EasyDyn problem: the Watt regulator

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1 Description of the system

The *flyball governor* was invented by the physicist James Watt in 1788, in order to assure a regular working speed of steam engines.

The device, illsutrated in figure 1 consists of two metal balls, supported by two main rods hinged about point O, at the top of the device. Two other rods PM and P'M', connect the main rods (P and P') to the collar (collet on figure). The collar translates along the vertical axis. When the machine rotates at the desired speed, the fork (fourchette on figure) remains horizontal. If the speed is too high, the balls move away from the axis due to the centrifugal efect, the collar moves upwards, and the fork rotates clockwise about A. On the other hand, if the speed is too low, the fork will rotate counterclockwise.

The fork controls the inlet valve of the steam engine in order that the steam flow decreases when the rotation speed is too high.

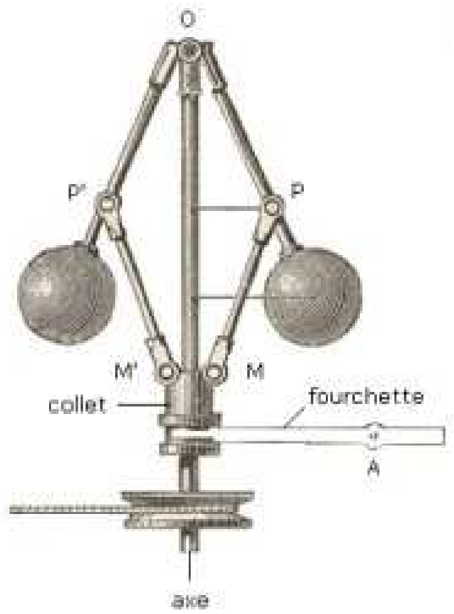

Figure 1: The flyball governor invented by James Watt

In order to study the dynamic behaviour of the system, only a half (one ball) will be modelled as illustrated in figure 2, with the following data

- the main rod is $0.2\,m$ long, with a negligible mass;

- the rod PM is $0.1\,m$ long, with a negligible mass;
- a spring-damper system ($k = 3000\,N/m$; $L_0 = 0.17\,m$; $c = 100\,N.s/m$) connects the collar to the top of the shaft;
- the inertia poroperties are detailed in table 1.

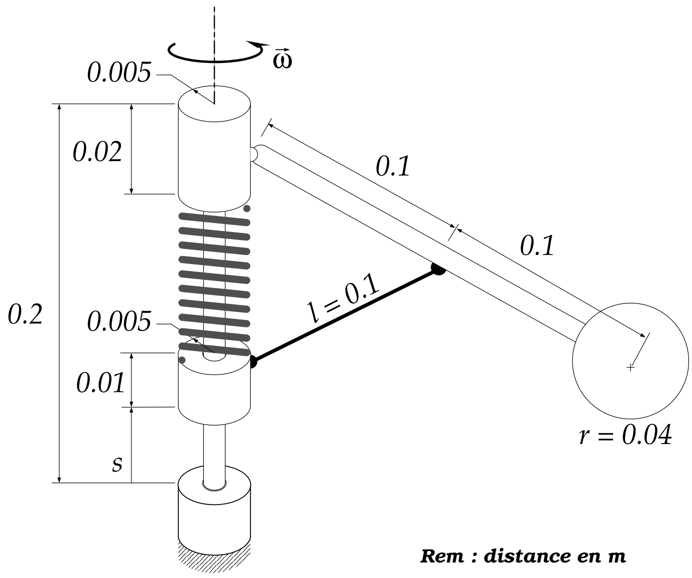

Figure 2: Scheme of the Watt regulator

Table 1: Inertia properties

Body	mass (kg)	I_{xx} $(kg.m^2)$	I_{yy} $(kg.m^2)$	I_{zz} $(kg.m^2)$
Collar	1	0.125	0.125	0.150
Shaft	2	1	1	1
Ball	1	0.1	0.1	0.1

2 Requested results

From the equilibrium position at null rotating speed (determined by calling `StaticEquilibrium()`), simulate the motion of the system from 0 to $2\,s$, for a rotating speed of $50\,rad/s$.

