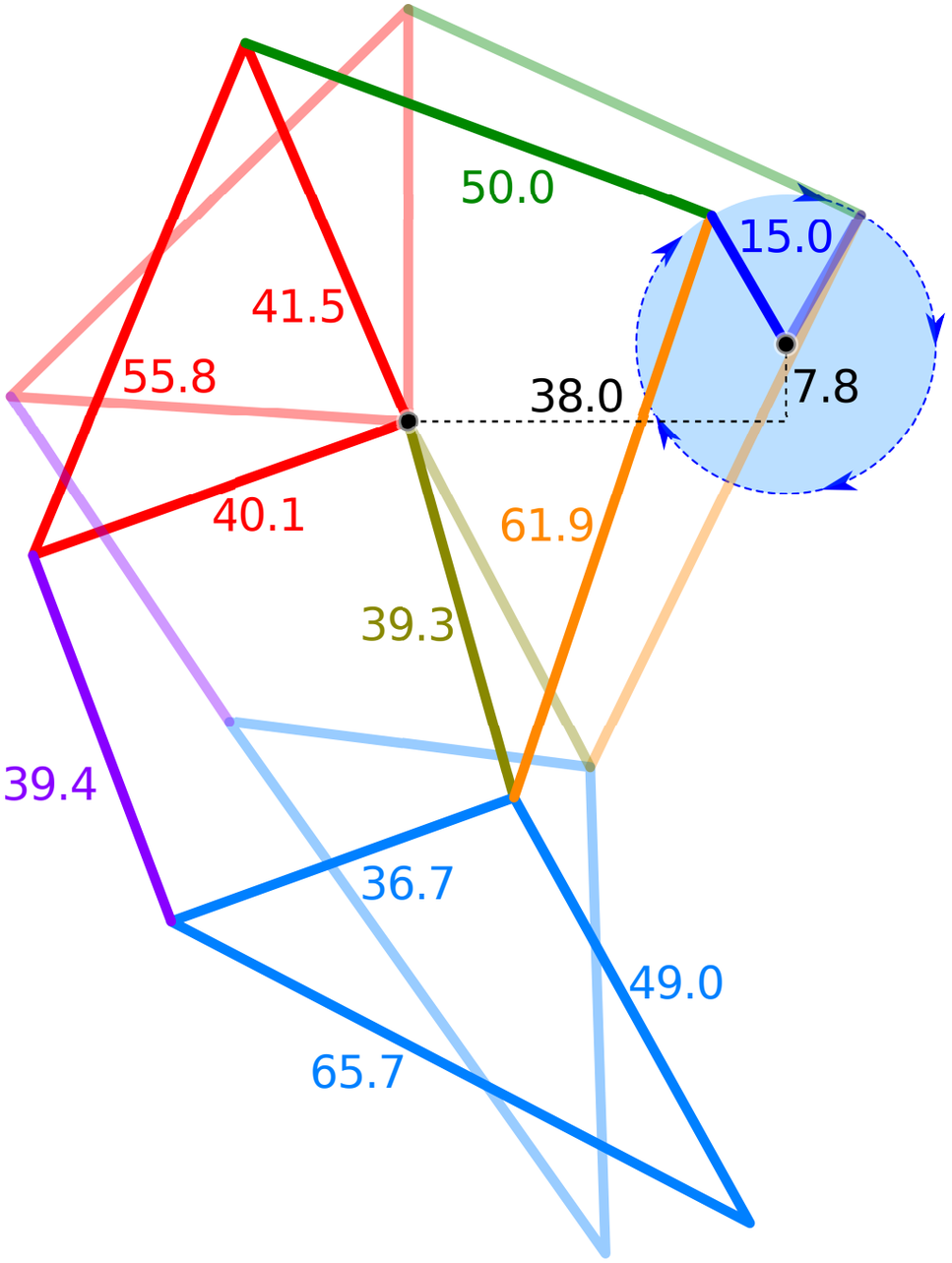
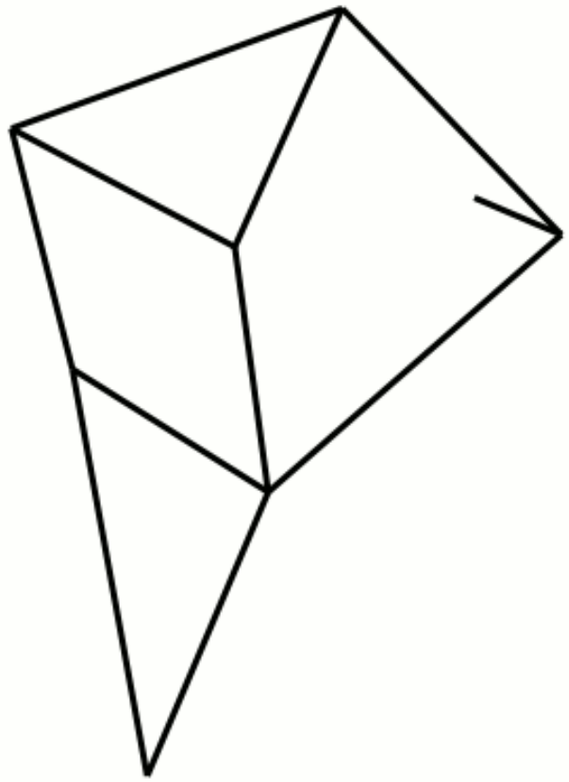
Linkage analysis

Works with only those linkages that can be set up as a succession of fourbars. Linkages having fivebars, such as Klann cannot be analyzed using this script

