Mechatronics System Design

EC4.404 - S2023

Lecture 11

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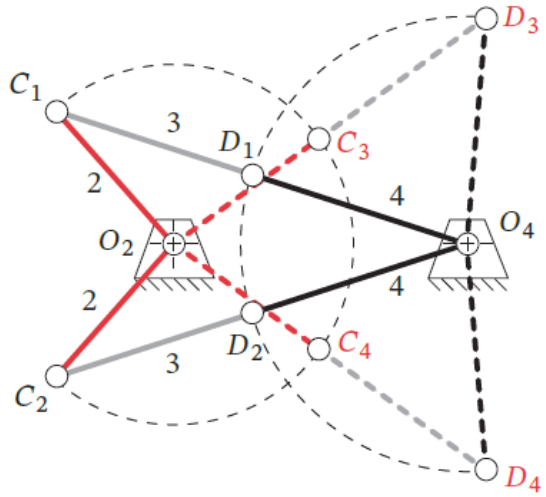
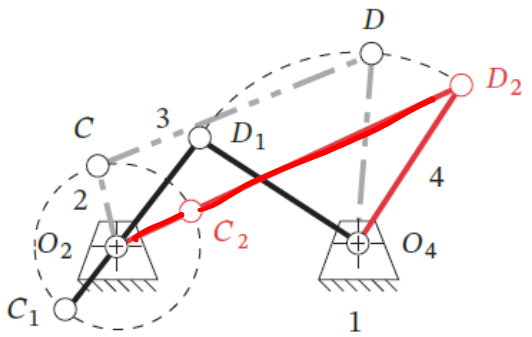
LIMITING CONDITIONS

- **Toggle Positions:**
  - determined by the colinearity of two of the moving links.
  - Will not allow further input motion in one direction from one of its rocker links



(*a*) Non-Grashof triple-rocker toggle positions



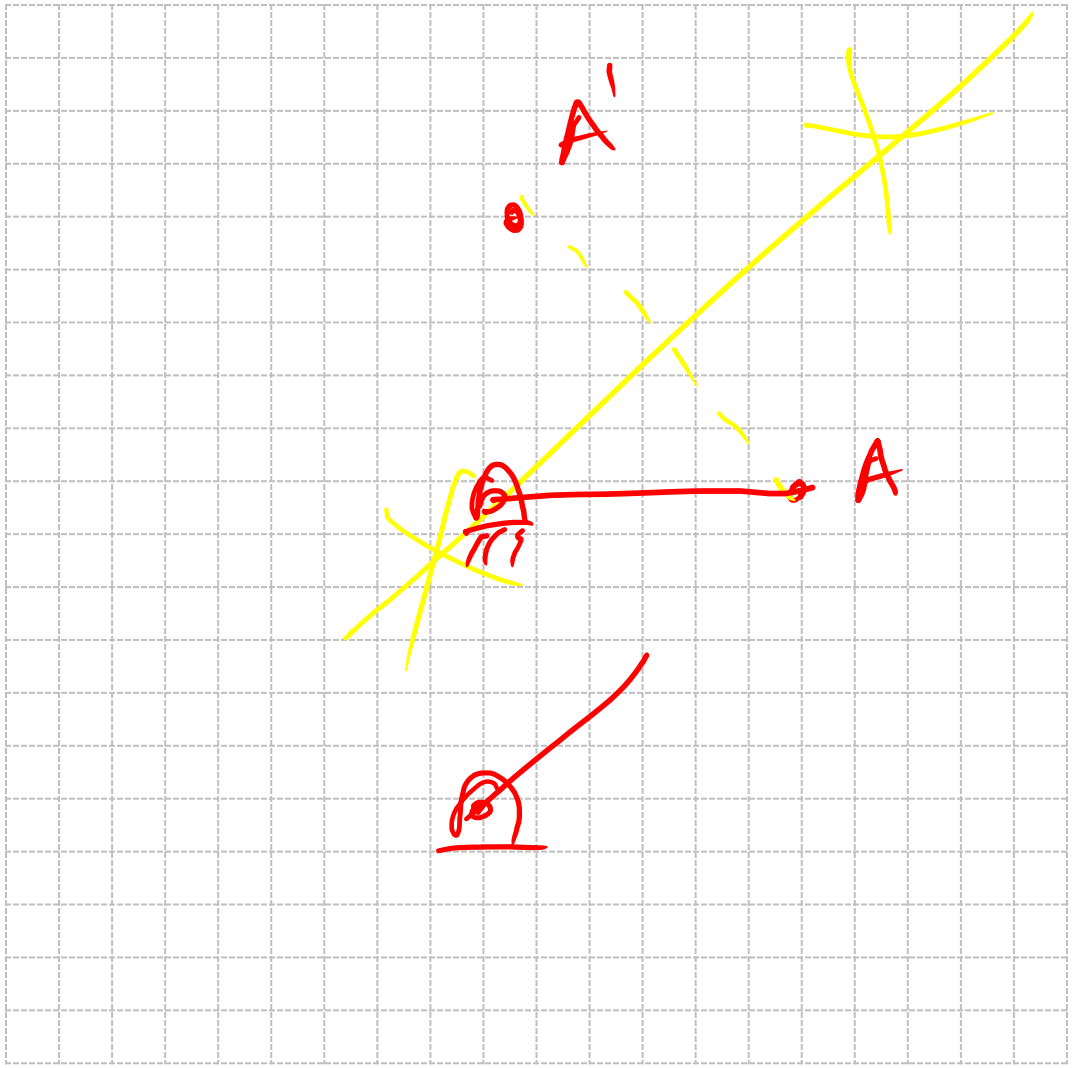
(*b*) Grashof crank-rocker stationary configurations

4-toggle positions

2 toggle positions

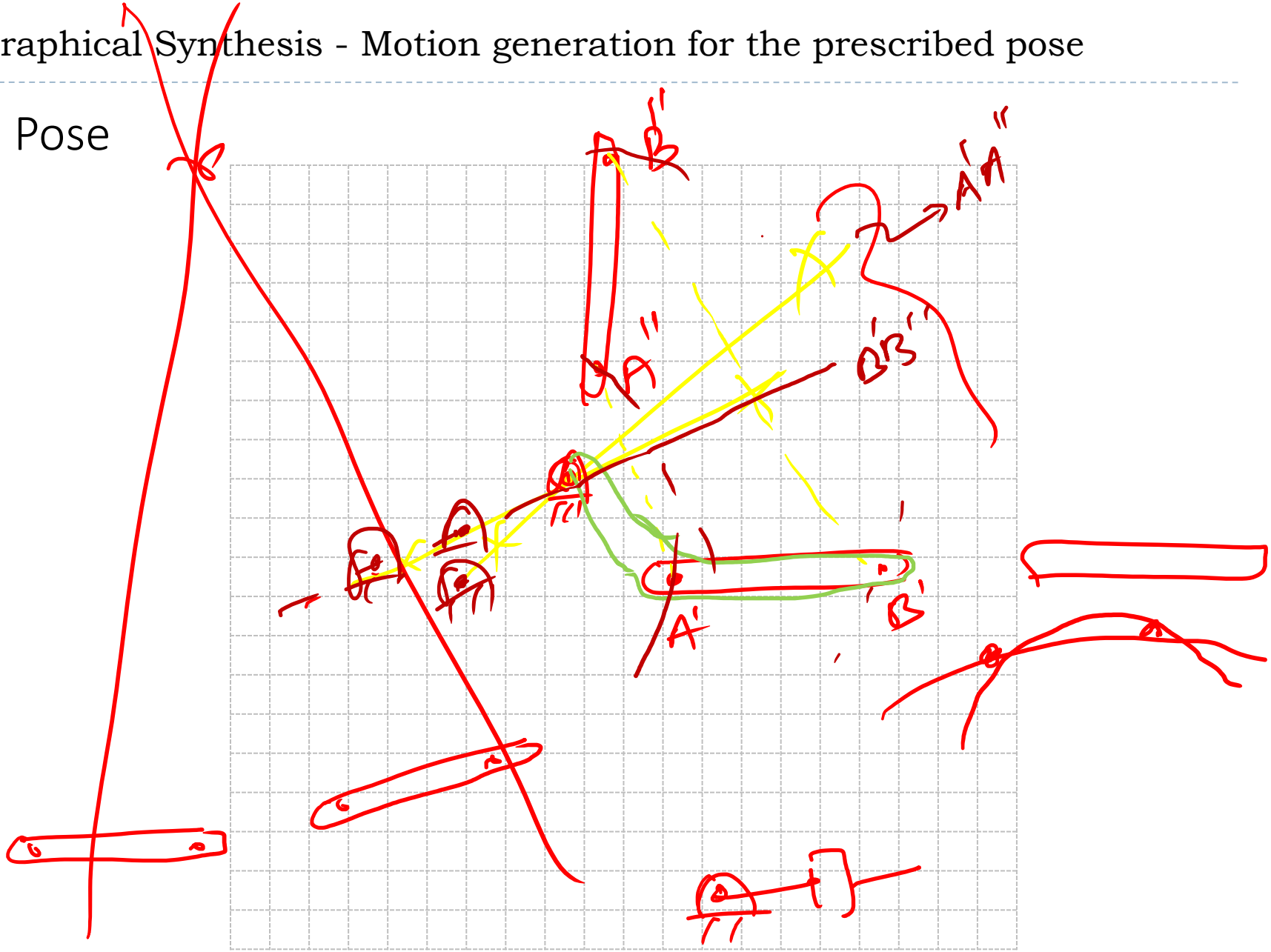
Graphical Synthesis - Motion generation for the prescribed point

