SDLD101 - Simple oscillator under random excitation

Abstract:

An oscillator simple, made up of a mass connected to a support by a spring and a damper, is subjected to a random excitation transmitted by the support, of standard imposed acceleration.

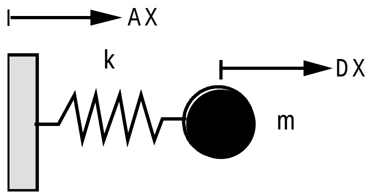
This test uses the functionalities of the stochastic analysis and also calculates power spectral density (DSP) motion of the mass from the excitation of type white vibration given by its DSP.

Motion is calculated according to various options: relative motion, absolute, differential.

One calculates then the statistical properties of the response while passing in all the options of the post - random dynamic processing.

1 Problem of reference

1.1 Geometry



the excitation is a seismic motion of standard imposed acceleration AX applied to the support in the meaning DX.

One is interested in motion of the mass m.

1.2 Material properties

Point mass:	$m=100\,kg$
Arises elastic:	$k=10^6\,N/m$
Modal damping:	$\xi_0=0.05$

1.3 Boundary conditions and loadings

the problem is unidimensional in the direction x, and to 1 degree of freedom: the displacement of the mass m.

The excitation is one power spectral density (DSP), of constant acceleration enters $0.$ and $100\,Hz$.

It is applied to the support.

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is analytical [bib1]. The own pulsation of the oscillator is $\sqrt{\frac{k}{m}}$,

that is to say $\omega_0=\sqrt{\frac{k}{m}}=100\,rad/s$, and $f_o=15{,}9155\,Hz$.

Moving absolute motion, the DSP of the response in noted acceleration $G_{\ddot{R}\ddot{R}}(\omega)$ is connected to the DSP of the excitation $G_{\ddot{E}\ddot{E}}$ in acceleration also by:

$$G_{\ddot{R}\ddot{R}}(\omega)=\frac{\omega_0^4+4\xi_0^2\omega_0^2\omega^2}{(\omega_0^2-\omega^2)^2+4\xi_0^2\omega_0^2\omega^2}G_{\ddot{E}\ddot{E}}(\omega)$$

Moving relative motion, one a:

$$G_{\ddot{R}\ddot{R}}(\omega)=\left|\left(\frac{\omega^2}{\omega_0^2-\omega^2+2j\xi_0\omega_0\omega}\right)\right|^2 G_{\ddot{E}\ddot{E}}(\omega)$$

Moving differential, one a:

$$G_{\ddot{R}\ddot{R}}(\omega)=G_{\ddot{E}\ddot{E}}(\omega)$$

2.2 Results of reference

One tests the DSP of the response for $0, 5, 10, 15, 20\,Hz$ in the three cases of motion: absolute, relative and differential.

2.3 Uncertainty on the analytical

solution Solution.

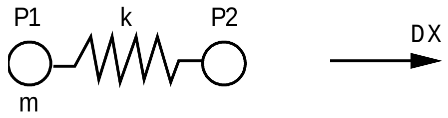
2.4 Bibliographical references

1 C. DUVAL "Dynamic response under random excitation in *the Code_Aster* : theoretical principles and examples of use" - Notes HP-61/92.148

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 Quantities tested and Dynamic response

results random

Identification	Reference
ABSOLU: $F=5.Hz$	1.2307
ABSOLU: $F=10.Hz$	2.7116
ABSOLU: $F=15.Hz$	47.2154
ABSOLU: $F=20.Hz$	2.8924
ABSOLU: $F=25.Hz$	0.47047
RELATIF: $F=5.Hz$	0.01197
RELATIF: $F=10.Hz$	0.04209
RELATIF: $F=15.Hz$	36.9225
RELATIF: $F=20.Hz$	7.1006
RELATIF: $F=25.Hz$	2.7953
DIFFERENTIEL: $F=5.Hz$	1.0
DIFFERENTIEL: $F=10.Hz$	1.0
DIFFERENTIEL: $F=15.Hz$	1.0
DIFFERENTIEL: $F=20.Hz$	1.0
DIFFERENTIEL: $F=25.Hz$	1.0

Postprocessing on the response in absolute displacement: spectral moments and statistical parameters

Identification	*Reference*	% Tolerance
spectral Moment n°0	505.70832	0.1%
spectral Moment n°1	49047.8 104	0.1%
spectral Moment n°2	5.025066 106	0.1%
spectral Moment n°3	5.52943 108	0.1%
spectral Moment n°4	7.2059956 1010	0.1%
Standard deviations	22.49	0.1%
Factor of irregularity	0.8324	0.1%
Frequency connects (Hz)	15.86	0.1%
Median number of transitions by zero a second	31.73	0.1%
spectral Moment n°6	4.186992 1015	0.1%
spectral Moment n°7	1.7826555 1018	0.1%
spectral Moment n°10	2.468734 1026	0.1%

4 Summary of the results

It is not astonishing that the results expected for the random dynamic response are got with an accuracy of 0%. Indeed the DSP of the responses do not result from an iterative process of resolution, but from an analytical statement bringing into play the modal transfer transfer functions. This analytical statement coincides with the reference solution for this problem.

For postprocessing, there is no reference solution.