Jansens linkage

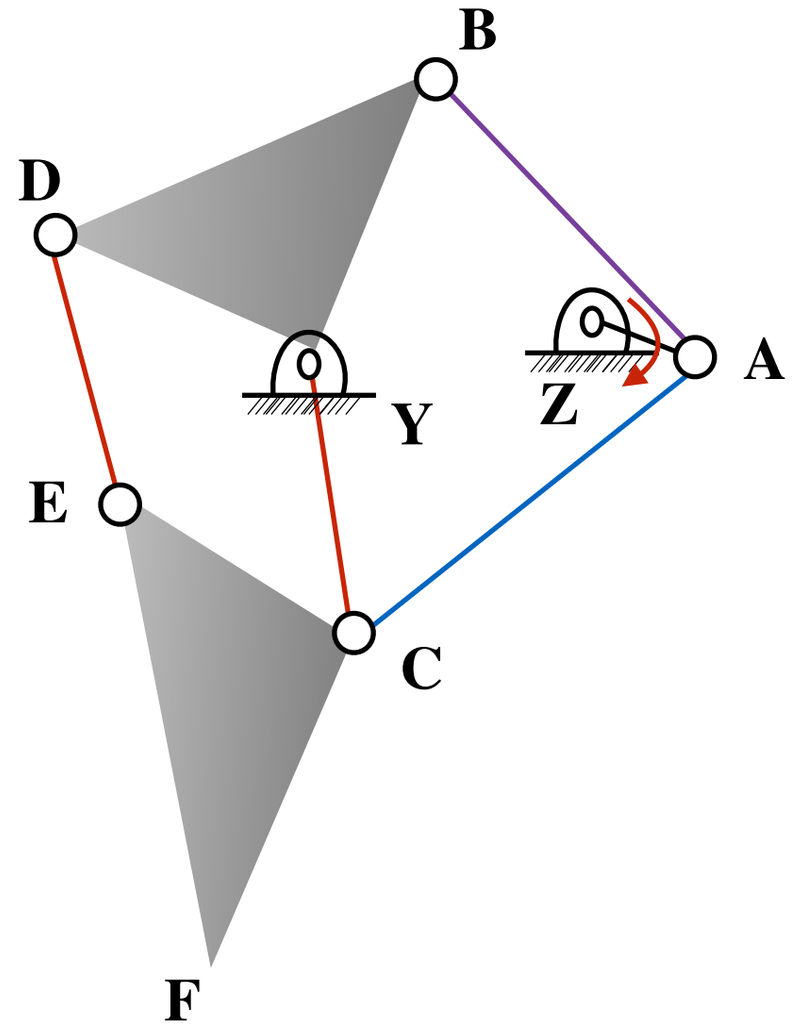
example14.m





wikipedia

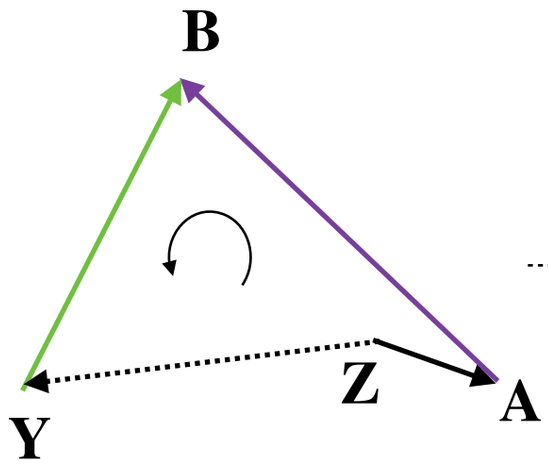
Linkages with 8 bars (Jansen's linkage)

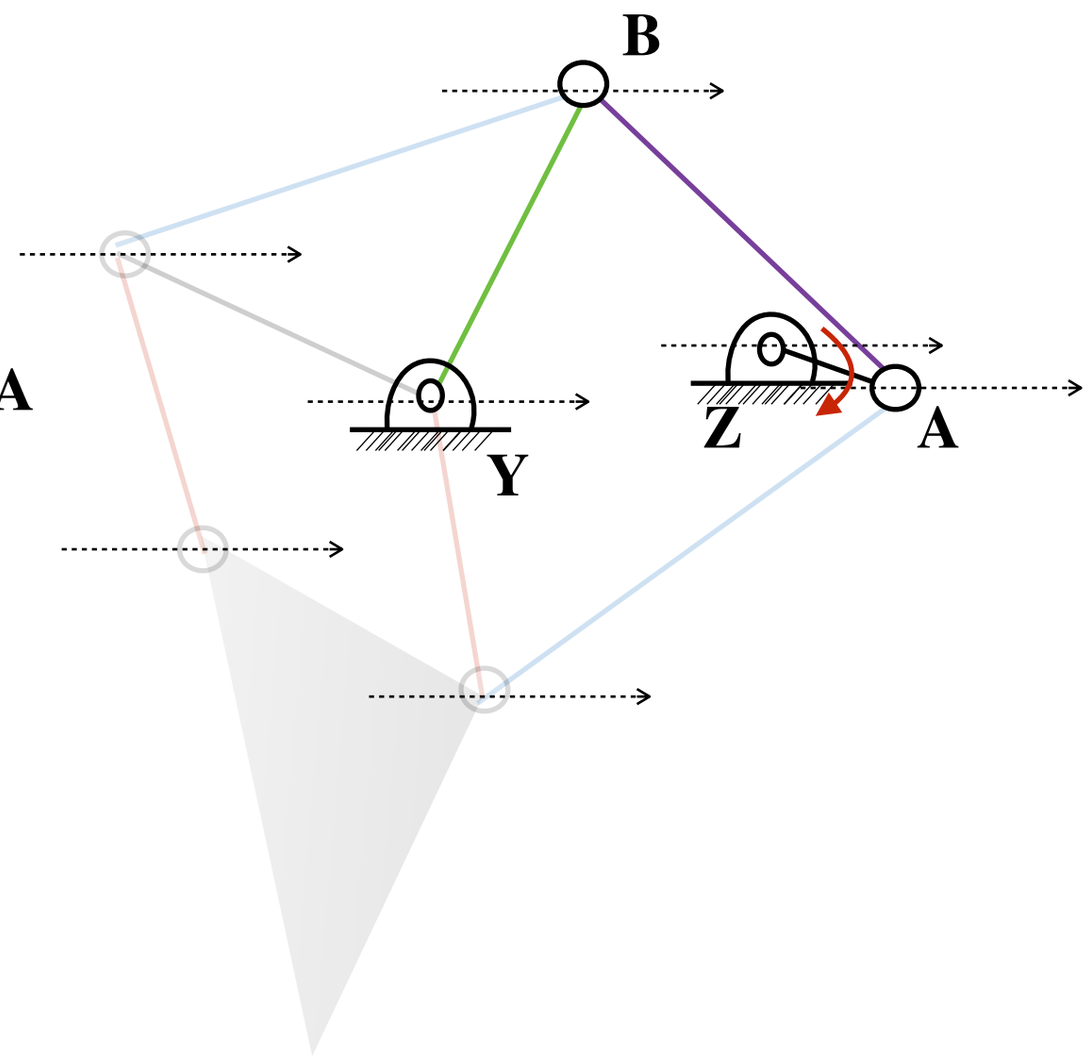


with so many links it is easier to write vectors using joint positions so that $\mathbf{R}_{AB}$ denotes position of A from B and $\mathbf{R}_{AB} = -\mathbf{R}_{BA}$

