4 Homework 6: Velocity and Acceleration Analysis

Problem 4.5

The mechanism in Fig. P4.5 has the dimensions: AB=200 mm, AC=600 mm, BD=1000 mm, L_a=150 mm, and L_b=250 mm. The driver link 1 rotates with a constant angular speed of n=60 rpm. Find the velocities and the accelerations of the mechanism for $\phi=\phi_1=120°$. For $\phi=120°$ the position of the mechanism is 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.

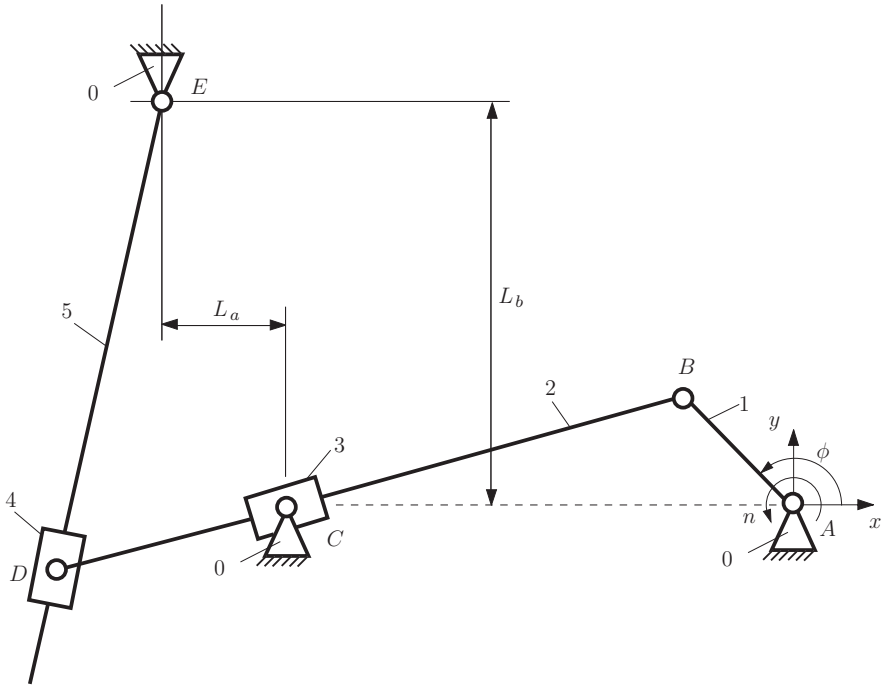

Figure P4.5: Mechanism P4.5

Results
$\dot{x}_{B_1}$=-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.

```
rA = [0, 0, 0] (m)
rB = [  -0.1,  0.173, 0] (m)
rC = [  -0.6,      0, 0] (m)
rD = [ -1.04, -0.154, 0] (m)
rE = [ -0.75,   0.25, 0] (m)
phi2 =    120 (degrees)
phi2 = phi3 =   19.1 (degrees)
phi4 = phi5 =   53.9 (degrees)

omega1 = [0, 0,   6.28] (rad/s)
alpha1 = [0, 0, 0] (rad/s^2)

vB = vB1 = vB2 = [ -1.09, -0.628, 0] (m/s)
aB = aB1 = aB2 = [  3.95,  -6.84, 0] (m/s^2)

omega2z = -0.449 (rad/s)
vC23 =  -1.23 (m/s)

omega3 = omega2 = [0, 0, -0.449] (rad/s)
vC2C3 = [ -1.17, -0.404, 0] (m/s)

alpha2z =  -16.7 (rad/s)
aC23 =    1.6 (m/s^2)

alpha2 = alpha3 = [0, 0,  -16.7] (rad/s^2)
aC2C3 = [  1.51,  0.523, 0] (m/s^2)

vD2 = vD4 = [ -1.24, -0.204, 0] (m/s)
```

```
omega5z =   -1.75 (rad/s)
vD54 =   0.893 (m/s)

omega4 = omega5 = [0, 0,  -1.75] (rad/s)
vD5D4 = [ 0.526,  0.721, 0] (m/s)

aD54cor = [  2.53,  -1.85, 0 ] (m/s^2)

alpha5z =  -6.57 (rad/s^2)
aD54 =  -4.98 (m/s^2)

alpha4 = alpha5 = [0, 0,  -6.57] (rad/s^2)
aD5D4 = [ -2.94,  -4.02, -0] (m/s^2)
```

Problem 4.6

The mechanism in Fig. P4.6 has the dimensions: AB=150 mm, AC=350 mm, BD=530 mm, DE=300 mm, EF=200 mm, L_a=55 mm, and L_b=125 mm. The constant angular speed of the driver link 1 is n=30 rpm. Find the velocities and the accelerations of the mechanism for ϕ=ϕ_1=120°. For ϕ=120° the position of the mechanism is given by: x_B=-0.075 m, y_B=0.129904 m, x_D=-0.554223 m, y_D=-0.0964704 m, x_E=-0.482421 m, y_E=0.19481 m, ϕ_2=0.441306 rad, ϕ_4=1.32911 rad, ϕ_5=-0.356559 rad.