3 Typical results

Figures 3 to 4 show the time evolutions of the configuration parameters and their first time derivatives. Parameters q_0 and q_1 correspond respectively to the rotation angle of the shaft and the distance s on figure 2.

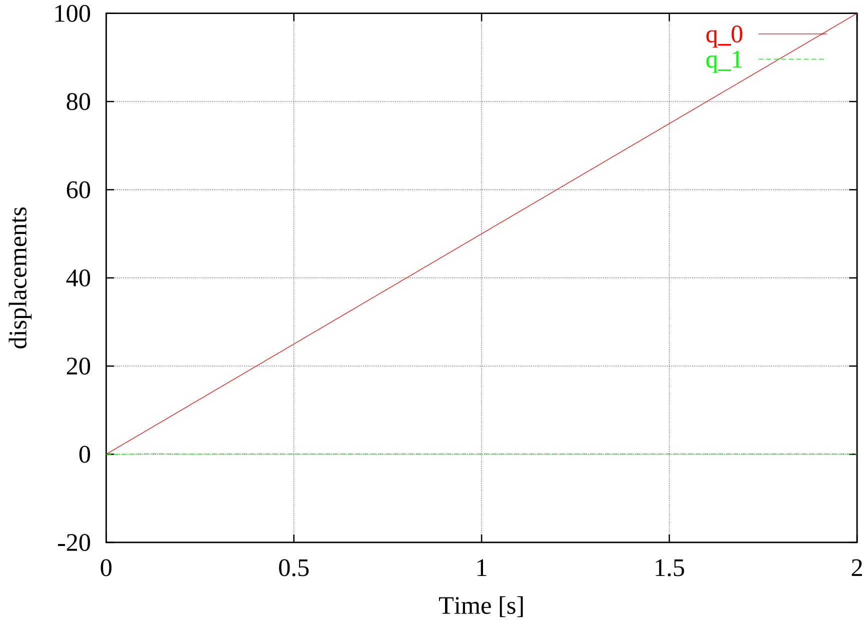

Figure 3: Evolution of configuration parameters

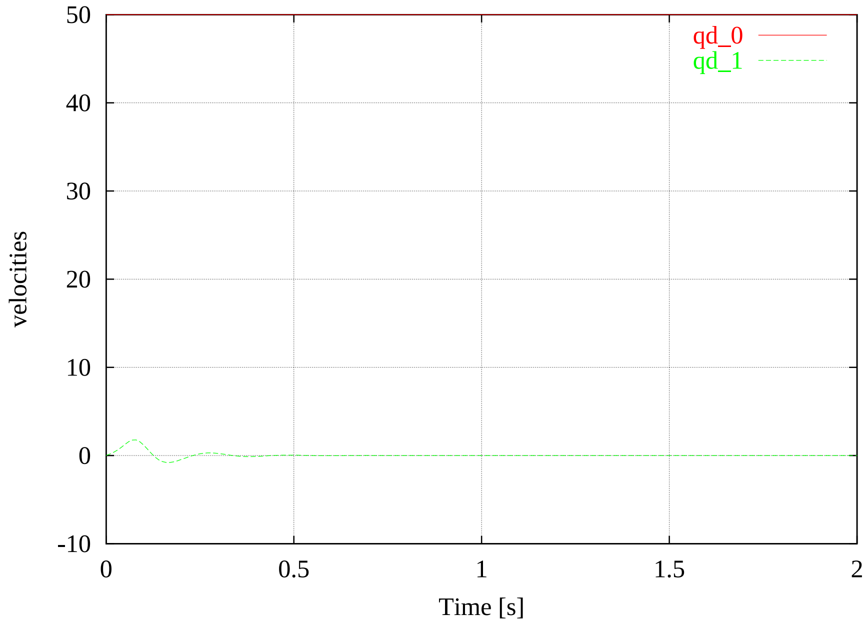

Figure 4: Evolution of first time derivative of configuration parameters