Multiple four-bar mechanism

Alfonso Callejo

The objective of this benchmark is to assess the efficiency of multibody formulations in the dynamic simulation of a 5-DOF multiple four-bar mechanism, as well as to test the management of redundant constraint equations and singular positions.

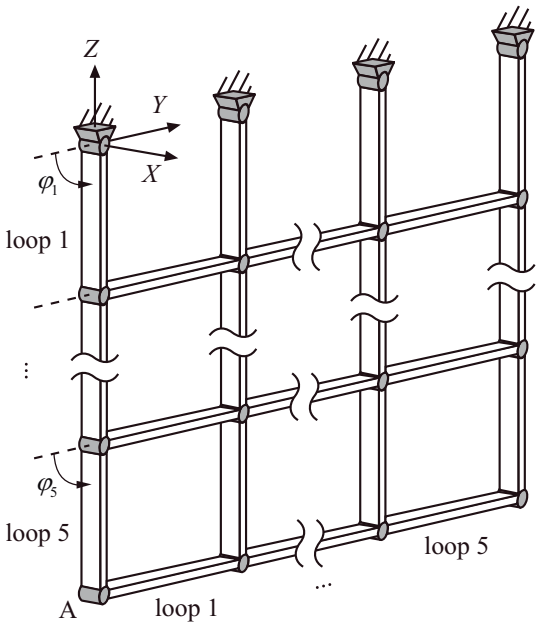


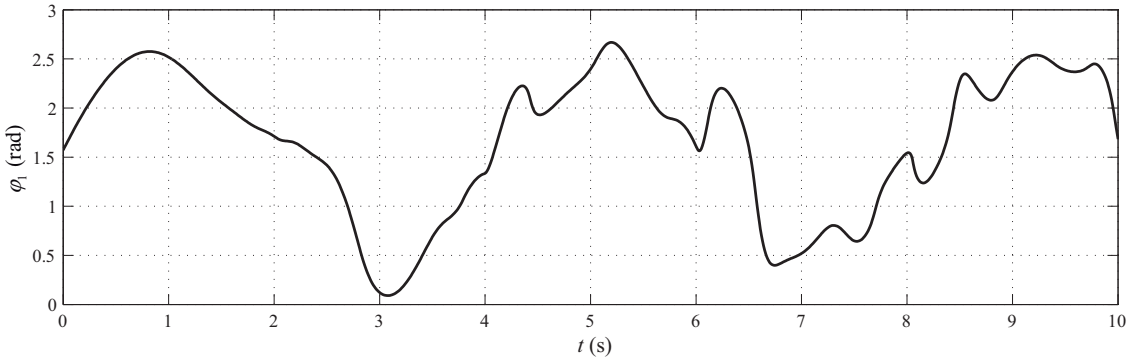
Figure 1. Multiple four-bar mechanism.

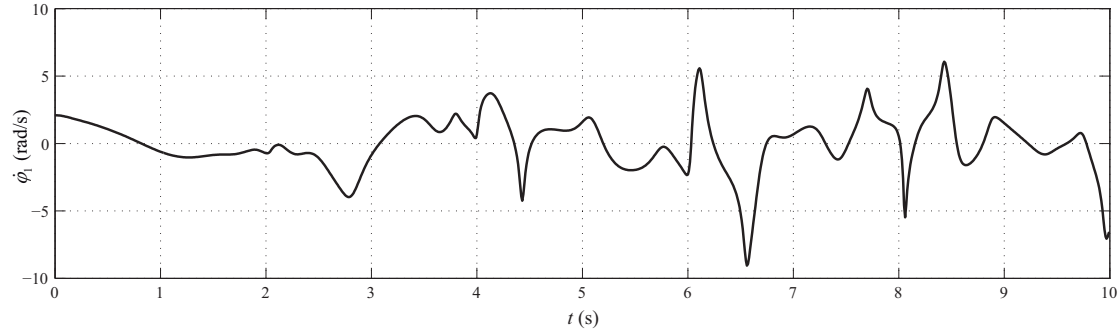
The system consists of a 5×5 grid of four-bar mechanisms in Y and Z directions. The initial position of the system is shown in Figure 1. The system is modeled in 3D, meaning that it is mechanically overconstrained. All joints are parallel revolute joints in the X-direction. All bars have a uniformly distributed mass of 1 kg, a length of 1 m, and negligible inertia with respect to their axis. Gravity acts in the $-Z$-direction and has a value of 9.81 m/s^2. The initial velocity of the six top bodies is $\dot{\varphi}_1 = 2\pi / 3$ rad/s, and the simulation time is 10 s. The total number of moving bodies is 55, and the number of joints is 80.

