EasyDyn Problem: 5 degrees of freedom robot

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1 Description of the system

This problem was used as a benchmark for multibody systems simulation softwares and is described in the book *Multibody System Handbook*, by Werner Schiehlen (Springer-Verlag, 1991).

The considered system is a a robot, as depicted in figure 1 consisting of 3 moving bodies. The configuration of the robot is described in terms of 5 parameters q_0 to q_4, whose meaning is given on figure 1. Body 0 is attached to the ground by a cylindrical joint of vertical axis (parameters q_0 and q_1). Body 1 is attached to body 0 by a cylindrical joint of horizontal axis (parameters q_2 and q_3). Body 2 rotates with respect to body 1, about an horizontal axis perpendicular to the ones of the previous joints (parameter q_4).

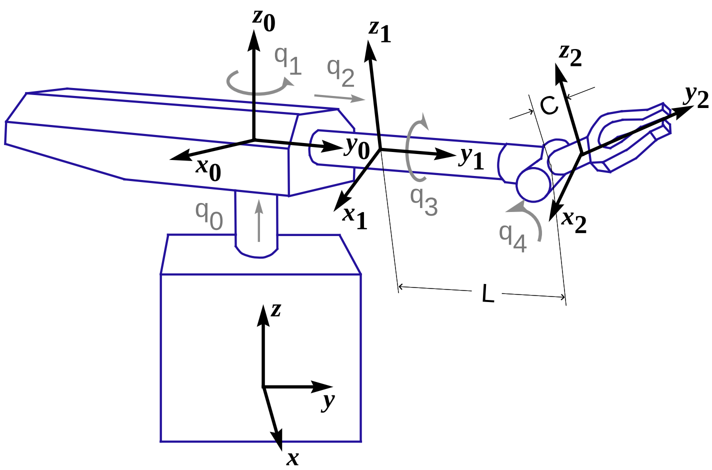

Figure 1: Layout of the robot with local coordinate systems

The inertia characteristics are listed in table 1. The geometric parameters C and L are equal respectively to $0,05\,m$ and $0,50\,m$. Each local coordinate system is located at the center of gravity of the body.

Table 1: Inertia parameters

	Body		
	0	1	2
mass (kg)	250	150	100
I_{xx} ($kg.m^2$)	(90)	13	4
I_{yy} ($kg.m^2$)	(10)	0.75	1
I_{zz} ($kg.m^2$)	90	13	4,3

2 Requested results

Simulate the behaviour of the robot, when subjected to joint actuator efforts (forces and torques), as defined in table 2. The simulation will be performed from 0 to 2 s, with the following initial conditions

$$q_0 = 2,25\,m \qquad q_1 = -0.5236\,rad \qquad q_2 = 0,75\,m \qquad q_3 = 0\,rad \qquad q_4 = 0\,rad$$

Table 2: Actuator efforts expressed in local coordinate systems

Simulation time τ [s]	Efforts [N] ou [$N.m$]

from 0 to 0,5	`F0Z = 6348`
	`F1Y = 36.t + 986`
	`C0Z = 673.t - 508`
	`C1Y = 0`
	`C2X = 63,5`

from 0,5 to 1,5	`F0Z = 4905`
	`F1Y = -2`
	`C0Z = 148.exp(-5,5.(τ - 0,5)) - 8`
	`C1Y = 0`
	`C2X = 49,05`

from 1,5 to 2	`F0Z = 3462`
	`F1Y = -1019`
	`C0Z = 240`
	`C1Y = 0`
	`C2X = 34,6`

It is recommended to illustrate the results by an animation.

3 Typical results

Figures 2 to 3 give the expected evolutions of the configuration parameters and their time derivatives.

Figure 4 illsutrates the initial and final configurations.