- Point

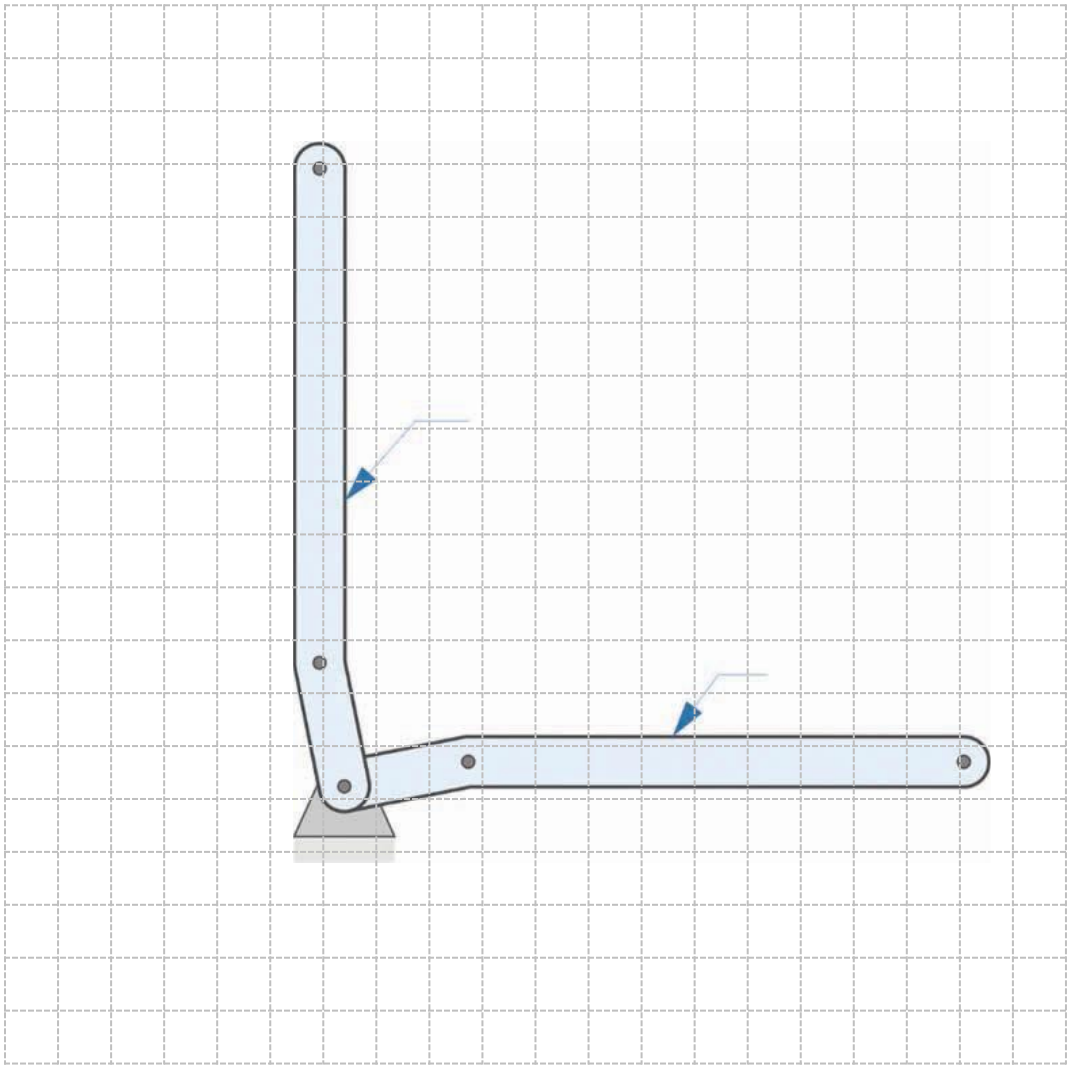


Graphical Synthesis - Motion generation for the prescribed pose

- Pose

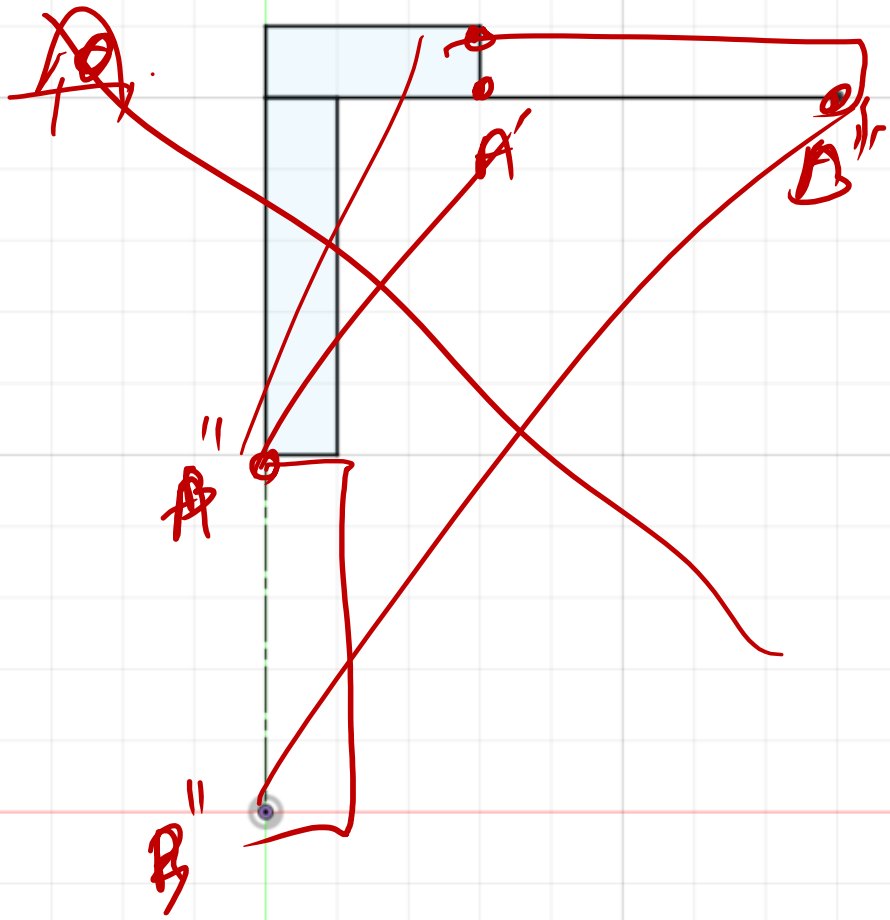


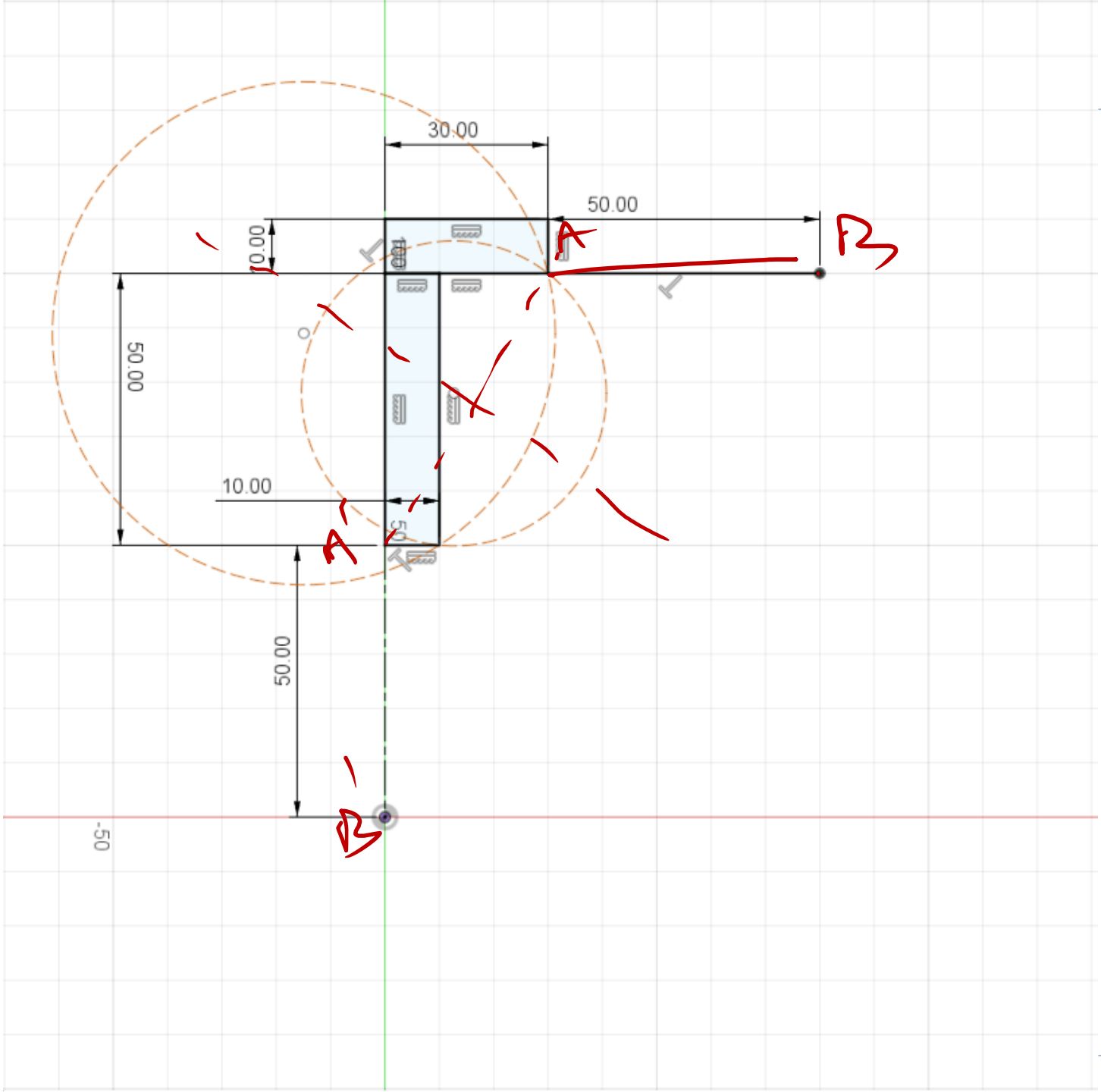
Graphical Synthesis - Motion generation for the two prescribed point



