EasyDyn Problem: vertical dynamics of a vehicle

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1 Description of the system

The purpose of the study is to introduce the vertical dynamics of the GLT vehicle (*Guided Light Transit*). The particularity of the vehicle is that it presents two displacement modes: a road mode as a bus or a rail mode as a tramway (Figure 1). It consists of three bodies, corresponding to the carbodies of the vehicle, articulated between each other.

Figure 1: Véhicule GLT en mode guidé (Bombardier BN)

As you can shown in figure 2, the joint at points A and B can be considered in this planar case as a revolute joints and the number of degrees of freedom is equal to

$$f = 3N_B - \sum_{j=1}^{N_J}(3 - n_j) = 3 \times \underbrace{3}_{N_B} - \underbrace{(3-1)}_{joint\,at\,A} - \underbrace{(3-1)}_{joint\,at\,B} = 5 \tag{1}$$

The chosen configuration parameters are : x_{G_1}, y_{G_1}, θ_1, θ_2 et θ_3 and correspond respectively to

- X and Y coordinates of the center of gravity of body 1;
- inclination angles of the carbodies with respect to the X axis.

The applied forces come from the gravity forces, purely vertical, and the forces coming from the suspension, composed of a spring of stiffness k and rest length L_{0i} and a damper of coeffcient c. All the constants are shown in figure 2 and Tables 1 and 2.

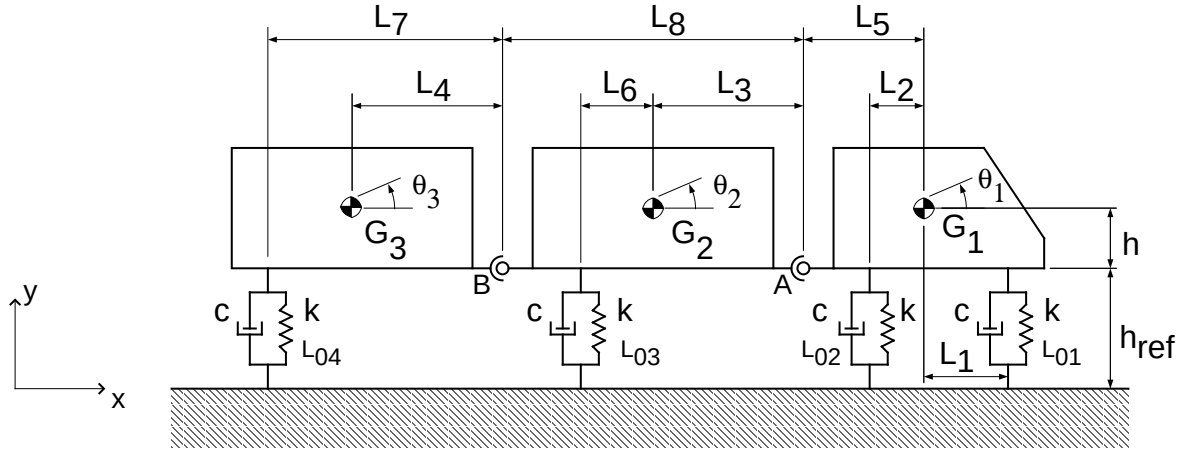

Figure 2: GLT vehicle scheme

Table 1: Inertial data of the mechanism

Body	1	2	3
Mass (kg)	13 560	3 866	10 652
Inertial momentum $I_{G,zz}$ $(kg.m)$	128 008	19 523	63 022

Table 2: Geometrical and dynamic data

$L_1 = 2,928\,m$	$L_2 = 2,700\,m$	$L_3 = 4,260\,m$
$L_4 = 4,710\,m$	$L_5 = 4,405\,m$	$L_6 = 0,950\,m$
$L_7 = 5,210\,m$	$L_8 = 6,915\,m$	$h_{ref} = 0,500\,m$
$h = 0,890\,m$	$k = 120\,000\,N/m$	$c = 20\,000\,N.s/m$
$L_{01} = 1,023\,m$	$L_{02} = 1,116\,m$	$L_{03} = 0,869\,m$
	$L_{04} = 1,287\,m$	

2 Requested results

It is asked to verify that the initial configuration, given by h_{ref} is a equilibrium configuration. It is also asked to simulate the vertical dynamics from equilibrium configuration when the center of gravity of body 1 lifts of **20 cm** (get the following parameters: final time of $10\,s$ and time step of $0.01\,s$). Give the time evolution of the vertical displacement and pitch angle of each carriage.

