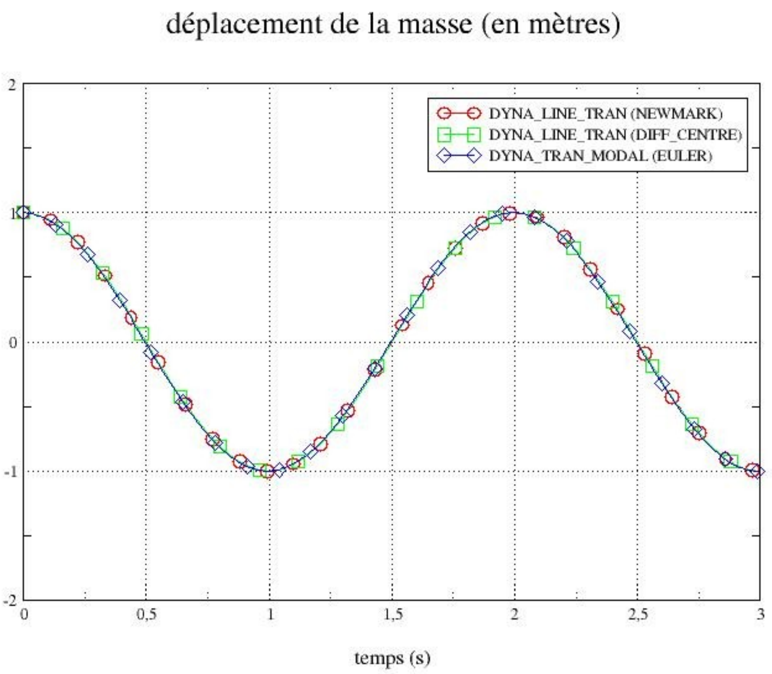
2.2 Results

Case 1 : conservative system (without damping)

For this system, the own pulsation $\omega_0=\pi\, rad/s$. The eigenfrequency is thus $f_0=\omega_0/2\pi=0{,}5\, Hz$.

Displacement (in m) and the velocity (in m/s) of the mass, given respectively by Eqs.1 and 2 are:

$$x(t)=\cos(\pi t) \quad \text{and} \quad v(t)=-\pi\sin(\pi t)$$



Case 2 : viscous dissipative system

The damping reduced is of $\zeta=0{,}1$. The pulsation is $\omega=0{,}995\pi\, rad/s$ and the frequency is thus $f=\omega/2\pi=0{,}4975\, Hz$.

Displacement (in m) can then be calculated according to Eq.3.

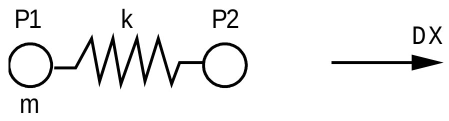
2.3 Uncertainty on the analytical

solution Solution.

3 Modelization A

3.1 Characteristic of the modelization

Discrete element in translation of the type `DIS_T`



Characteristics of the elements:

With the nodes $P1$ and $P2$: mass matrixes of the type `M_T_D_N` with $m=100\,kg$.
Enter $P1$ and $P2$: a stiffness matrix of the type `K_T_D_L` with $K_x=10^6\,N/m$

Boundary conditions:

All the degrees of freedom are blocked except the degree of freedom DX of the node $P2$.

3.2 Characteristics of the mesh

Many nodes: 2

Number of meshes and types: 1 `SEG2`, 2 `POI1`

3.3 Features tested

One tests the features of linear transient computation on the basis of physical base and modal base operator `DYNA_VIBRA`.

3.4 Quantities tested and Dynamic response

results

One tests the position of the mass at the end of one period, i.e. 2 seconds. Moreover, one tests the value of the modal participation of mode 1. As it is about a single mode and that he is normalized according to the node which carries the mass, the modal participation is identical to displacement.

Identification	Reference	physical
`DYNA_VIBRA/base` Tolerance `(NEWMARK)`	1 m	1.E- 4%
`physical (DIFF_CENTRE)` DYNA_VIBRA/base	1 m	1.E- 4%
`DYNA_VIBRA/base_modale (EULER)`	1 m	0,01%
`DYNA_VIBRA` (modal participation)	1 m	0,01%

passes by One tests also the value the velocity (in m/s) of the mass with T = 1,5 S, i.e. when it the static equilibrium position $(x=0)$.

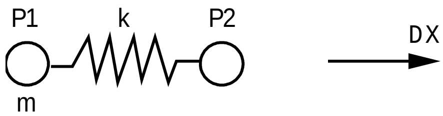
`Physical` DYNA_VIBRA/base `(NEWMARK)`	π	1.E- 4%
`DYNA_VIBRA/base_modale (EULER)`	π	0,1%

4 Modelization B

4.1 Characteristic of the modelization

One takes again the modelization A, but by adding a damping to the system/spring masses.

Discrete element in translation of the type DIS_T



Characteristics of the elements:

With the nodes $P1$ and $P2$: mass matrixes of the type M_T_D_N with $m=100\,kg$.
Enter $P1$ and $P2$: a stiffness matrix of the type K_T_D_L with $K_x=10^6\,N/m$

Boundary conditions:

All the degrees of freedom are blocked except the degree of freedom DX of the node $P2$.

Damping: one adds to the system a reduced damping of $0{,}1$.
It is introduced into the case test, either in a usual way by key key AMOR_REDUIT, or, to validate functionality RELA_EFFO_VITE, by a linear relation between the velocity of the mass/spring and an applied force with the node $P2$.

4.2 Characteristics of the mesh

Many nodes: 2

Number of meshes and types: 1 SEG2, 2 POI1

4.3 Functionalities tested

One tests in particular, in an elementary way, in this modelization functionality RELA_EFFO_VITE of operator DYNA_VIBRA (BASE_CALCUL=' GENE'). By his use, one can introduce a nonlinear behavior depend on the velocity of a point. Here one validates in a simple way this relation in the linear case by comparing it with a behavior of modal damping (which, in the case with only one mode, returns to a viscous damping).

4.4 Quantities tested and results

Identification	Reference	Tolerance
DYNA_VIBRA (BASE_CALCUL=' GENE') AMOR_REDUIT	$0{,}53\,\mathrm{m}$	1%
DYNA_VIBRA (BASE_CALCUL=' GENE') RELA_EFFO_VITE	$0{,}53\,\mathrm{m}$	1%
DYNA_VIBRA (BASE_CALCUL=' GENE') AMOR_REDUIT	0.531338 (non regression)	1.E-4%
DYNA_VIBRA (BASE_CALCUL=' GENE') RELA_EFFO_VITE	0.531338 (non regression)	1.E-4%

5 Summary of the results

the results are satisfactory. The relative error corresponds to the numerical error related to integration in time. The initial conditions are well taken into account. One concludes from it that *Code_Aster* correctly simulates to release in linear dynamics.

This test is also a functional validation of recovery in the form of function of the evolution in time of the participation of a mode, as well as a validation, on the case of a linear relation, functionality `RELA_EFFO_VITE`.