

MBS Benchmark A03: Andrew's Mechanism

Benchmark Objective

The NMS benchmark problem **A03** shows a very small time scale, thus making it difficult to simulate for solvers that cannot reach small time steps [1].

Benchmark Description

Andrew's mechanism [2] (Fig. 1) is a planar system composed of seven bodies interconnected through revolution joints, and driven by a motor located in O. Detailed information about the mechanical structure of each body is reported in Table 4. Positions of reference systems are presented in Fig. 2

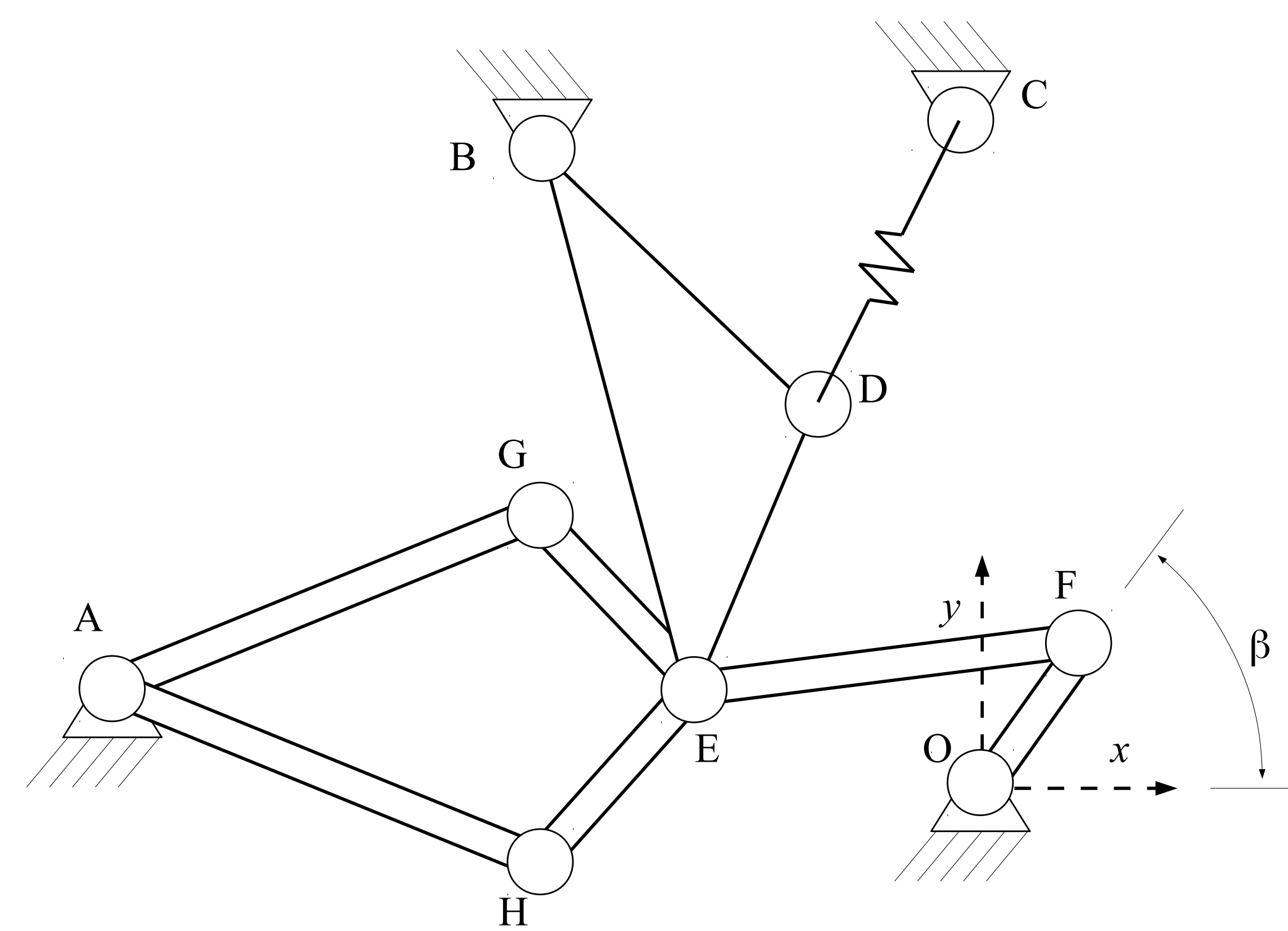


Figure 1: Andrew's mechanism sketch.

