6 Force Analysis

Homework 11: Joint reaction forces and equilibrium moment

Problem 6.3

The mechanism in Fig. P6.3 has the dimensions: AB=200 mm, AC=600 mm, BD=1000 mm, L_a=150 mm, L_b=250 mm, and EF=600 mm. The driver link 1 rotates with a constant angular speed of n=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 sliders 3 and 4 have 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 moment on 5 is opposed to the motion of the link $\mathbf{M}_{ext} = \mathbf{M}_{5ext} = -|\mathbf{M}_{ext}|\dfrac{\boldsymbol{\omega}_5}{|\boldsymbol{\omega}_5|}$, where $|\mathbf{M}_{ext}| = 900$ N·m.

Find the equilibrium moment on link AB and the joint reaction forces for ϕ=ϕ_1=120°.

For ϕ=120° the kinematics of the mechanism are given by:
x_B=-0.1 m, y_B=0.173205 m,
x_C=-0.6 m, y_C=0 m,
x_D=-1.04491 m, y_D=-0.154122 m,
ϕ_2=0.333473 rad, ϕ_5=0.940376 rad,
$\dot{x}_{B_1}$=-1.08828 m/s, $\dot{y}_{B_1}$=-0.628319 m/s,
$\ddot{x}_{B_1}$=3.94784 m/s^2, $\ddot{y}_{B_1}$=-6.83786 m/s^2,
$v_{C_2C_3}$=-1.23399 m/s, ω_2=-0.448799 rad/s,
$\dot{x}_{D_2}$=-1.23518 m/s, $\dot{y}_{D_2}$=-0.204243 m/s,
$a^{cor}_{C_2C_3x}$=-0.362557 m/s^2, $a^{cor}_{C_2C_3y}$=1.04661 m/s^2,
$a_{C_2C_3}$=1.59873 m/s^2, α_3=-16.7458 rad/s^2,
$\ddot{x}_{D_2}$=-1.34318 m/s^2, $\ddot{y}_{D_2}$=9.05135 m/s^2,
$v_{D_5D_4}$=0.893105 m/s, ω_5=-1.75371 rad/s,
$a^{cor}_{D_5D_4x}$=2.53037 m/s^2, $a^{cor}_{D_5D_4y}$=-1.84656 m/s^2,
$a_{D_5D_4}$=-4.98108m/s^2, α_5=-6.57248 rad/s^2.