Graph

- Rig




30.00
50.00
10.00
50.00
10.00
50.00
A
B
A
B
-50

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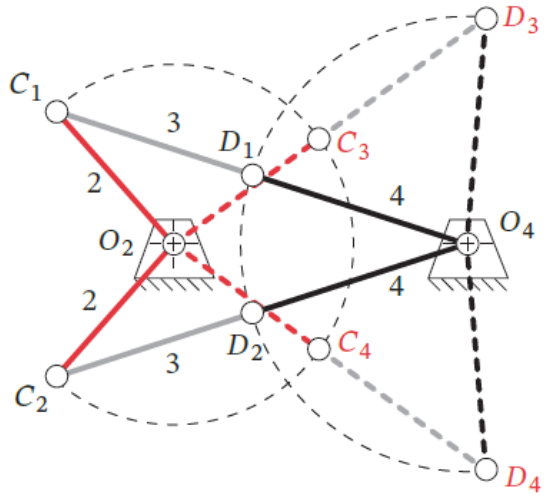

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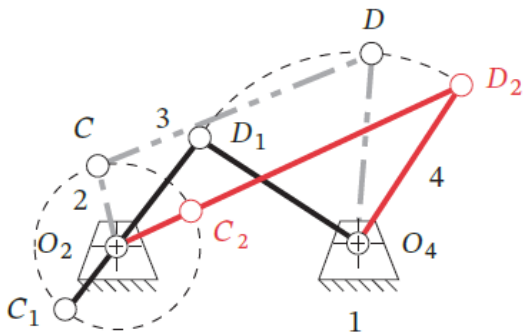