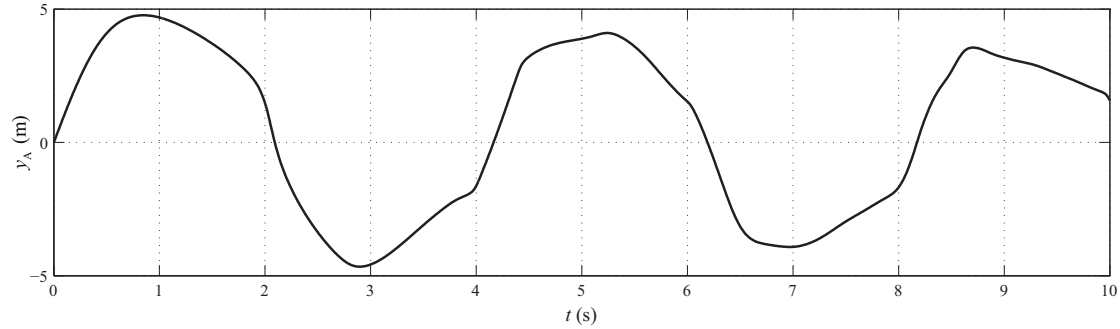
The total energy (kinematic and potential) is computed on every time-step. The energy drift is defined as the absolute value of the difference between the current system energy and the initial one. The simulation error is computed as the maximum energy drift, and is expressed in J. The maximum allowed value of the error is 1 J. The provided text file contains output data for comparison purposes. The meaning of the text file columns is:

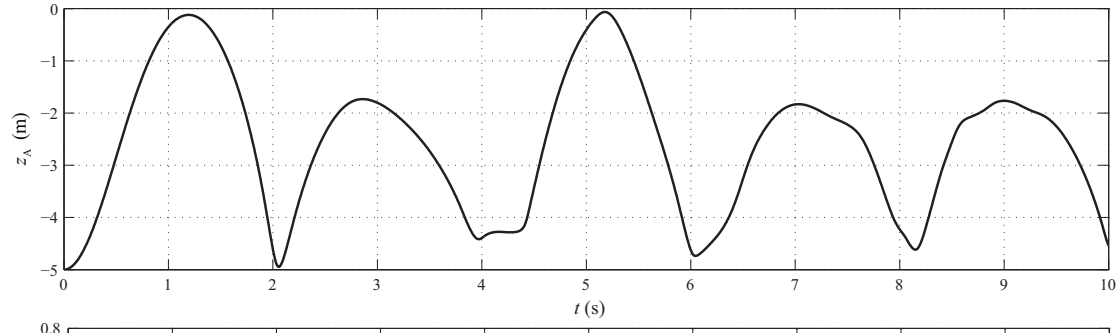
- Simulation time (s)
- φ_1 (rad), angular position of the first row of four-bar mechanisms
- $\dot{\varphi}_1$ (rad/s), angular velocity of the first row of four-bar mechanisms
- y_A (m), Y-coordinate of point A
- z_A (m), Z-coordinate of point A
- Total energy (J)

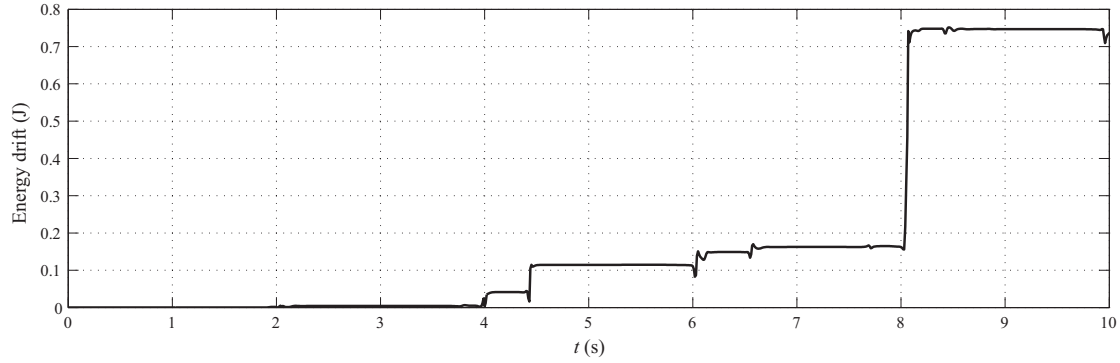
Finally, five simulation outputs are plotted in the following figures:


φ_1 (rad)
t (s)


$\dot{\varphi}_1$ (rad/s)
t (s)


y_A (m)
t (s)


z_A (m)
t (s)


Energy drift (J)
t (s)