Linkages with 8 bars (Jansen's linkage)

$$\mathbf{R}_{AZ} + \mathbf{R}_{BA} - \mathbf{R}_{BY} - \mathbf{R}_{YZ} = 0$$





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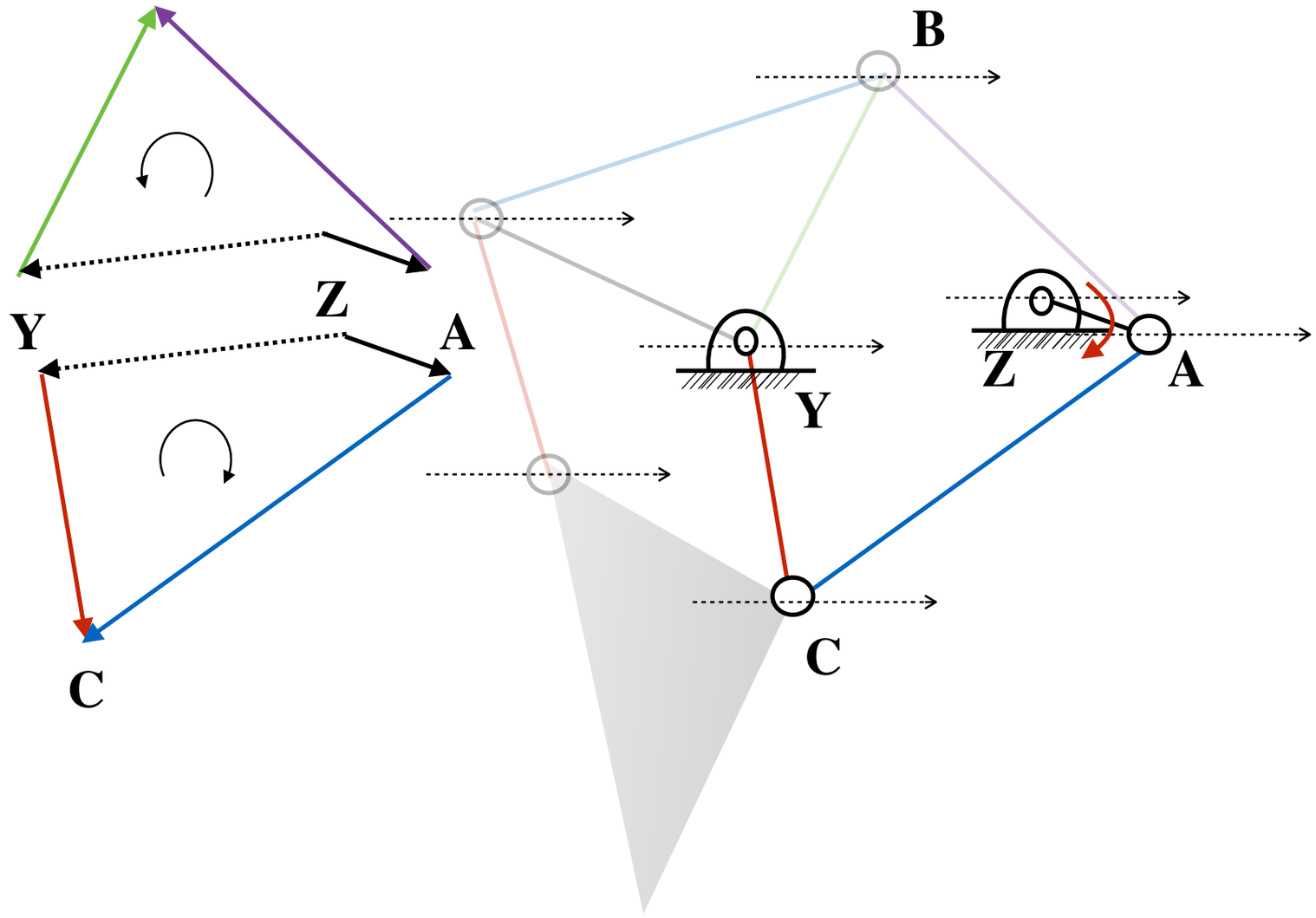

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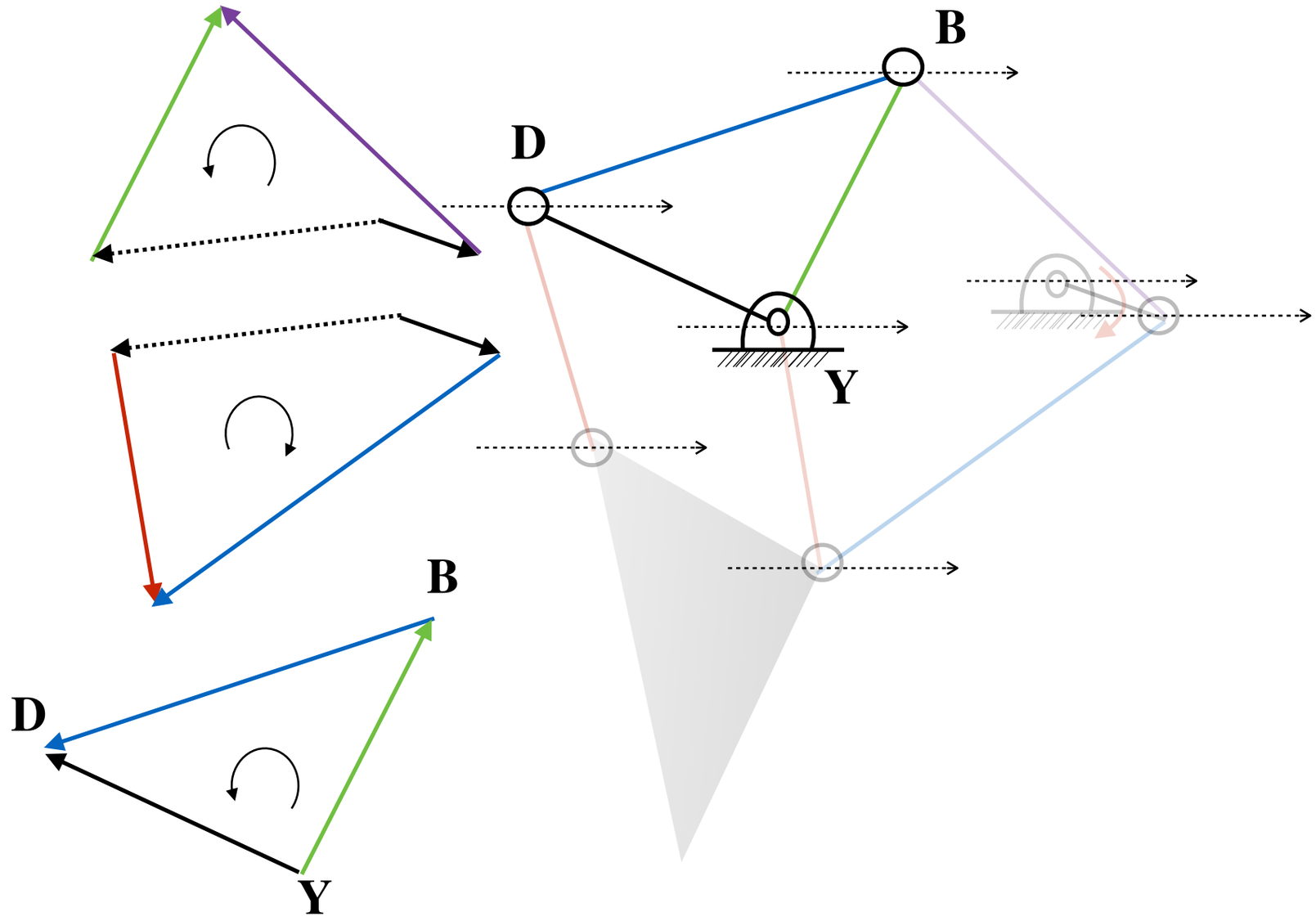
$$\mathbf{R}_{BY} + \mathbf{R}_{DB} - \mathbf{R}_{DY} - \mathbf{R}_{YY} = 0$$



