6 Force Analysis

Homework 9: Joint reaction forces and equilibrium moment

Problem 6.1: four-bar mechanism

The four-bar mechanism shown in Fig. P6.1 has the dimensions: AB=CD=0.04 m and AD=BC=0.09 m. The driver link AB rotates with a constant angular speed of 120 rpm. The links are homogeneous rectangular prisms made of steel with the width $h = 0.01$ m and the depth $d = 0.001$ m. The density of the material is $\rho_{Steel} = 8000$ kg/m^3 and the gravitational acceleration is $g = 9.807$ m/s^2. The external moment applied on the link CD is opposed to the motion of the link and has the value $\mathbf{M}_{ext} = -|\mathbf{M}_{ext}|\frac{\boldsymbol{\omega}_3}{|\boldsymbol{\omega}_3|}$, where $|\mathbf{M}_{ext}| = 500$ N·m. Find the equilibrium moment on link AB and the joint forces for $\phi = 30°$ using: a) free-body diagram of individual links and b) dyad method.

For ϕ=30° the kinematics of the mechanism are given by:
x_B=0.034641 m, y_B=0.02 m,
x_C=0.103859 m, y_C=-0.0375222 m,
ϕ_2=-39.7274°, ϕ_3=-69.7274°,
$\dot{x}_B$=-0.251327 m/s, $\dot{y}_B$=0.435312 m/s,
$\ddot{x}_B$=-5.47029 m/s^2, $\ddot{y}_B$=-3.15827 m/s^2,
$\dot{x}_C$=-0.884619 m/s, $\dot{y}_C$=-0.32675 m/s,
$\ddot{x}_C$=3.84741 m/s^2, $\ddot{y}_C$=25.1222 m/s^2,
ω_2=$\dot{\phi}_2$=-11.0095 rad/s, α_2=$\ddot{\phi}_2$=307.84 rad/s^2,
ω_3=$\dot{\phi}_3$=-23.5759 rad/s, α_3=$\ddot{\phi}_3$=307.84 rad/s^2.

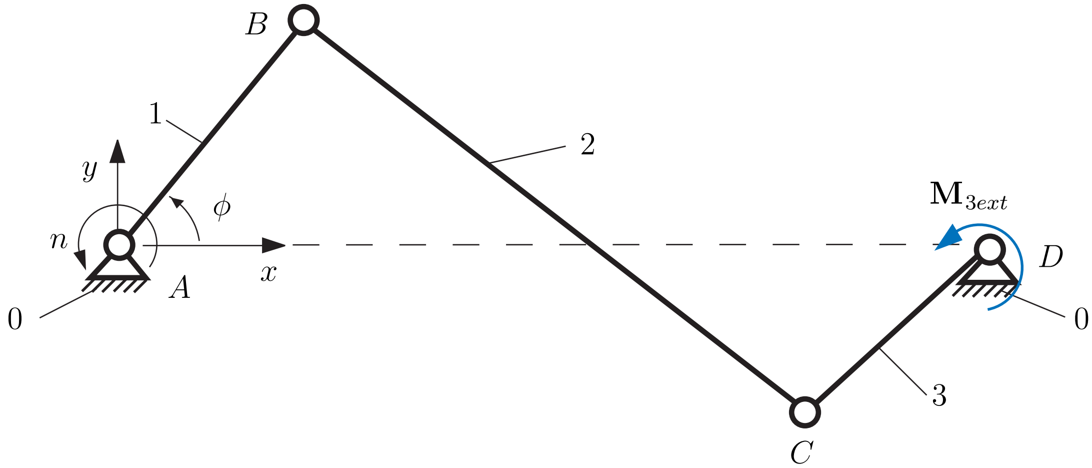

Figure P6.1

Problem 6.2: R-RRR-RRT mechanism

A planar mechanism is shown in Fig. P6.2. The following data are given: AB=0.150 m, BC=0.400 m, CD=0.370 m, CE=0.230 m, EF=CE, L_a=0.300 m, L_b=0.450 m, and L_c=CD. The constant angular speed of the driver link 1 is 60 rpm. The links are homogeneous rectangular prisms made of steel with the width $h = 0.01$ m and the depth $d = 0.001$ m. The steel slider 5 has the width $w_{Slider} = 0.05$ m, the height $h_{Slider} = 0.02$ m, and the depth $d = 0.001$ m. The density of the material is $\rho_{Steel} = 8000$ kg/m^3 and the gravitational acceleration is $g = 9.807$ m/s^2.