(*b*) Grashof crank-rocker stationary configurations

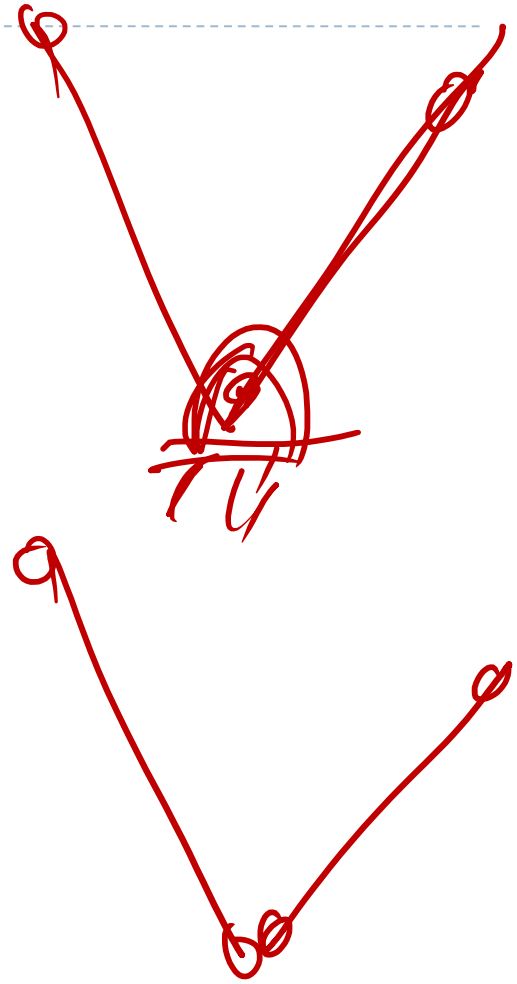
4-toggle positions

2 toggle positions

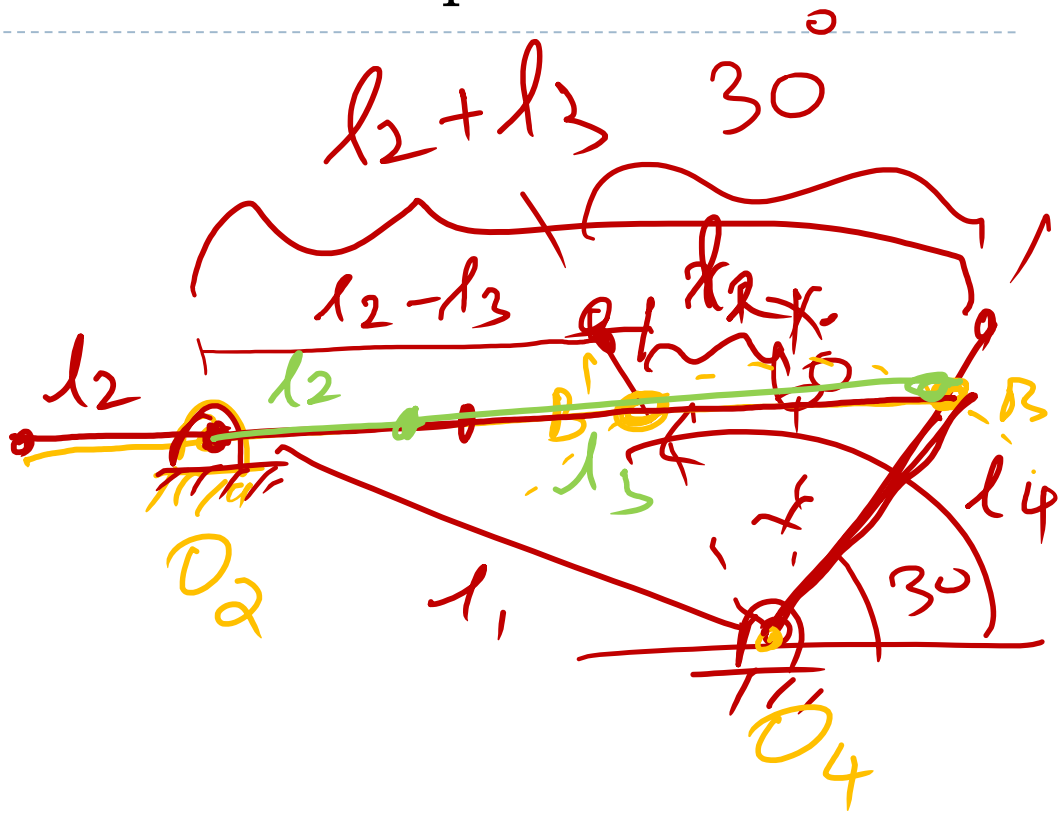
Two-Position Synthesis

Two categories:

- Rocker output
  - Grashof
  - Non-Grashof
- Coupler output (complex motion).



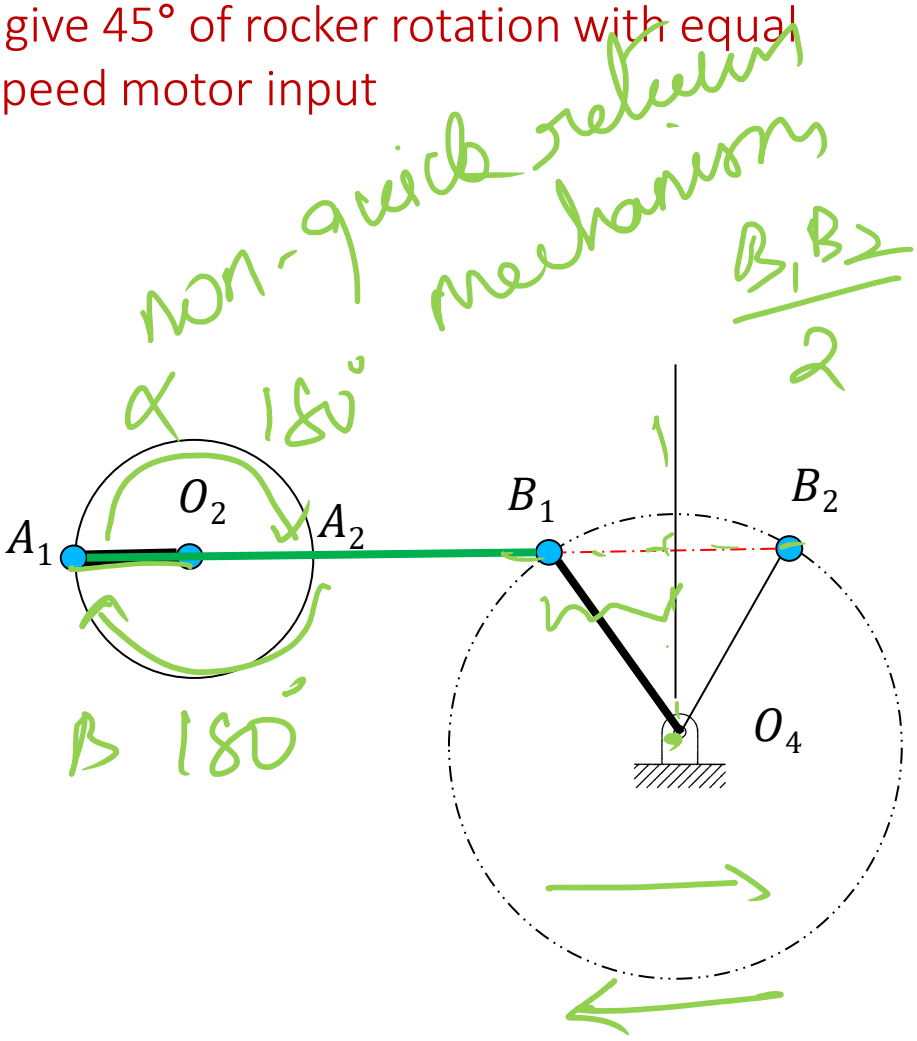
Two-Position Synthesis - Rocker output



Two-Position Synthesis - Rocker output

Design a fourbar Grashof crank-rocker to give 45° of rocker rotation with equal time forward and back, from a constant speed motor input

1. Draw the output link O_4B in both extreme cases, and ensure desired angle
2. Draw $B_1\,B_2$ chord and extend it
3. Select O_2 on the extended line $B_1\,B_2$
4. Bisect line segment $B_1\,B_2$, and draw a circle of that radius about O_2.
5. Coupler length $A_1\,B_1$, Crank length $O_2\,A_1$
6. Find the Grashof condition. If non-Grashof, redo from steps 3 with O_2 farther from O_4.