Spring coefficient	4530 N/ m
Spring rest length	0.077 85 m
Motor torque	0.033 N m ⁻¹

Table 1: System Properties and Configuration

	Center of Mass (CoM)		Mass	Inertia (CoM)	Length
	X [m]	Y [m]	[Kg]	[Kg m ²]	[m]
OF	0.00092	0	0.04325	$2.194e^{-6}$	0.007
FE	-0.0115	0	0.00365	$4.41e^{-7}$	0.028
EG	0	0.01421	0.00706	$5.667e^{-7}$	0.02
AG	0.02308	0.00916	0.0705	$1.169e^{-5}$	0.04
AH	-0.00449	-0.01228	0.05498	$1.912e^{-5}$	0.04
HE	-0.01421	0	0.00706	$5.667e^{-7}$	0.02

Table 2: Rod Elements Properties

Center of Mass (CoM)		Mass	Inertia	Point X [m] Y [m]	
X [m]	Y [m]	[Kg]	Kg m ²		
0.01043	-0.01874	0.02373	$5.255e^{-6}$	B	0 0
				D	0.02 -0.018
				E	0 -0.035

Table 3: Triangular Element Properties, points defined in X_{BDE} - Y_{BDE} SoR

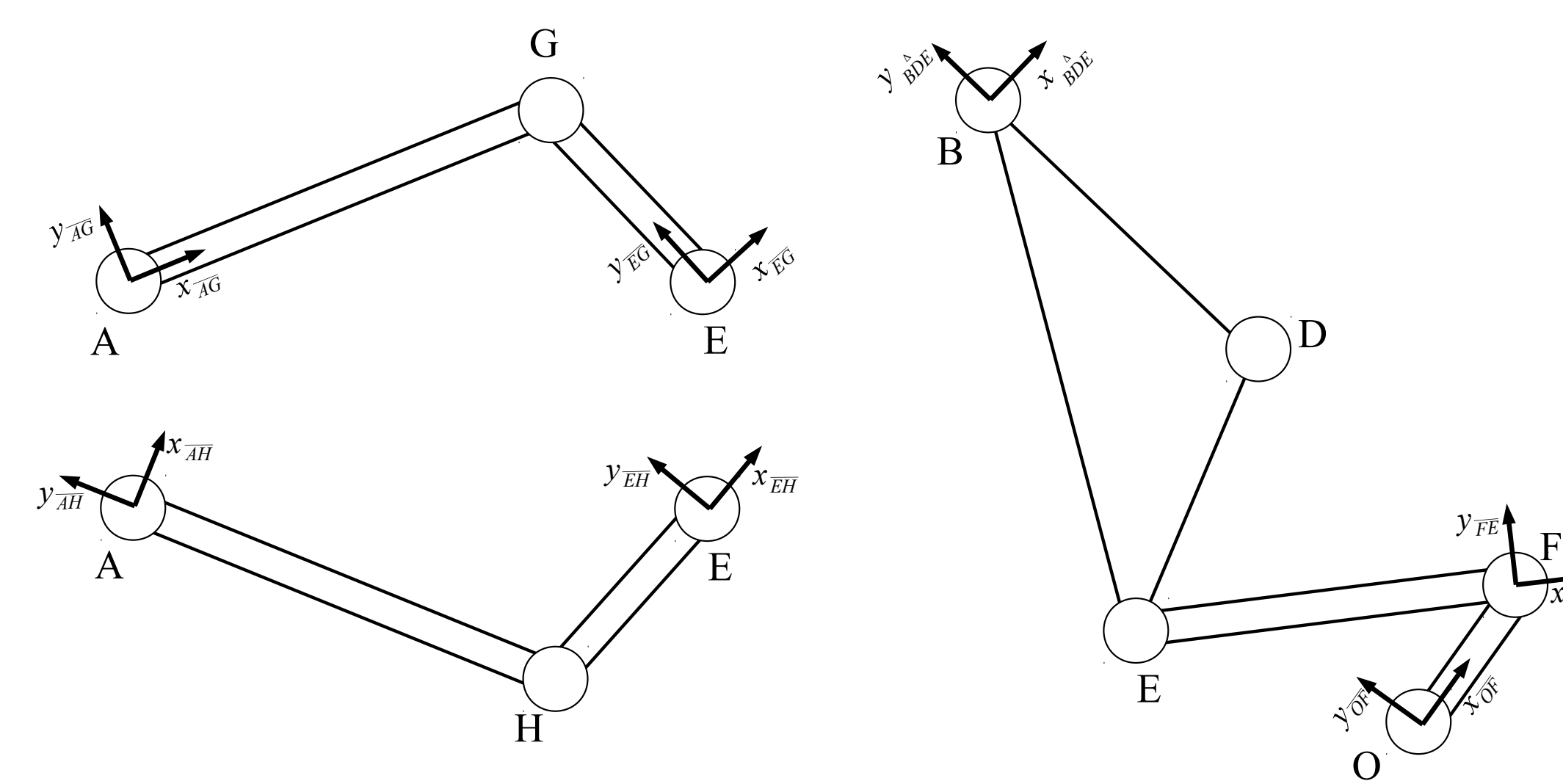


Figure 2: Systems of Reference defined for each body of the mechanism.

