SDNL100 - Pendulum simple in great oscillation

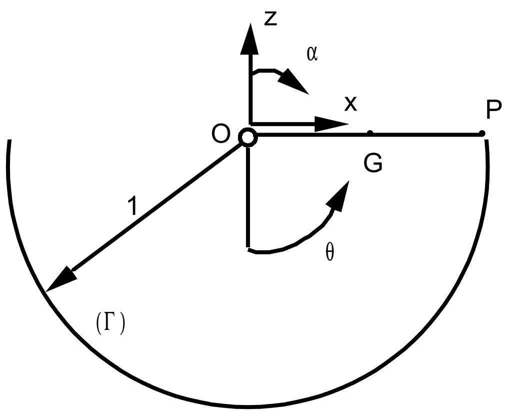
Summarized:

The object of this test is to calculate the motion of a heavy bar articulated at a point fixed by one of its ends, free elsewhere and oscillating with great amplitude in a vertical plan.

Interest: to test the cable element with two nodes - which is in fact an element of bar - under dynamics and its operation in operator `DYNA_NON_LINE`.

1 Problem of reference

1.1 Geometry



a rigid OP pendulum length 1 and center of gravity G oscillates around the point O.

The angular position of the pendulum is located by: $\alpha=\theta-\pi$

1.2 Material properties

linear Density of the pendulum: $1.kg/m$

Axial rigidity (produced Young modulus by the area of the cross-section): $1.10^8 N$

1.3 Boundary conditions and loadings

the pendulum is articulated at the fixed point O. Under the action of gravity, its end P oscillates on the half-circle (Γ) of center O and 1. There is no friction.

1.4 Initial conditions

the pendulum is released without velocity of the horizontal position OP.

$$\theta=+\frac{\pi}{2}\ ,\ \dot{\theta}=0$$

2 Reference solution

2.1 Method of calculating used for the reference solution

the period T of a mobile pendulum without friction around the fixed point O, of which the mass is concentrated at the center of gravity G ($OG=l$) and whose maximum angular amplitude east θ_0 is given by the series [bib1]:

$$T=2\pi\sqrt{\frac{l}{g}}\left[1+\sum_{n=1}^{\infty} a_n^2\left(\sin\frac{\theta_0}{2}\right)^{2\mathrm{n}}\right]$$

with

$$a_n=\frac{2\mathrm{n}-1}{2\mathrm{n}}$$

2.2 Results of reference

For $l=0.5\,m$, $g=9.81\,m/s^2$ and $\theta_0=\pi/2$, one finds: $T=1.6744\,s$

2.3 Uncertainty on the solution

One added the terms of the series until $n=12$ inclusively, the last term taken into account being lower than 10^{-5} time the calculated sum.

2.4 Bibliographical references

1) J. HAAG, “motions vibratory”, P.U.F. (1952). Modelization

3 A Characteristic

3.1 of the modelization the pendulum

is modelled by a cable element with 2 nodes, identical to an element of bar of constant section. Discretizations

: spatial

- : a cable element MECABL `2 temporal`
- : motion analyzes over one period supplements by T time step equal to. Characteristics $T/40$

3.2 of the mesh Many

nodes: 2 Number of meshes
and types: 1 mesh SEG2 Results

4 of the modelization A Values

4.1 tested Identification

Reference		Tolerance	DX on
node to P $t=0{,}4186$	-1,000000	-1.000000	(relative) DZ on
node with P $t=0{,}4186$	-1,000000	-1.000000	(relative) DX on
node with P $t=0{,}8372$	-2,000000	-2.000000	(relative) DZ on
node with P $t=0{,}8372$	0,000000	0.000000	- 4% (absolute) DX on
node with P $t=1{,}2558$	-1,000000	-1.000000	(relative) DZ on
node with P $t=1{,}2558$	-1,000000	-1.000000	(relative) DX on
node with P $t=1{,}6744$	0,000000	0.000000	- 6% (absolute) DZ on
node with P $t=1{,}6744$	0,000000	0.000000	- 3% (absolute) One also

test the parameters of the data structure results: Identification

Reference	Tolerance	INST
`for` NUMERICAL `_ORDRE= 10 0,418600`	0.418600	ITER
`_GLOB for` NUMERICAL `_ORDRE= 10 9,000000`	9.000000	0.00%
`for` NUMERICAL `_ORDRE= 15 0,837200`	0.837200	ITER
`_GLOB for` NUMERICAL `_ORDRE= 15 5,000000`	5.000000	0.00%
`for` NUMERICAL `_ORDRE= 19 1,674400`	1.674400	ITER
`_GLOB for` NUMERICAL `_ORDRE= 19 6,000000`	6.000000	0.00%

4.2 temporal

- integration is done by the method of NEWMARK (trapezoidal rule), A each
- time step, convergence is reached in less than 9 iterations. Summary

5 of the results One sees

on this benchmark which temporal integration by the “trapezoidal rule” of Newmark only modifies very slightly the frequency and does not bring parasitic damping, since at the end of one period one returns to very little close with the initial position.