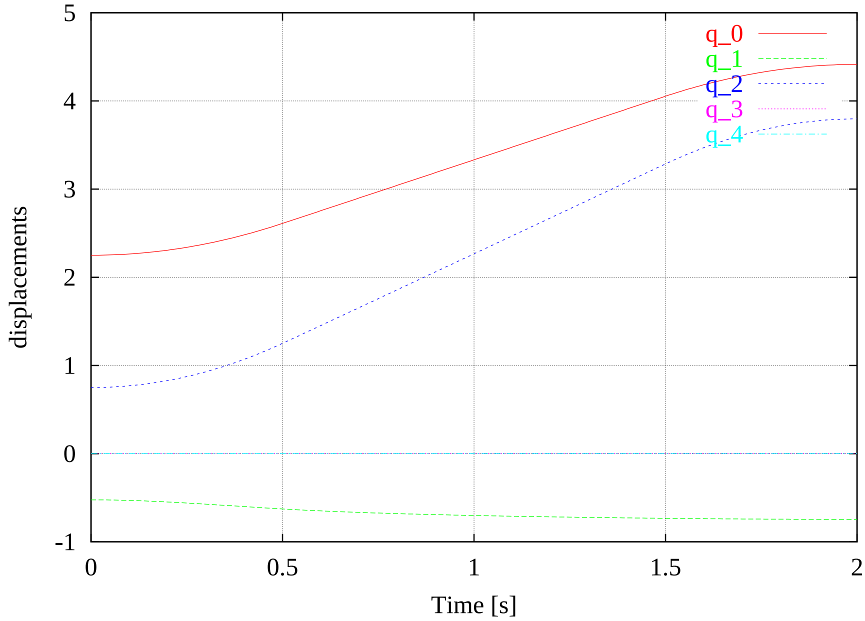

Figure 2: Evolution of configuration parameters

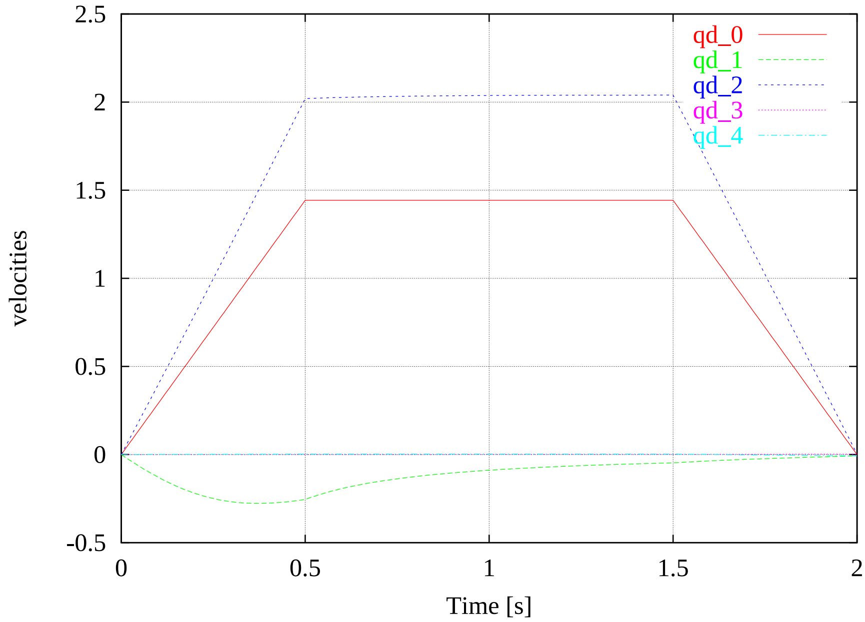

Figure 3: Evolution of time derivatives of configuration parameters

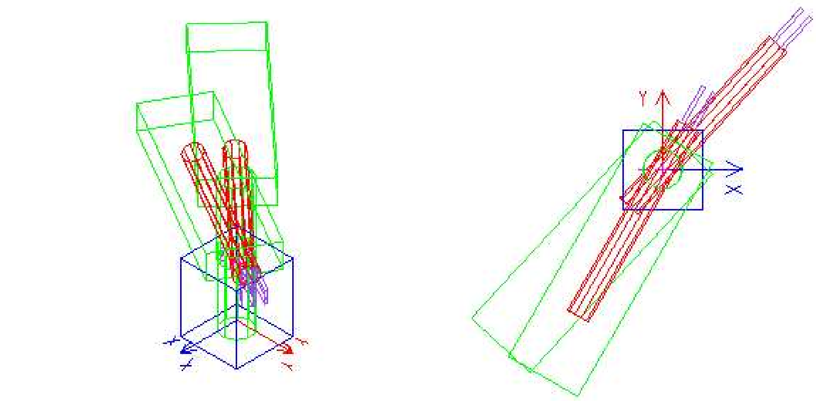

Figure 4: Initial and final configurations