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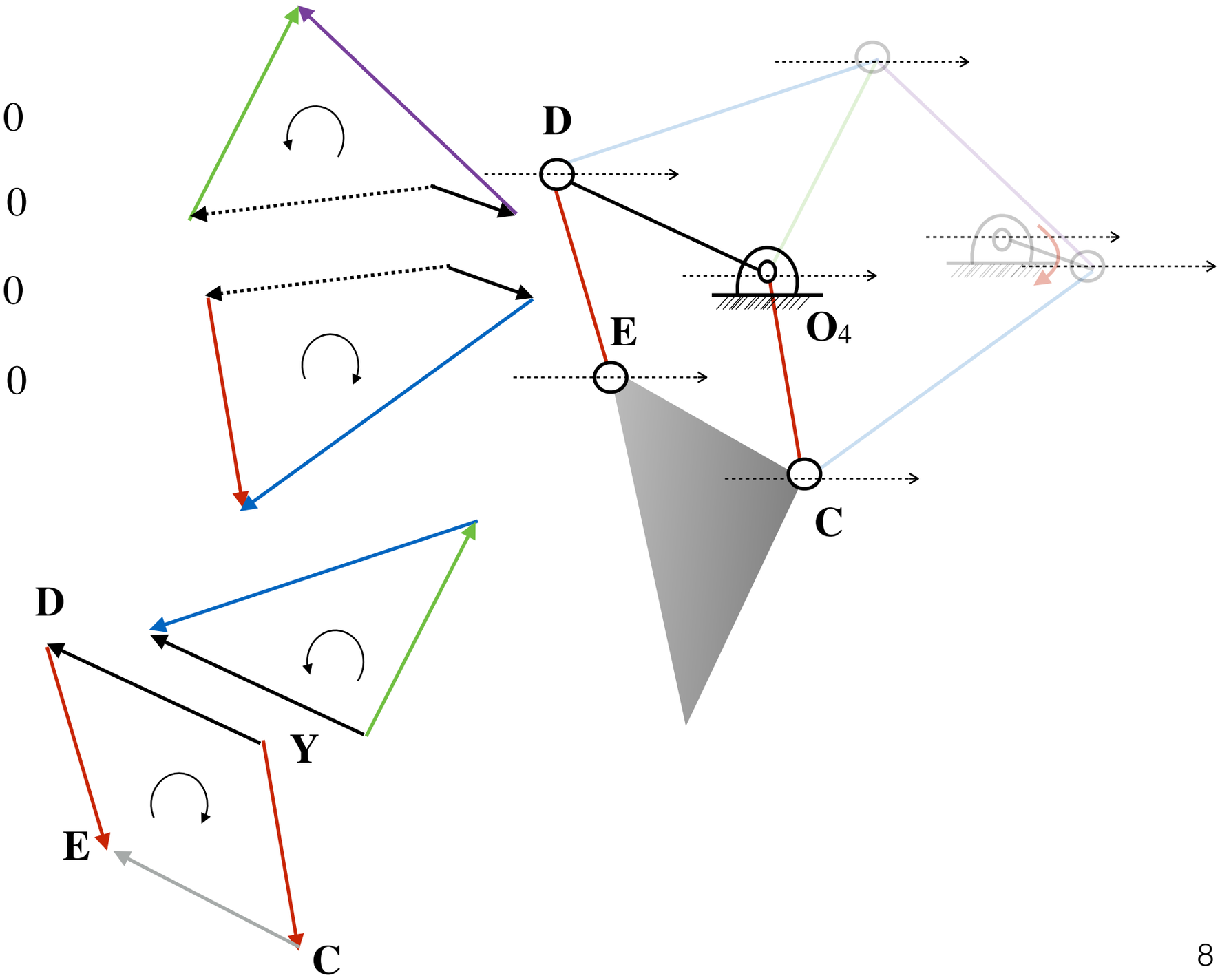
$$\mathbf{R}_{BY} + \mathbf{R}_{DB} - \mathbf{R}_{DY} - \mathbf{R}_{YY} = 0$$