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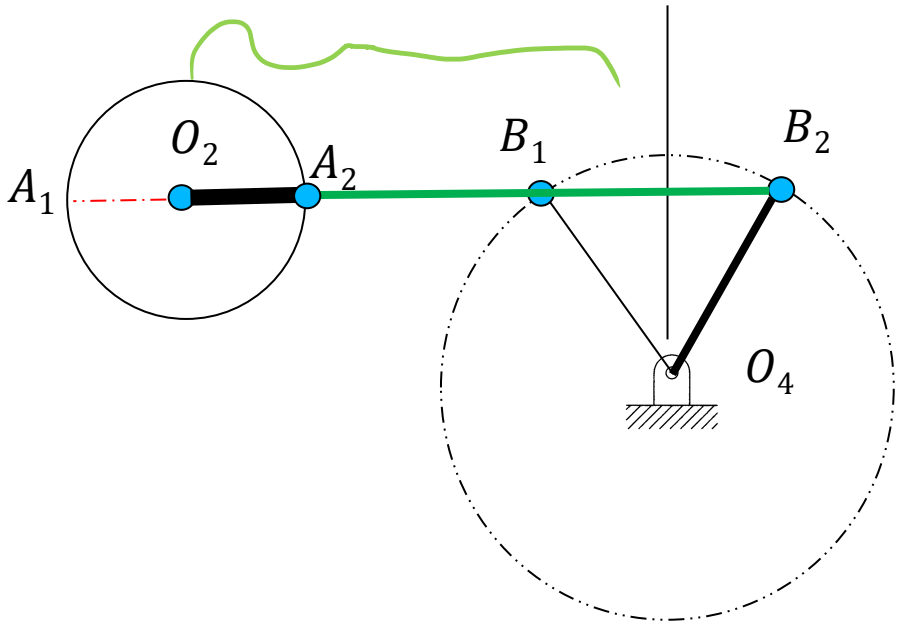
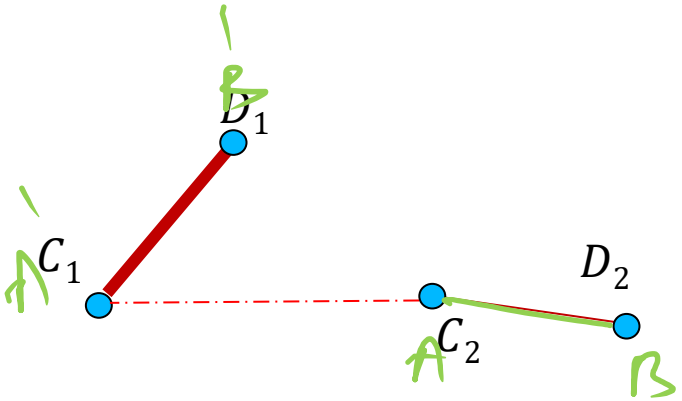
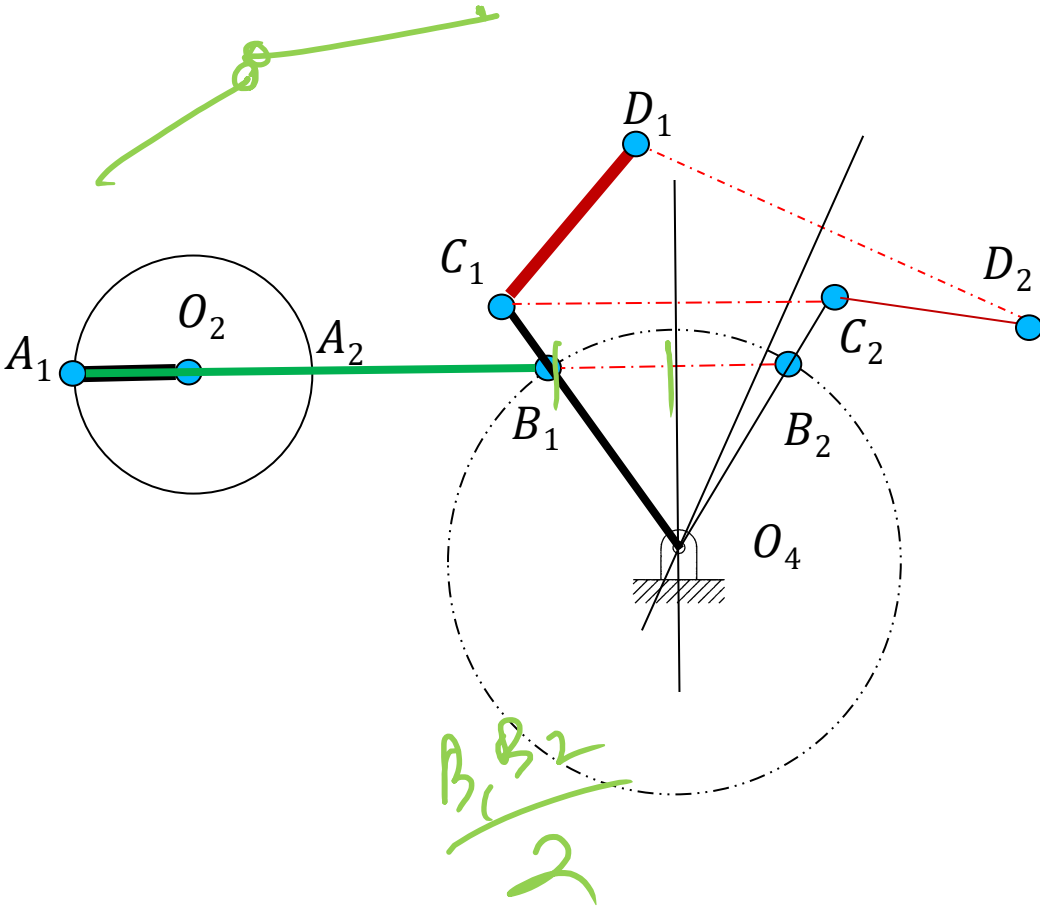


Rocker Output - Two Positions with Complex Displacement. (Motion Generation)



- Design a fourbar linkage to move link CD from position $C_1 D_1$ to $C_2 D_2$

1. Draw construction lines from point C_1 to C_2 and from point D_1 to D_2.
2. Bisect line $C_1 C_2$ and line $D_1 D_2$ and extend the perpendicular bisectors
3. Draw the output link $O_4 C$ in both extreme cases, and ensure desired angle
4. Draw a circle with radius $B_1 B_2 / 2$ The radius is the length of the sixth link.



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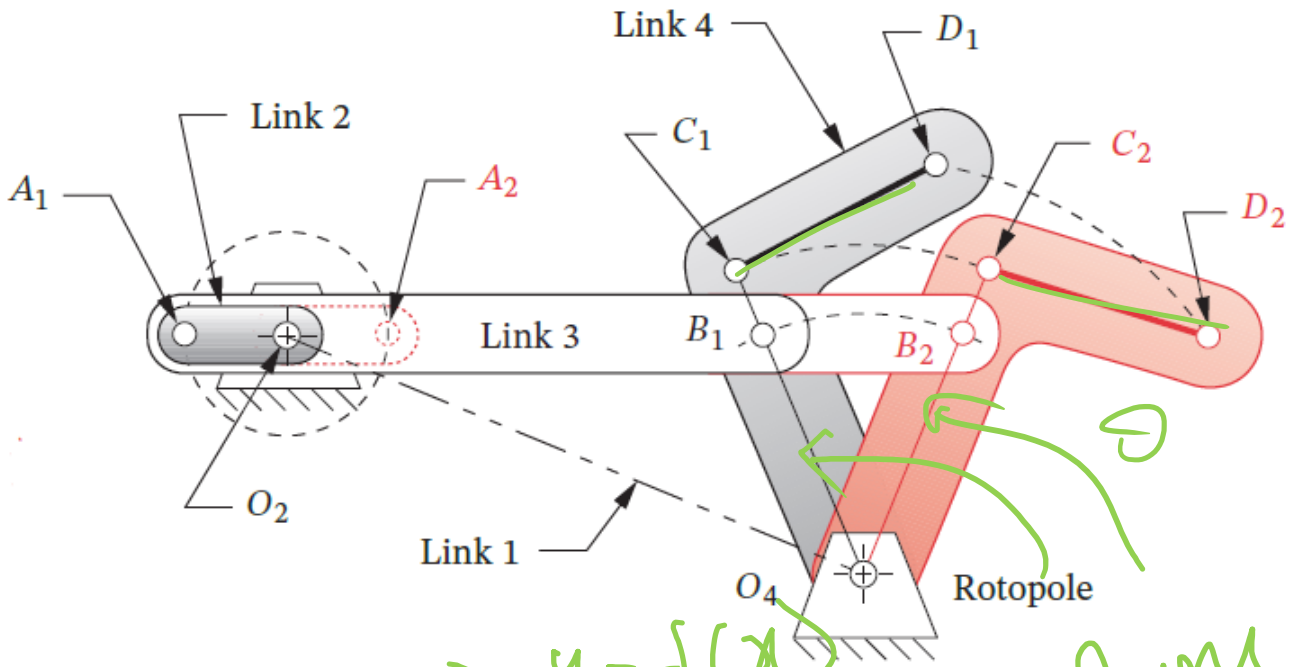
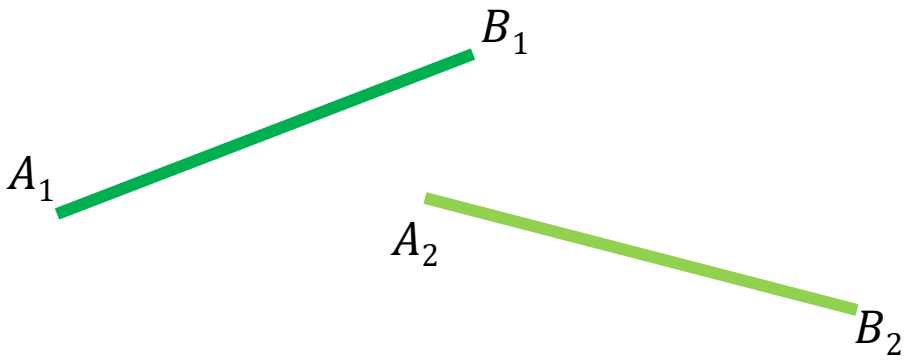