The external force on 5 is opposed to the motion of the link
$\mathbf{F}_{ext} = \mathbf{F}_{5ext} = -|\mathbf{F}_{ext}|\dfrac{\mathbf{v}_F}{|\mathbf{v}_F|}$, where $|\mathbf{F}_{ext}| = 500$ N.

Find the equilibrium moment on link AB and the joint reaction forces for ϕ=ϕ_1=30°.

For ϕ=30° the kinematics of the mechanism are given by:
x_B=0.129904 m, y_B=0.075 m,
x_C=-0.0689445 m, y_C=0.422073 m,
x_E=-0.298288 m, y_E=0.404712 m,
x_F=-0.37 m, y_F=0.186177 m,
ϕ_2=-1.05052 rad, ϕ_3=0.0755515 rad, ϕ_4=1.25372 rad.
$\dot{x}_B$=-0.471239 m/s, $\dot{y}_B$=0.81621 m/s,
$\ddot{x}_B$=-5.1284 m/s^2, $\ddot{y}_B$=-2.96088 m/s^2,
$\dot{x}_C$=-0.0788027 m/s, $\dot{y}_C$=1.04105 m/s,
$\ddot{x}_C$=2.87595 m/s^2, $\ddot{y}_C$=1.03567 m/s^2,
$\dot{x}_E$=-0.127788 m/s, $\dot{y}_E$=1.68819 m/s,
$\ddot{x}_E$=4.66371 m/s^2, $\ddot{y}_E$=1.67947 m/s^2,
$\dot{x}_F$=0 m/s, $\dot{y}_F$=1.64625 m/s,
$\ddot{x}_F$=0 m/s^2, $\ddot{y}_F$=3.29262 m/s^2,
ω_2=$\dot{\phi}_2$=-1.1307 rad/s, α_2=$\ddot{\phi}_2$=-22.33 rad/s^2,
ω_3=$\dot{\phi}_3$=-2.82169 rad/s, α_3=$\ddot{\phi}_3$=-2.20443 rad/s^2.
ω_4=$\dot{\phi}_3$=0.58475 rad/s, α_4=$\ddot{\phi}_3$=-21.453 rad/s^2.

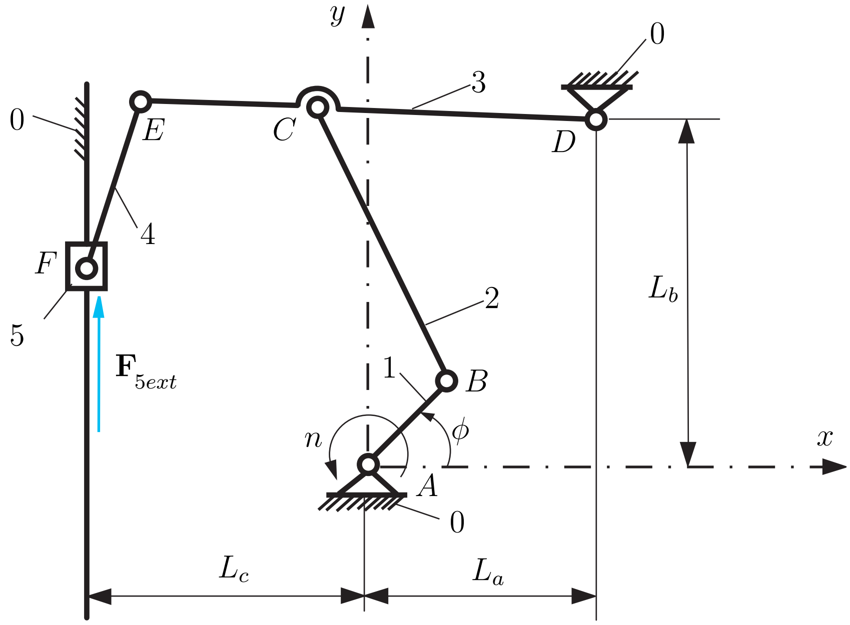

Figure P6.2