$$\mathbf{R}_{CY} + \mathbf{R}_{EC} - \mathbf{R}_{ED} - \mathbf{R}_{DY} = 0$$



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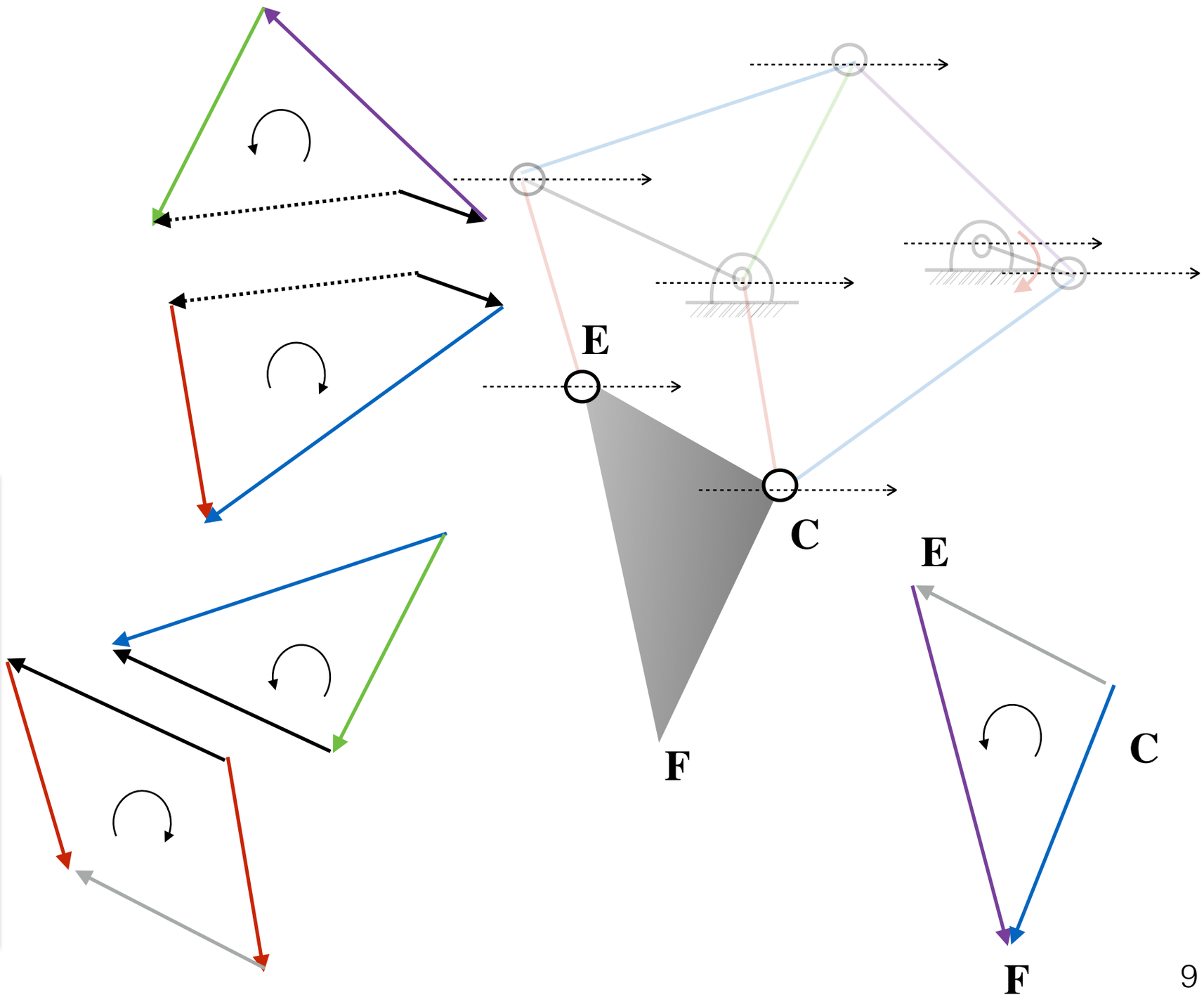
$$\mathbf{R}_{CY} + \mathbf{R}_{EC} - \mathbf{R}_{ED} - \mathbf{R}_{DY} = 0$$

$$\mathbf{R}_{EC} + \mathbf{R}_{FE} - \mathbf{R}_{FC} - \mathbf{R}_{CC} = 0$$

10 unknowns, 10 equations!
Since each loop adds 2 new unknowns we can solve them sequentially or all at once numerically (need a good guess to avoid falling into a local minima)



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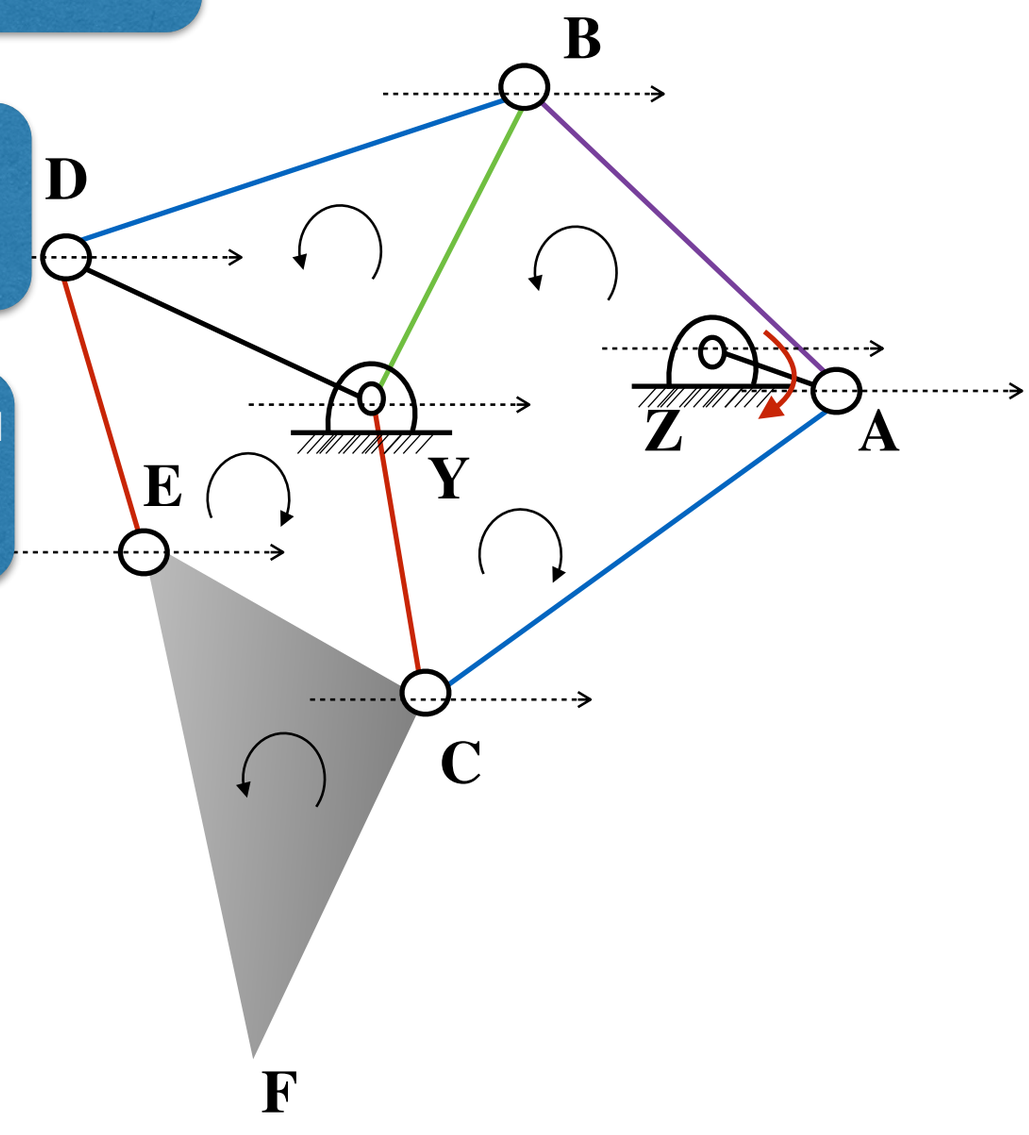
Check for open and cross configurations each time until you get the right assembly, **try cross for CCW and open for CW**

$R_{YY}=0$

The angle of a moving ground should be put as input to the next equation

$R_{CC}=0$



$$\mathbf{R}_F = \mathbf{R}_{FC} + \mathbf{R}_{CA} + \mathbf{R}_{AZ}$$

$$\dot{\mathbf{R}}_F = \dot{\mathbf{R}}_{FC} + \dot{\mathbf{R}}_{CA} + \dot{\mathbf{R}}_{AZ}$$

$$\ddot{\mathbf{R}}_F = \ddot{\mathbf{R}}_{FC} + \ddot{\mathbf{R}}_{CA} + \ddot{\mathbf{R}}_{AZ}$$