Coupler Output - Two Positions with Complex Displacement. (Motion Generation)

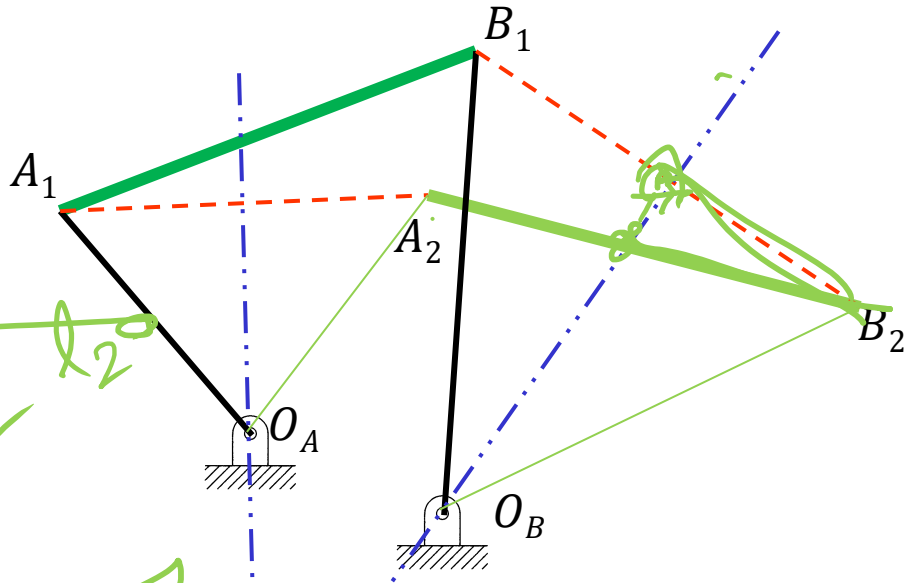


Two positions, coupler as the output

1. Draw the link AB in its two desired positions, A_1B_1 and A_2B_2
2. Connect A_1 to A_2 and B_1 to B_2.
3. Draw two lines perpendicular to A_1A_2 and B_1B_2 at the midpoint (midnormals).
4. Select two fixed pivot points, O_2 and O_4, anywhere on the two midnormals.
5. Measure the length of all links,

   O_2A = link 2, AB = link 3,

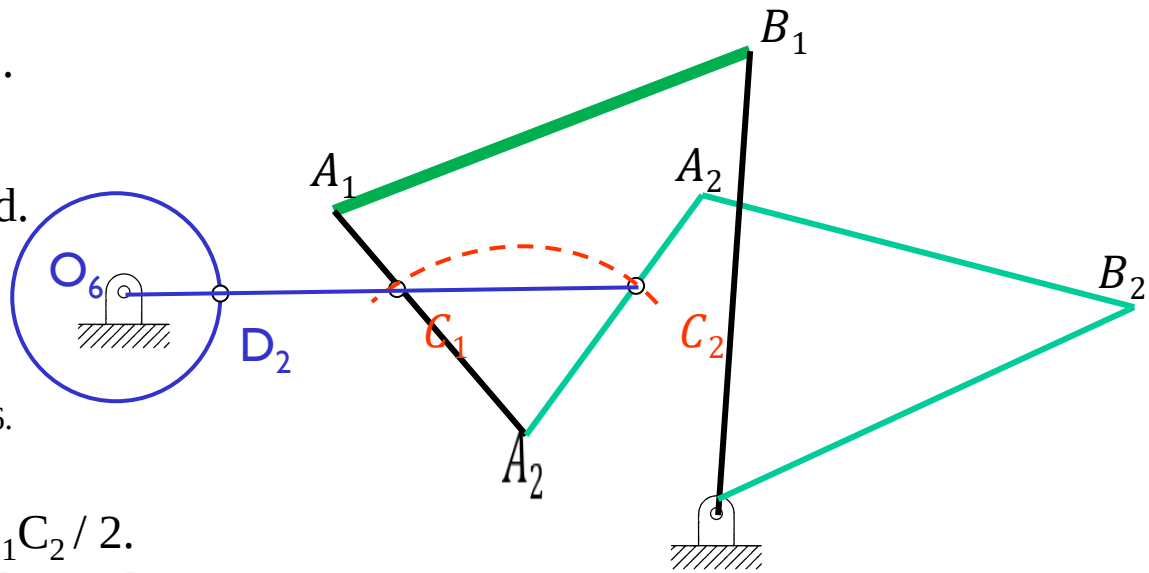
   O_4B = link 4 and O_2O_4 = link 1



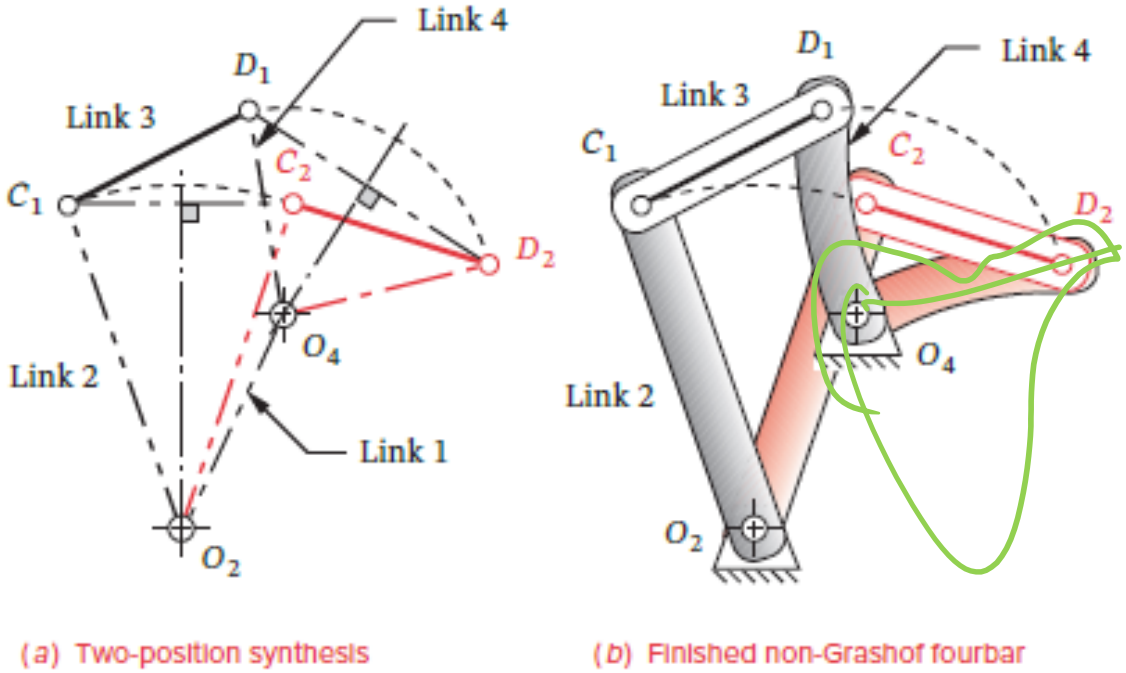
Coupler Output - Two Positions with Complex Displacement. (Motion Generation)