3 Typical results

Figure 3 shows the expected behaviour.

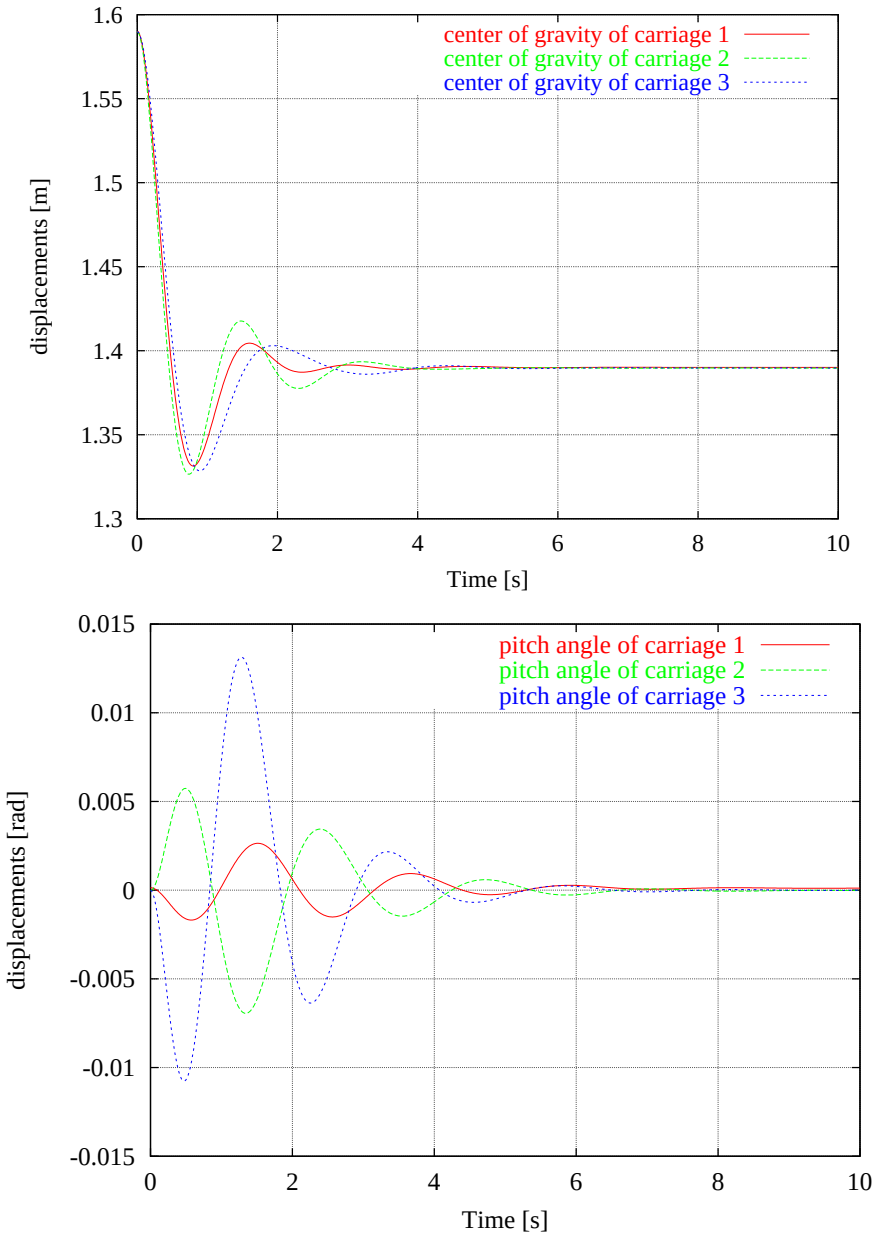

Figure 3: Time evolution of vehicle parameters