Linkages with 8 bars (Jansen's linkage)

Check for open and cross configurations each time until you get the right assembly, **try cross for CCW and open for CW**

$$\mathbf{R}_{AZ} + \mathbf{R}_{BA} - \mathbf{R}_{BY} - \mathbf{R}_{YZ} = 0$$

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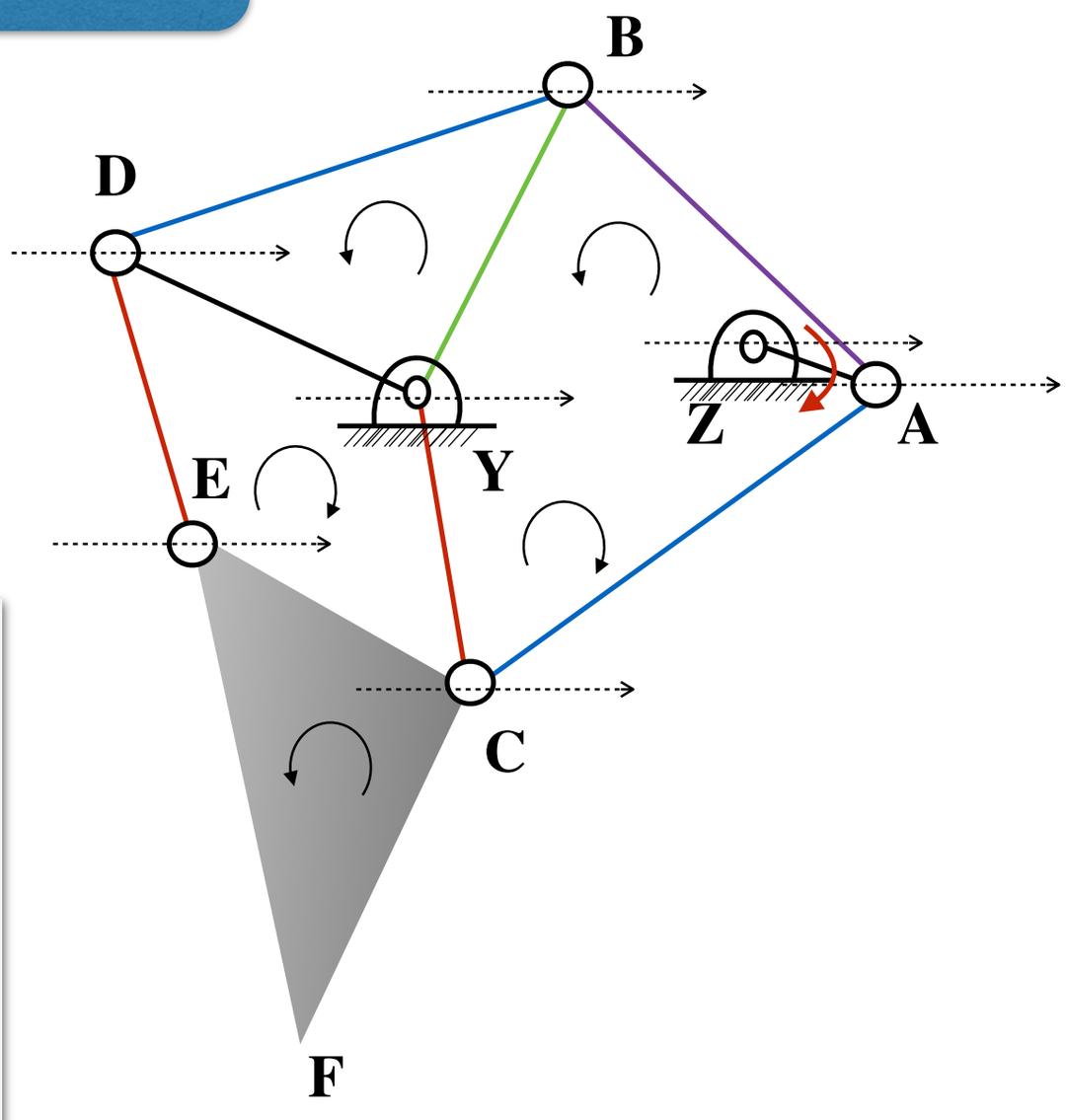
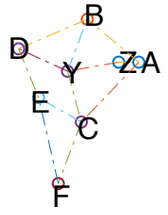
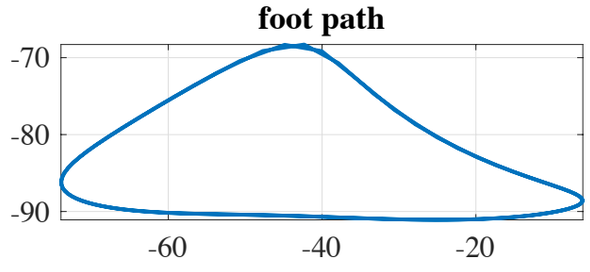
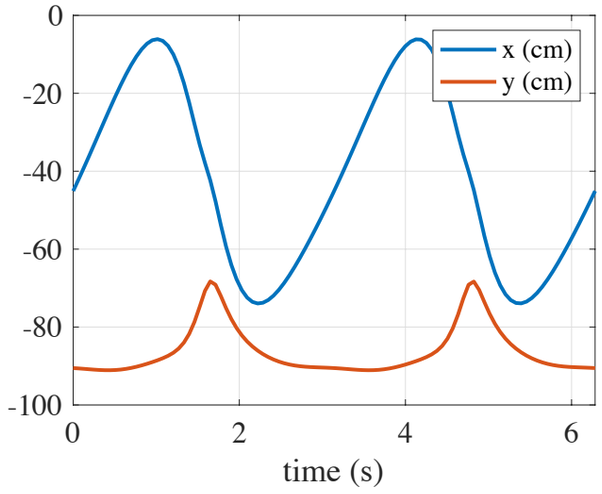
$$\mathbf{R}_{EC} + \mathbf{R}_{FE} - \mathbf{R}_{FC} - \mathbf{R}_{CC} = 0$$

