SDLL100 - Response transient dynamics of a beam in simple tension

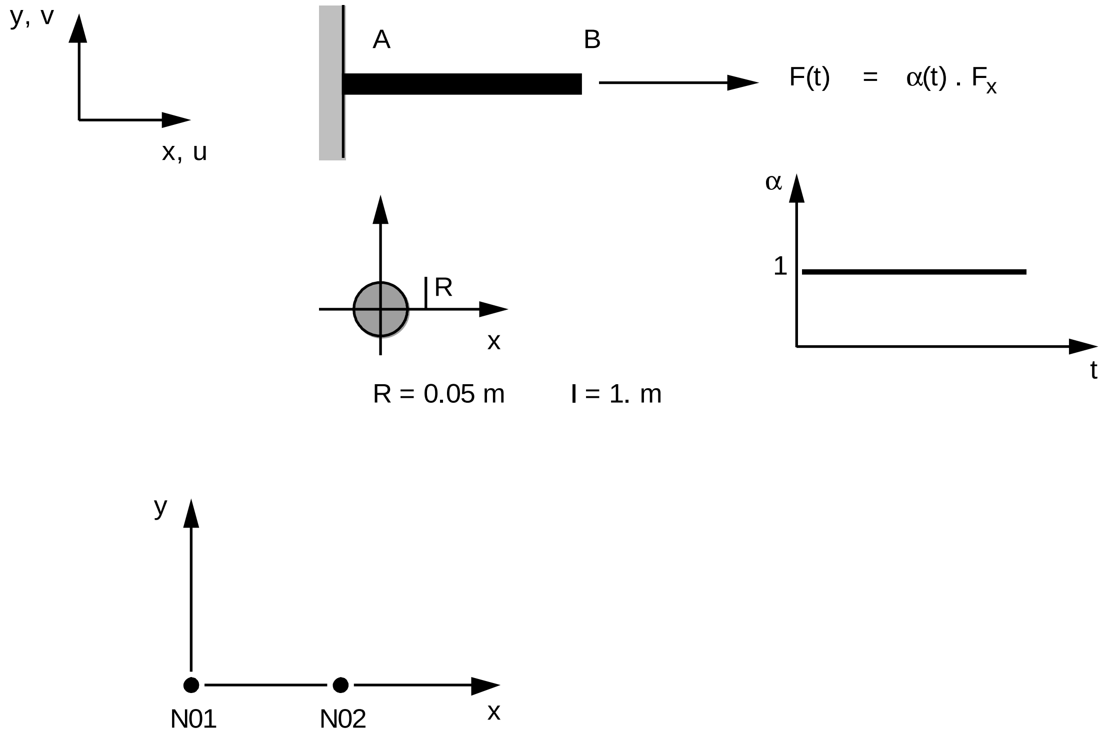
Summarized:

This problem-test corresponds to a direct transient analysis of a damped linear system or not, made up of a beam in simple tension, subjected to a loading of the Heaviside type applied from initial time.

The problem discretized with a single beam element has an analytical reference solution.

1 Problem of reference

1.1 Geometry



1.2 Material properties

$E=98\ 696.044\ MPa$
$\nu=0.$
$\rho=3.10^{6}\ kg/m^{3}$
Without damping: $C=0.$ or with proportional damping of Rayleigh: $C=\lambda K+\mu M$ $\lambda=5.10^{-4}$
$\mu=-5$.

1.3 Boundary conditions and loadings

Applied force with the node $N02$ in B : $Fx=1.10^{6}N$
Function $\alpha(t)$ evolution of the loading: $\alpha(t)=1.$, $t\geq 0.$

1.4 Initial conditions

initial Displacement no one.
Initial velocity null.

2 Reference solution

2.1 Method of calculating used for the reference solution

- Without damping: the analytical solution of the problem to an element is:

$$x_B(t)=\frac{F_x}{m\omega_0^2}(1-\cos\omega_0 t)$$

$$m=\frac{1}{3}\rho SI \quad \omega_0^2=\frac{3E}{\rho I^2}\ ,\ T_0=\frac{2\pi}{\omega_0}$$

where S is the area of the section (πR^2) .