Adding a Dyad to a non-Grashof mechanism.

1. Draw the four bar in both positions
2. Select any point C on link 2.
3. Connect C_1 to C_2 and extend.
4. Select any location on this line for third fixed pivot, O_6.
5. Draw a circle with radius C_1C_2 / 2. The radius is the length of the sixth link.
6. Measure O_6D = link 6, DC = link 5



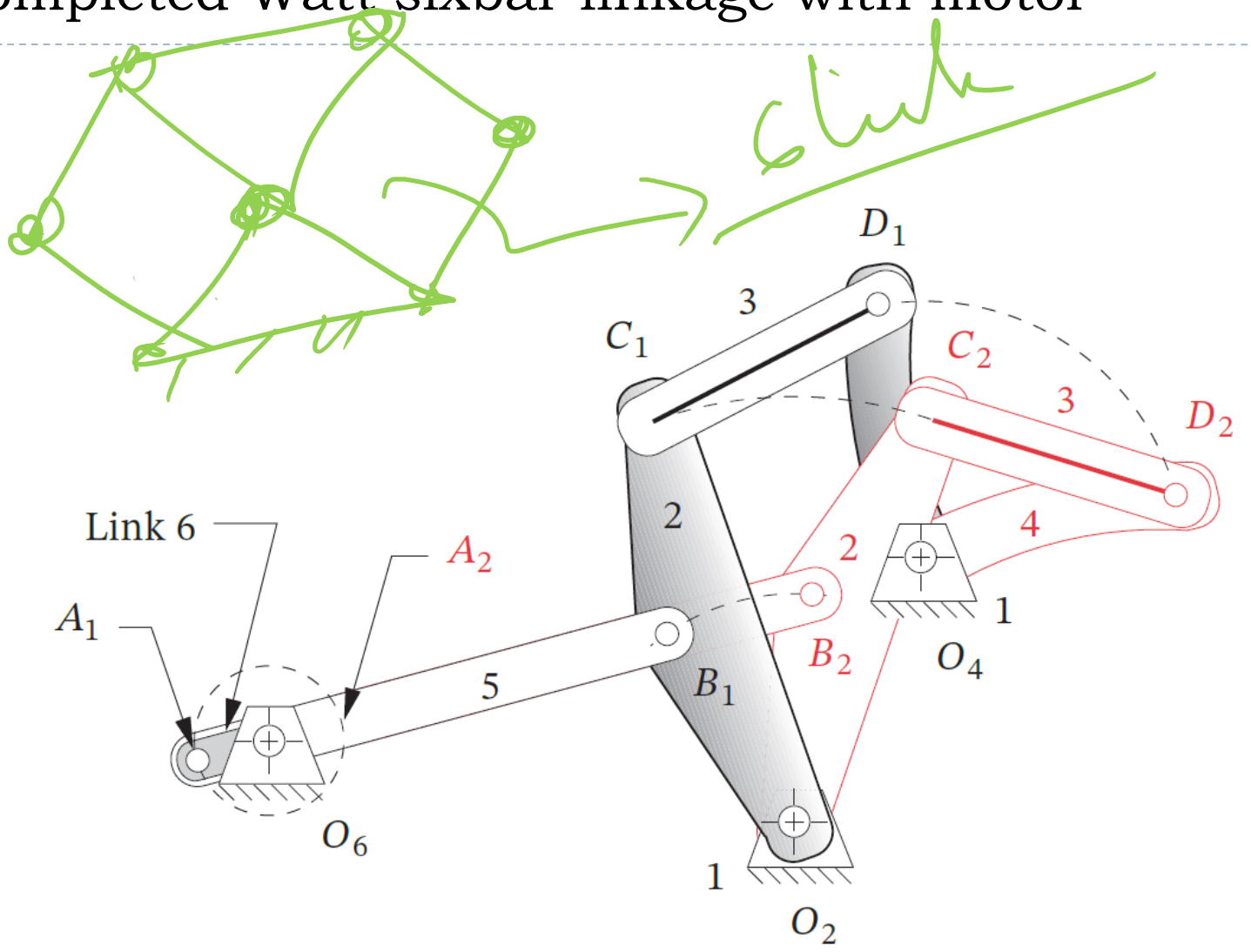
Coupler Output - Two Positions with Complex Displacement. (Motion Generation)