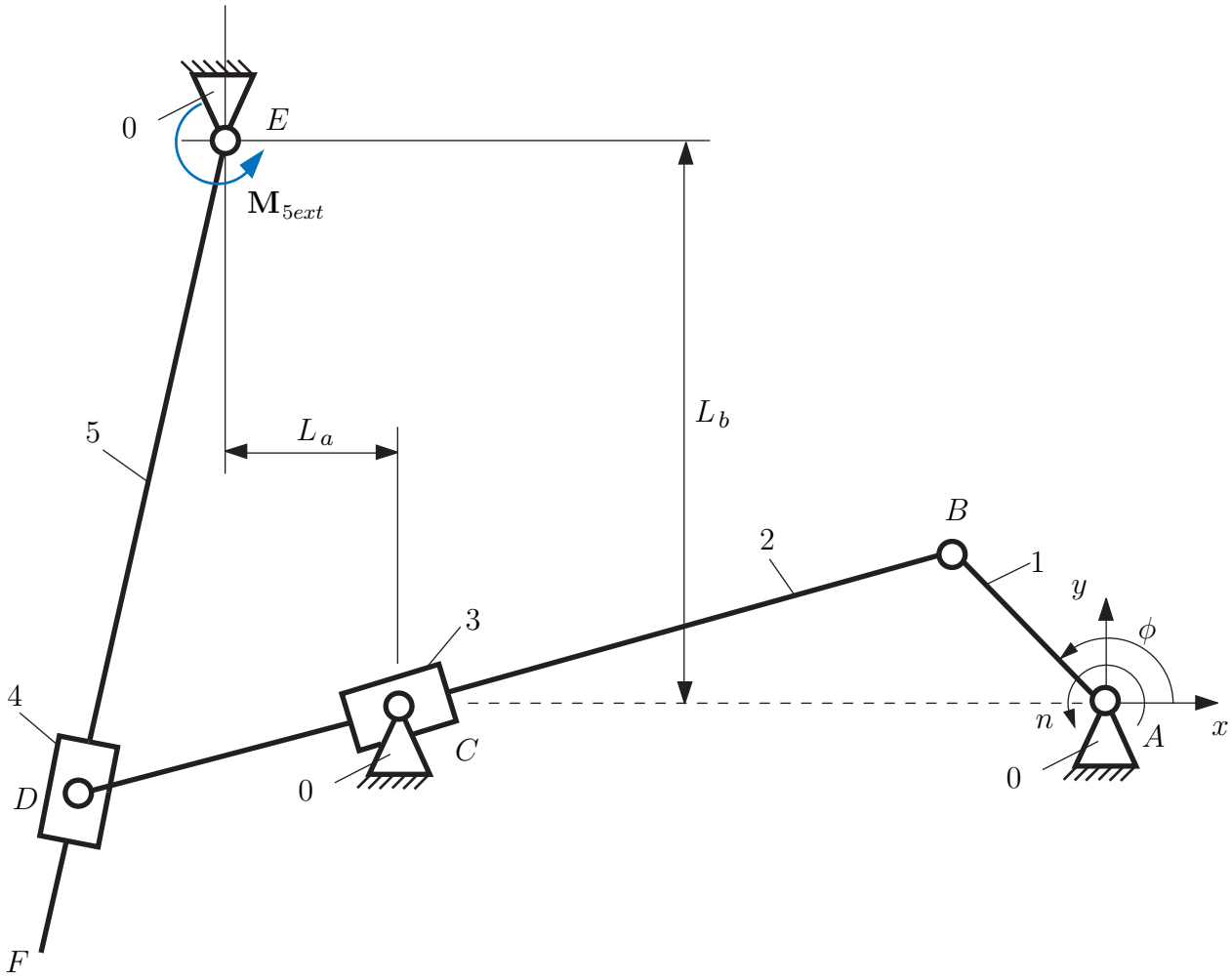

Figure P6.3

Problem 6.6

The dimensions of the mechanism shown in Fig. P6.6 are: AB=180 mm, AC=90 mm, CD=200 mm, $CF = CD$, and $AG = CD + AC$. The constant angular speed of the driver link 1 is n=180 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 sliders 2 and 4 have 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 moment on 5 is opposed to the motion of the link $\mathbf{M}_{ext} = \mathbf{M}_{5ext} = -|\mathbf{M}_{ext}|\dfrac{\boldsymbol{\omega}_5}{|\boldsymbol{\omega}_5|}$, where $|\mathbf{M}_{ext}| = 1500$ N·m.

Find the equilibrium moment on link AB and the joint reaction forces for ϕ=ϕ_1=60°.

For ϕ=60° the kinematics of the mechanism are given by:
x_B=0.09 m, y_B=0.155885 m,
x_D=-0.16138 m, y_D=-0.0281381 m,
ϕ_2=0.631914 rad, ϕ_4=0.172624 rad,
$\dot{x}_{B_1}$=-2.93835 m/s, $\dot{y}_{B_1}$=1.69646 m/s,
$\ddot{x}_{B_1}$=-31.9775 m/s^2, $\ddot{y}_{B_1}$=-55.3867 m/s^2,
$\dot{x}_{D_3}$=3.28823 m/s, $\dot{y}_{D_3}$=-4.4918 m/s,
$\ddot{x}_{D_3}$=178.405 m/s^2, $\ddot{y}_{D_3}$=18.6037 m/s^2,
ω_2=$\dot{\phi}_2$=27.8338 rad/s, α_2=$\ddot{\phi}_2$=451.854 rad/s^2,
ω_4=$\dot{\phi}_3$=30.4604 rad/s, α_4=$\ddot{\phi}_3$=992.942 rad/s^2.

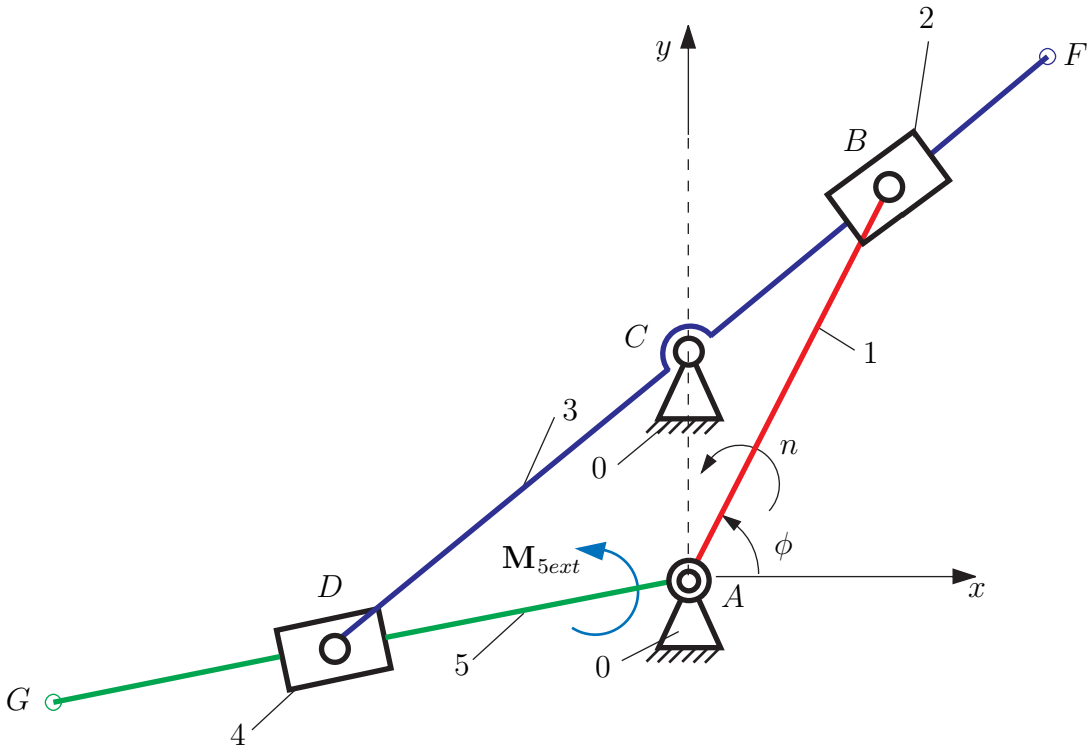

Figure P6.6