- With damping: the analytical solution of the problem to an element is:

$$x_B(t)=\frac{F_x}{m\omega_0^2}\left[1-\exp\left(-\frac{\mu+\lambda\omega_0^2}{2}.t\right).\left(\frac{\mu+\lambda\omega_0^2}{2\omega_1}\sin(\omega_1 t)+\cos(\omega_1 t)\right)\right]$$

λ, μ coefficient of proportional damping $C=\lambda K+\mu M$

$$\omega_1=\frac{\sqrt{(4-2\lambda\mu)\omega_0^2-\mu^2-\lambda^2\omega_0^4}}{2}$$

2.2 Results of reference

Displacement x_B to $t=\frac{i T_0}{10}\quad i=1,\dots,10$

with: $T_0=\frac{2\pi}{\omega_0}$

2.3 Uncertainty on the analytical

solution Solution.

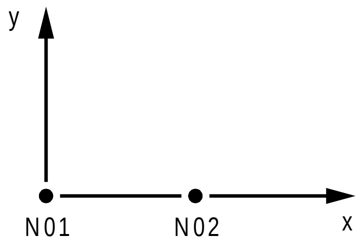
Note:

The reference solution corresponds to the solution obtained with the discretization to an element and by keeping a full mass matrix. That makes it possible to validate the algorithm but it is not the solution of the physical problem.

3 Modelization A

3.1 Characteristic of modelization

POU_D_T



Cutting: $N01$ $N02$ 1 limiting mesh

SEG2 Conditions: DDL_IMPO with the node is outside the field of definition with a right profile of the EXCLU type node: $N01$

DX: 0. , DY: 0. , DZ: 0. , DRX: 0, DRY: 0, DRZ: 0

Time step: $10^{-5}s.$
Integration NEWMARK $\alpha=0.25$, $\delta=0.5$
Integration WILSON $\theta=1.4$

3.2 Characteristics of the mesh

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

3.3 Quantities tested and results

Without damping:

Time in dryness.	Reference	*Aster* NEWMARK	% difference	*Aster* WILSON	% difference
2.E-3	2.4638E-04	2.4519E-04	0.5	2.4424E-04	0.86
4.E-3	8.9141E-04	8.8948E-04	1.93	8.8794E-04	0.38
6.E-3	1.6887E-03	1.6868E-03	0.11	1.6852E-03	0.20
8.E-3	2.3337E-03	2.3325E-03	0.05	2.3316E-03	0.09
1.E-2	2.5801E-03	2.5801E-03	0.03	2.5801E-03	
0.1.2E-2	2.3337E-03	2.3349E-03	0.05	2.3359E-03	0.09
1.4E-2	1.6887E-3	1.6906E-03	0.43	1.6922E-03	0.21
1.6E-2	8.9141E-04	8.9334E-04	0.21	8.9489E-04	
0.4.1.8E-2	2.4638E-04	2.4758E-04	0.48	2.4854E-04	0.87
2.E-2	0.0000	3.1989E-09	-	9.3188E-09	-

With damping:

Time in dryness.	Reference	*Aster* NEWMARK	% difference	*Aster* WILSON	% difference
2.E-3	2.3775E-04	2.3662E0-4	0.47	2.3572E-04	0.85
4.E-3	8.3189E-04	8.3015E-04	0.21	8.2877E-04	0.37
6.E-3	1.5307E-03	1.5290E-03	0.11	1.5277E-03	0.2
8.E-3	2.0704E-03	2.0694E-03	0.04	2.0686E-03	0.09
1.E-2	2.2721E-03	2.2721E-03	0.	2.2720E-03	0.004
1.2E-2	2.0976E-03	2.0984E-03	0.04	2.0991E-03	0.07
1.4E-2	1.6488E-03	1.6501E-03	0.08	1.6511E-03	0.14
1.6E-2	1.1164E-03	1.1176E-03	0.11	1.1186E-03	
0.2.1.8E-2	7.0165E-04	7.0241E-04	0.11	7.0302E-04	0.19
2.E-2	5.4263E-04	5.4266E-04	0.005	5.4269E-04	0.01

3.4 Remarks

After the two first time step, the solution with damping is obtained with an error lower than 0.2% .

4 Summary of the results

the two algorithms time step give a solution with an error lower 0.2% than reference solution after the two first.

This problem requires time step integration of $10^{-5} s$.