Dynamic Analysis of Four Bar Mechanism

Vinay Kumar[1] Naveen Kumar Sahu[1] Raghavendra K[2] Saurabh Kumar[2]

[1]Mechanical Department
IIT Delhi

[2]DRDO India

MCL 738 : Multibody Dynamics

The Long And Short of Analysis

- Formulated lagrangian based equation of motion for four bar mechanism
- Reduced all the expression to those of θ
- Created a interactive geometric construction in Cinderella Geometry [1] for verifying Inverse Kinematics (Angles and Velocities)
- Computed inverse dynamics for cycloidal motion of input link
- Applied the computed torques to four bar mechanism for forward dynamics

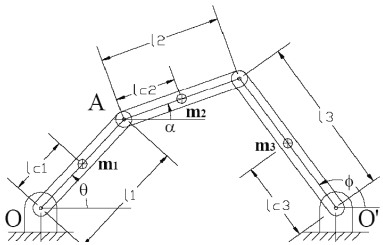


Figure 1: Symbols used. Source:[2]

Features of Code

- Can carry out analysis for all types of Grashof's mechanisms i.e. Crank-Crank, Crank-Rocker, Rocker-Crank and Rocker-Rocker
- Checks if the mechanism is *possible* for the given link lengths
- Can take different modes of assembly (elbow-up, elbow-down) as input
- Computes the possible range of motion for mechanism
- Takes care of mechanical limits in case the mechanism have one or more rocker linkages
- Decides the type of four bar mechanism and exits accordingly for special cases [3]

Heuristics for restarting ODE

- Based on event detection whenever the mechanism hits a mechanical limits, its velocity is reversed and reduced by 10%
- However the ode sometimes still goes in region of in-feasible configurations, in such cases the error is caught by a try & catch statement; and the ode is restarted with a reduced maximum time step and a slightly incremented starting time 0.1 *second*.

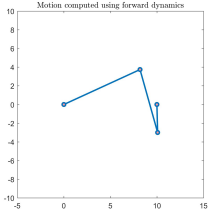


Figure 2: Rocker Crank One

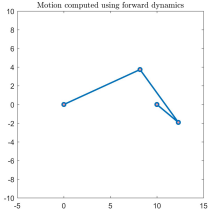
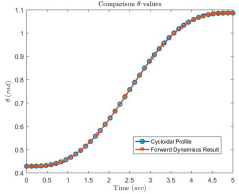


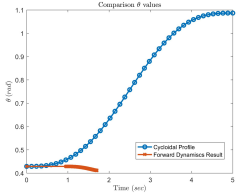
Figure 3: Rocker Crank Two

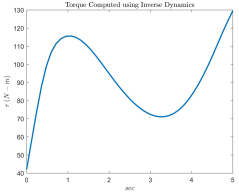
Table 1: Parameters used for forward dynamics

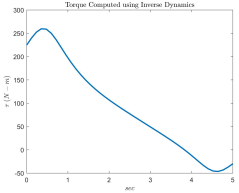
Parameter	*Value*
L_0	10 (m)
L_1	9 (m)
L_2	7 (m)
L_3	3 (m)
m_1	0.5 Kg
m_2	0.7 Kg
m_3	0.6 Kg

Heuristics for restarting ODE (contd...)





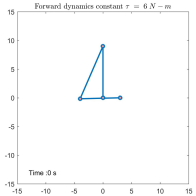


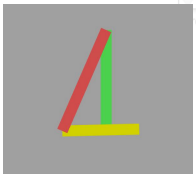


In the second configuration since the input interpolated torque is small to make the link move, the ode fails to start again

The Recurdyn Alternative ????

A constant torque of 6 $N - m$ was applied to input link both in simMechanics and Matlab code. The close proximity of the two trajectories shows that the code was bug free.





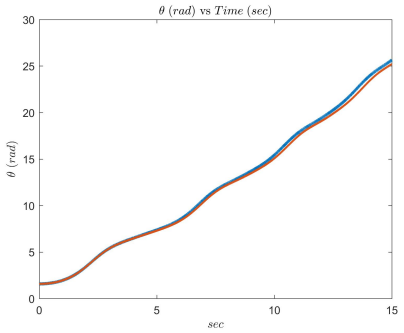


Figure 4: θ *vs time*

Table 2: Parameters used for forward dynamics

Parameter	*Value*
L_0	3 m
L_1	9 m
L_2	10 m
L_3	7 m
m_1	1 Kg
m_2	1 Kg
m_3	1 Kg
θ	$\pi/2$ (rad)
$\dot{\theta}$	0 (rad/sec)
τ	6 $N - m$

Its All About "Energy"

A constant torque of 6 $N - m$ applied to the input link, for same link lengths as that of previous slides but with second mode of assembly.

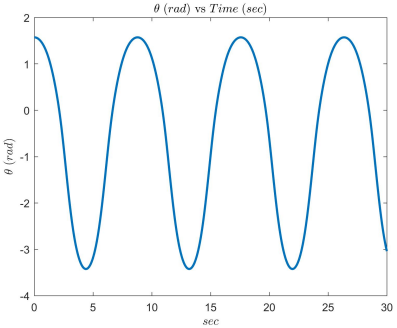
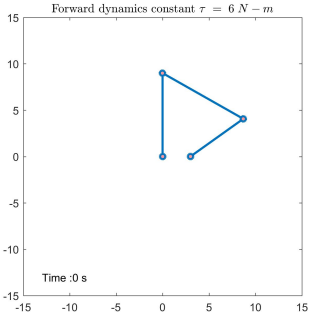


Figure 5: θ *vs time*



Some Pretty Videos

- Crank Crank One
- Crank Rocker One
- Rocker Crank One
- Rocker Rocker One

- Crank Crank Two
- Crank Rocker Two
- Rocker Crank Two
- Rocker Rocker Two

Parameter	*Value*
L_0	10 (m)
L_1	9 (m)
L_2	7 (m)
L_3	3 (m)
m_1	0.5 Kg
m_2	0.7 Kg
m_3	0.6 Kg

References


R.-G. Jürgen and U. Kortenkamp, *The Interactive Geometry Software Cinderella*, vol. 107. 01 1999.


C. P. Tang, "Lagrangian dynamic formulation of a four-bar mechanism with minimal coordinates," 2006.


Wikipedia contributors, "Four-bar linkage — Wikipedia, the free encyclopedia," 2018. [Online; accessed 15-April-2018].

Thank You