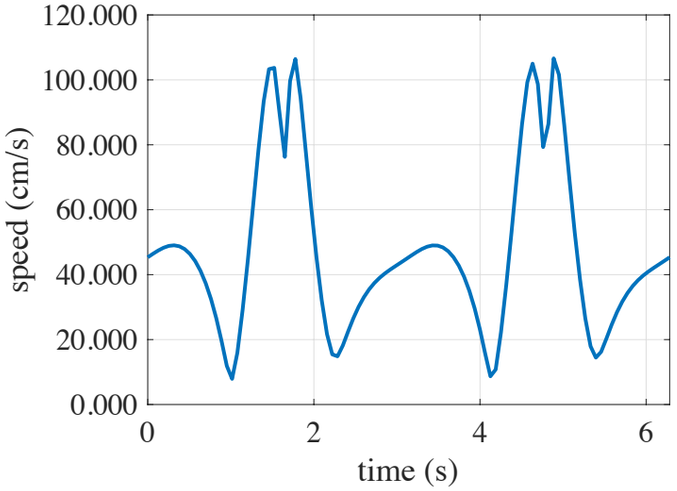
```
% VECTOR LOOP EQUATIONS
% ** note that the vecloop equation MUST be in one of these forms with spa
% between each position vector, upper case letters and the same exact
% signs. Modify your vectors so that these are satisfied
%
% RAZ + RBA - RBY - RZY = 0
% RAB + RBA = 0 % when the vectors are opposite to each other
% RAZ - RBA = 0 % when links are extended in the same direction
% for angled links simply use the fourbar loop as if for a ternary link.

% (1) RAZ + RBA - RBY - RZY = 0
% the second argument is 1 for open configuration and 2 for cross
links=solve_vecloop('RAZ + RBA - RBY - RYZ = 0', 2, links);

% ** (2) RAZ + RCA - RCY - RYZ = 0
links=solve_vecloop('RAZ + RCA - RCY - RYZ = 0', 1, links);

% ** (3) RBY + RDB - RDY - RYY = 0
links=solve_vecloop('RBY + RDB - RDY - RYY = 0', 2, links);

% ** (4) RCY + REC - RED - RDY = 0
links=solve_vecloop('RCY + REC - RED - RDY = 0', 1, links);

% ** (5) REC + RFE - RFC - RCC= 0
links=solve_vecloop('REC + RFE - RFC - RCC = 0', 2, links);
```

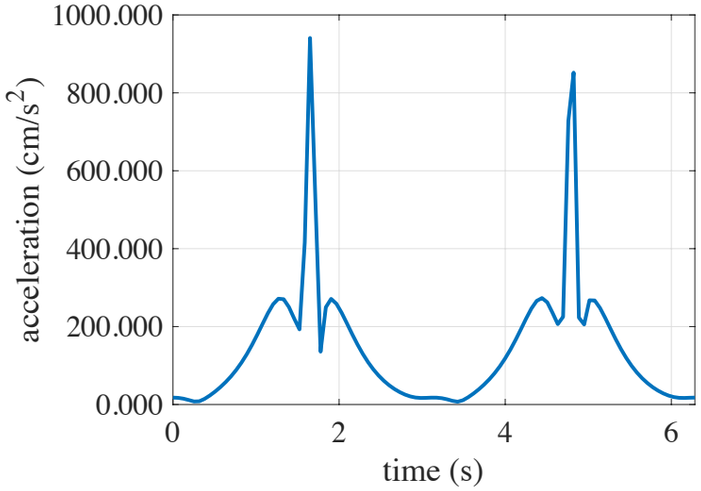


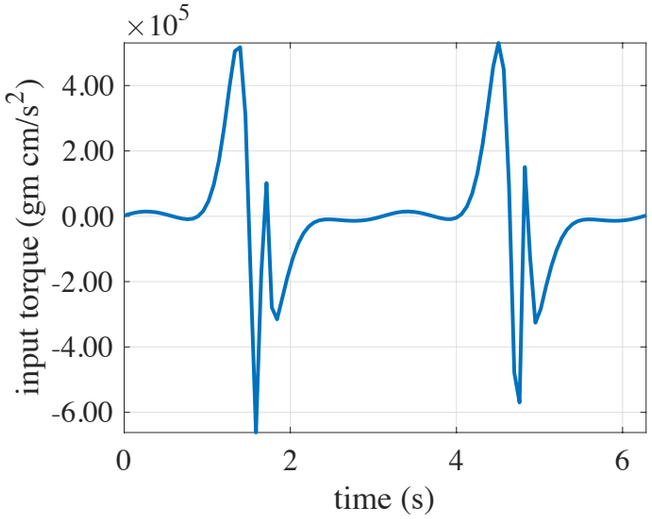

B
D
Z
A
Y
E
C
F


foot path
-70
-80
-90
-60
-40
-20


0
-20
-40
-60
-80
-100
0
2
4
6
time (s)
x (cm)
y (cm)


120.000
100.000
80.000
60.000
40.000
20.000
0.000
speed (cm/s)
0
2
4
6
time (s)


1000.000
800.000
600.000
400.000
200.000
0.000
acceleration (cm/s^2)
0
2
4
6
time (s)