Point	X [m]	Y[m]	Angle [rad]
O	0	0	β -0.0620
A	-0.06934	-0.00227	\widehat{OFE} 0
B	0.03635	0.03273	\widehat{FEB} 2.088
C	0.014	0.072	\widehat{FEG} 2.341
			\widehat{EGA} 1.792
			\widehat{EHA} 1.348

Table 4: Points in ground X - Y SoR

Table 5: Initial Joints Position

Results

The dynamic simulation of the **A03** benchmark was executed for **0.5 s**. The starting position of the simulation is defined by the values in Tab. 5. The objective of the simulation is to measure F displacements and compare them with the reference solution [1]. The simulation with OpenSim perfectly match the reference values as shown in Fig. 3 for a **0.05 s** simulation.

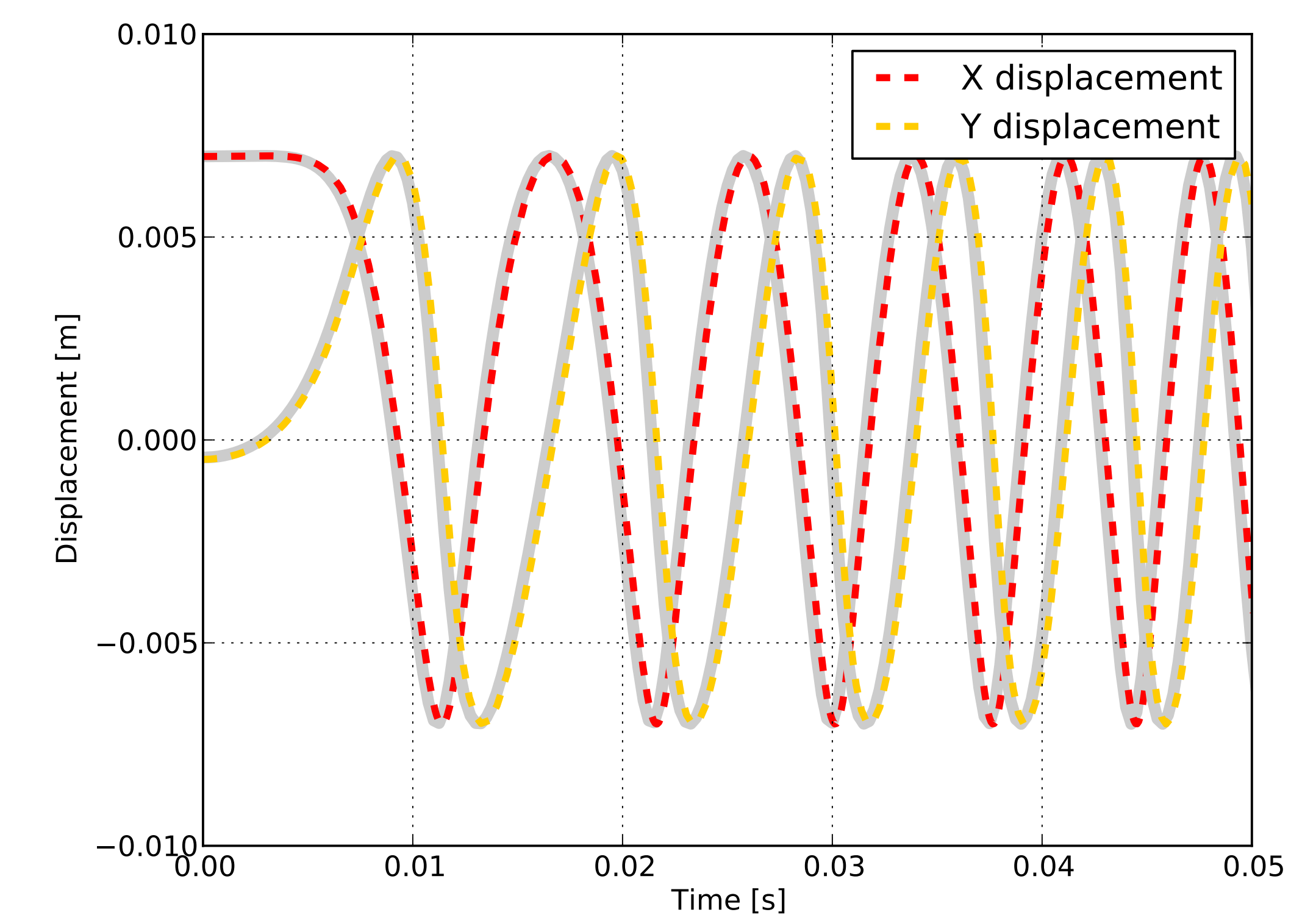


Figure 3: Comparison of the point F displacements between Andrew's mechanism model simulated in OpenSim (dashed lines) and MBS benchmark reference (grey lines).

Download

- MBS Benchmark available at: <http://goo.gl/ySQ5me>
- OpenSim implementation available at: <http://goo.gl/R9t13z>
- Videos of OpenSim simulation available at: <http://goo.gl/9BBdZH>

References

- [1] M. González, D. Dopico, U. Lugiés, J. Cuadrado, "A benchmarking system for MBS simulation software: Problem standardization and performance measurement," in *Multibody System Dyn.*, vol. 6, no.2, 2006, pp. 179–190.
- [2] M. Schiehlen, *Multibody Systems Handbook*. Springer-Verlag, Dordrecht (1990)

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