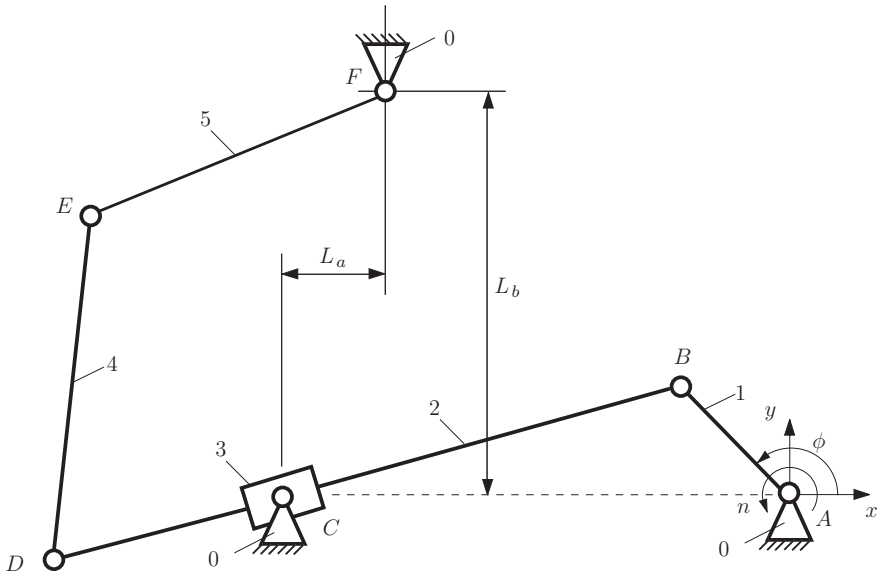

Figure P4.6: Mechanism P4.6

Results
$\dot{x}_B$=-0.408105 m/s, $\dot{y}_B$=-0.235619 m/s, $\ddot{x}_B$=0.74022 m/s^2, $\ddot{y}_B$=-1.2821 m/s^2, $v_{C_3C_2x}$=0.42465 m/s, $v_{C_3C_2y}$=0.200595 m/s, ω_2=-0.127362 rad/s, ω_4=-1.16943 rad/s, ω_5=1.37953 rad/s, $\dot{x}_E$=-0.0963053 m/s, $\dot{y}_E$=-0.258552 m/s, $a^{cor}_{C_3C_2x}$=0.0510963 m/s^2, $a^{cor}_{C_3C_2y}$=-0.108168 m/s^2, α_2=-5.24453 rad/s^2, $a_{C_3C_2x}$=-0.114494 m/s^2, $a_{C_3C_2y}$=-0.0540842 m/s^2, $\ddot{x}_D$=-0.439231 m/s^2, $\ddot{y}_D$=1.23487 m/s^2, α_4=-3.94679 rad/s^2, α_5=-3.66019 rad/s^2, $\ddot{x}_E$=0.612199 m/s^2, $\ddot{y}_E$=0.553139 m/s^2.

```
rA = [ 0.000,  0.000, 0] (m)
rD = [-0.554, -0.096, 0] (m)
rB = [-0.075,  0.130, 0] (m)
rC = [-0.350,  0.000, 0] (m)
rE = [-0.482,  0.195, 0] (m)
rF = [-0.295,  0.125, 0] (m)
phi2 = 25.285 (degrees)
phi3 = 25.285 (degrees)
phi4 = 40.509 (degrees)
phi5 = -20.429 (degrees)

Velocity and acceleration analysis

omega1=[0, 0,  3.142] (rad/s)
alpha1=[0, 0, 0] (rad/s^2)

vB=[-0.408, -0.236, 0] (m/s)
aB=[ 0.740, -1.282, 0] (m/s^2)

vC2 = vB + omega2 x rBC = vC3 + vC23 =>
x-axis: 0.13*omega2z - 0.904*v23 - 0.408 = 0
y-axis: - 0.275*omega2z - 0.427*v23 - 0.236 = 0
=>
omega2z = -0.127 (rad/s)
vC23 = -0.470 (m/s)

omega3=omega2=[0, 0, -0.127](rad/s)
vC2C3=[-0.425, -0.201, -0](m/s)
```

```
aC23cor=[-0.051,  0.108, 0](m/s^2)

aC2=aB+omega2xrBC-(omega2.omega2)rBC=aC3+aC23+aC23cor =>
x-axis: 0.13*alpha2z - 0.904*a23 + 0.796 = 0
y-axis: - 0.427*a23 - 0.275*alpha2z - 1.39 = 0
=>
alpha2z = -5.245 (rad/s)
aC23 =  0.127 (m/s)

alpha3=alpha2=[0, 0, -5.245](rad/s^2)
aC3C2=[ 0.114,  0.054, 0](m/s^2)

vD=[-0.437, -0.175, 0](m/s)
aD=[-0.439,  1.235, 0](m/s^2)

vE = vD + omega4 x rDE = vF + omega5 x rFE  =>
x-axis: 0.0698*omega5z - 0.291*omega4z - 0.437 = 0
y-axis: 0.0718*omega4z + 0.187*omega5z - 0.175 = 0
=>
omega4z= -1.169 (rad/s)
omega5z=  1.380 (rad/s)

omega4=[0, 0, -1.169](rad/s)
omega5=[0, 0,  1.380](rad/s)

vE=[-0.096, -0.259, 0](m/s)

aE = aD + alpha4 x rDE - (omega4.omega4)rDE
aE = aF + alpha5 x rFE - (omega5.omega5)rFE
x-axis: 0.0698*alpha5z - 0.291*alpha4z - 0.894 = 0
y-axis: 0.0718*alpha4z + 0.187*alpha5z + 0.969 = 0
=>
alpha4z= -3.947 (rad/s^2)
alpha5z= -3.660 (rad/s^2)

alpha4=[0, 0, -3.947] (rad/s^2)
alpha5=[0, 0, -3.660] (rad/s^2)
```

```
aE=[ 0.612,  0.553, 0] (m/s^2)
```