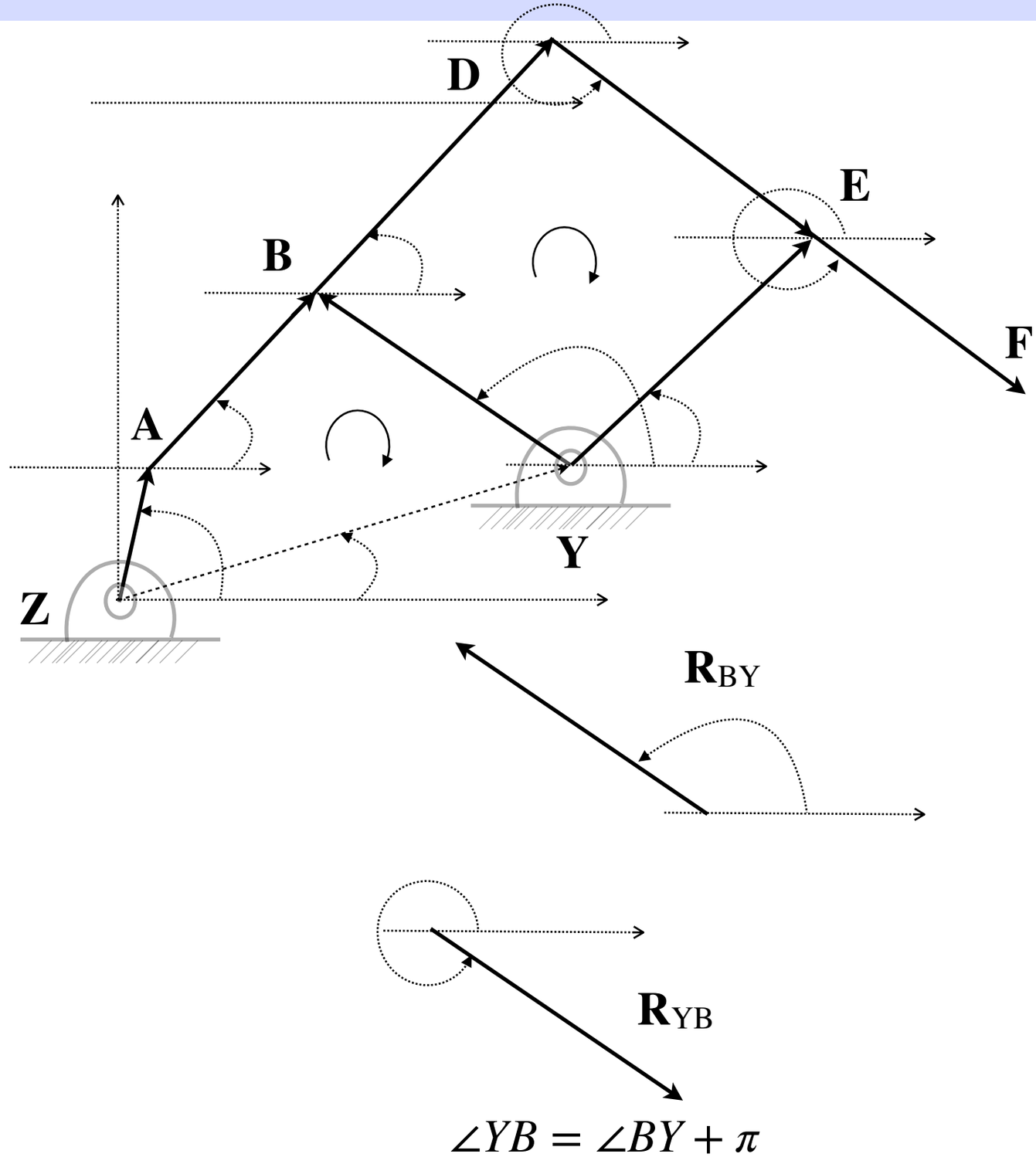

$\times 10^5$
4.00
2.00
0.00
-2.00
-4.00
-6.00
input torque (gm cm/s^2)
0
2
4
6
time (s)

Pantograph

example13.m

Analysis of linkages with > 4 bars

1. Draw the kinematic diagram
2. Draw the vector loop, showing all the angles
3. Identify each loop, taking care that you have no more than 2 unknowns per vector loop.
4. Compare the equations with the form for which the formulae have been derived to identify which angles are being output



$$\mathbf{R}_{AZ} + \mathbf{R}_{BA} - \mathbf{R}_{BY} - \mathbf{R}_{YZ} = 0$$

$$\mathbf{R}_{YB} + \mathbf{R}_{BY} = 0$$

$$\mathbf{R}_{DB} - \mathbf{R}_{BA} = 0$$

$$\mathbf{R}_{DB} + \mathbf{R}_{ED} - \mathbf{R}_{EY} - \mathbf{R}_{YB} = 0$$

$$\mathbf{R}_{FE} - \mathbf{R}_{ED} = 0$$

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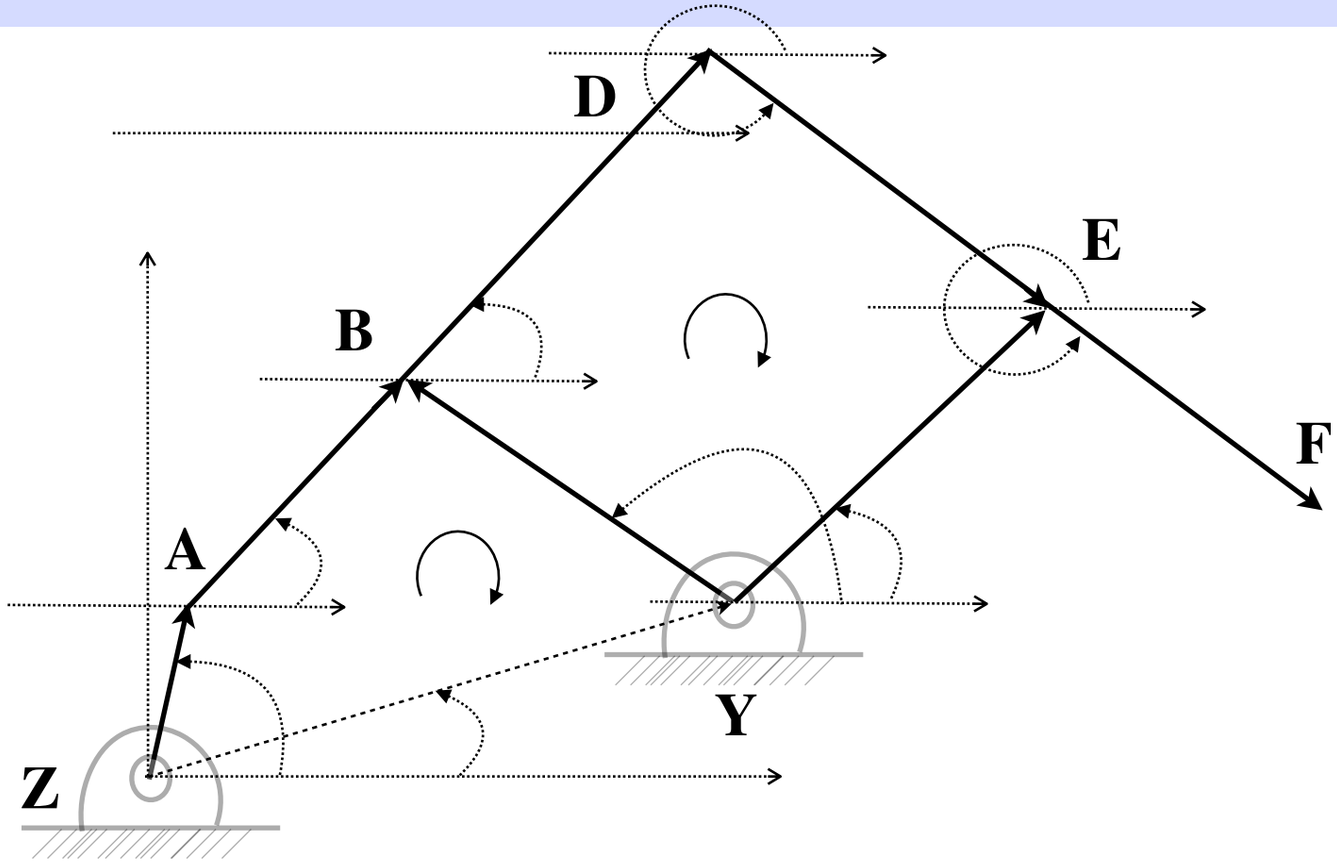

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$$\mathbf{R}_{YB} + \mathbf{R}_{BY} = 0$$
$$\mathbf{R}_{DB} - \mathbf{R}_{BA} = 0$$
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```
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% the second argument is 1 for open configuration and 2 for cross
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links=solve_vecloop('RDB - RBA = 0', 1, links);
links=solve_vecloop('RYB + RBY = 0', 1, links);
links=solve_vecloop('RDB + RED - REY - RYB = 0', 1, links);
links=solve_vecloop('RFE - RED = 0', 1, links);
```