(a) Two-position synthesis

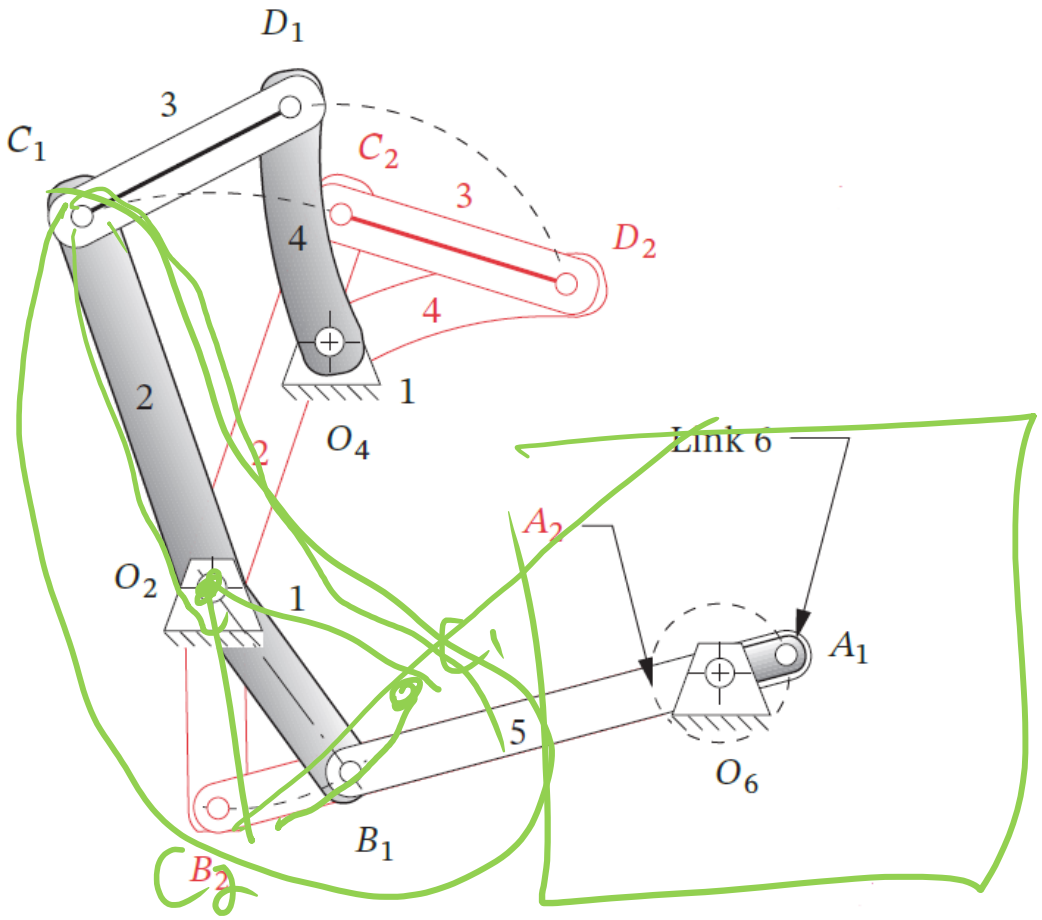
(b) Finished non-Grashof fourbar

Completed Watt sixbar linkage with motor

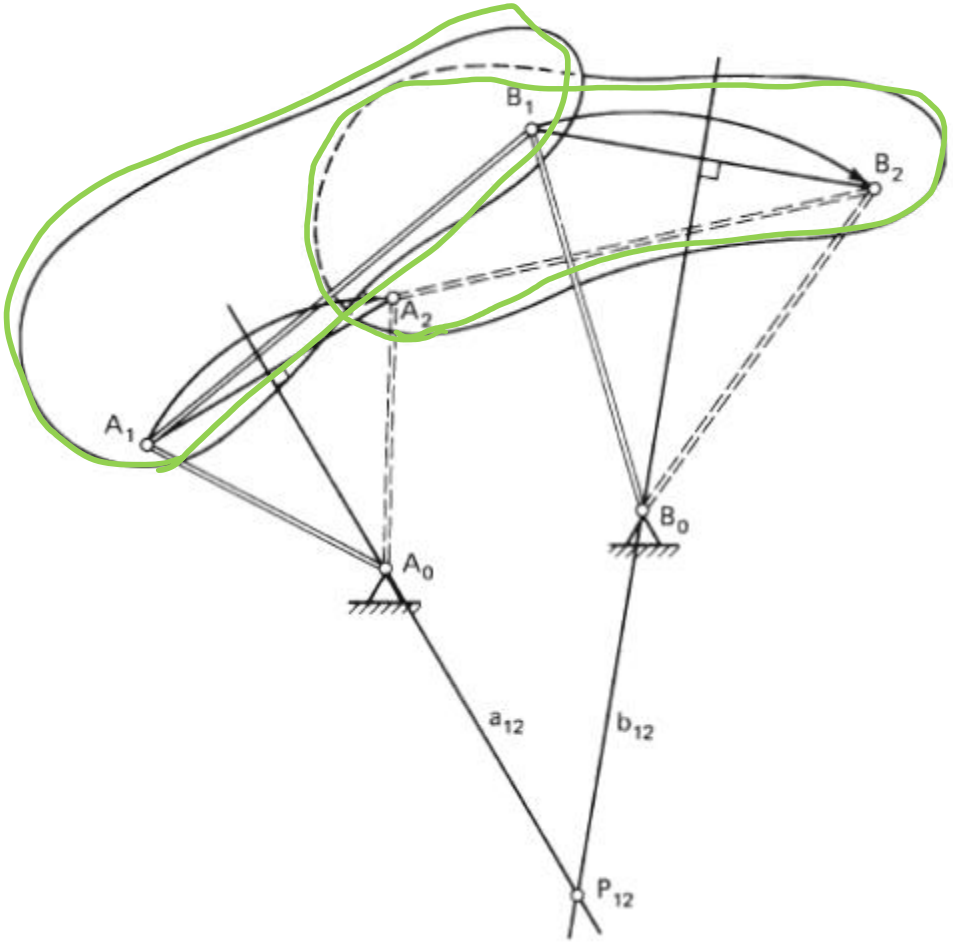


Completed Watt sixbar linkage with motor

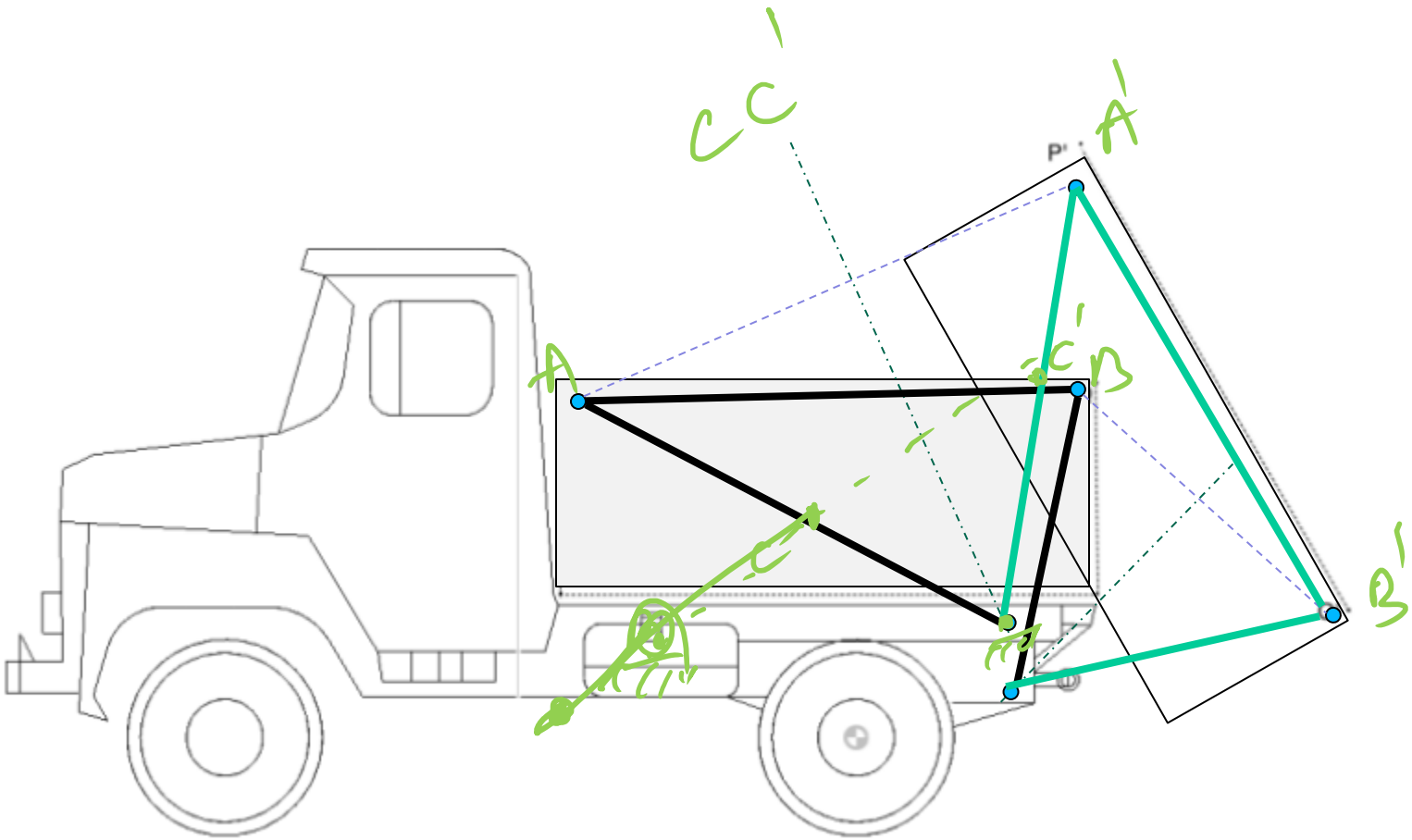
- There is an infinity of driver dyads possible that will drive any double-rocker assemblage of links



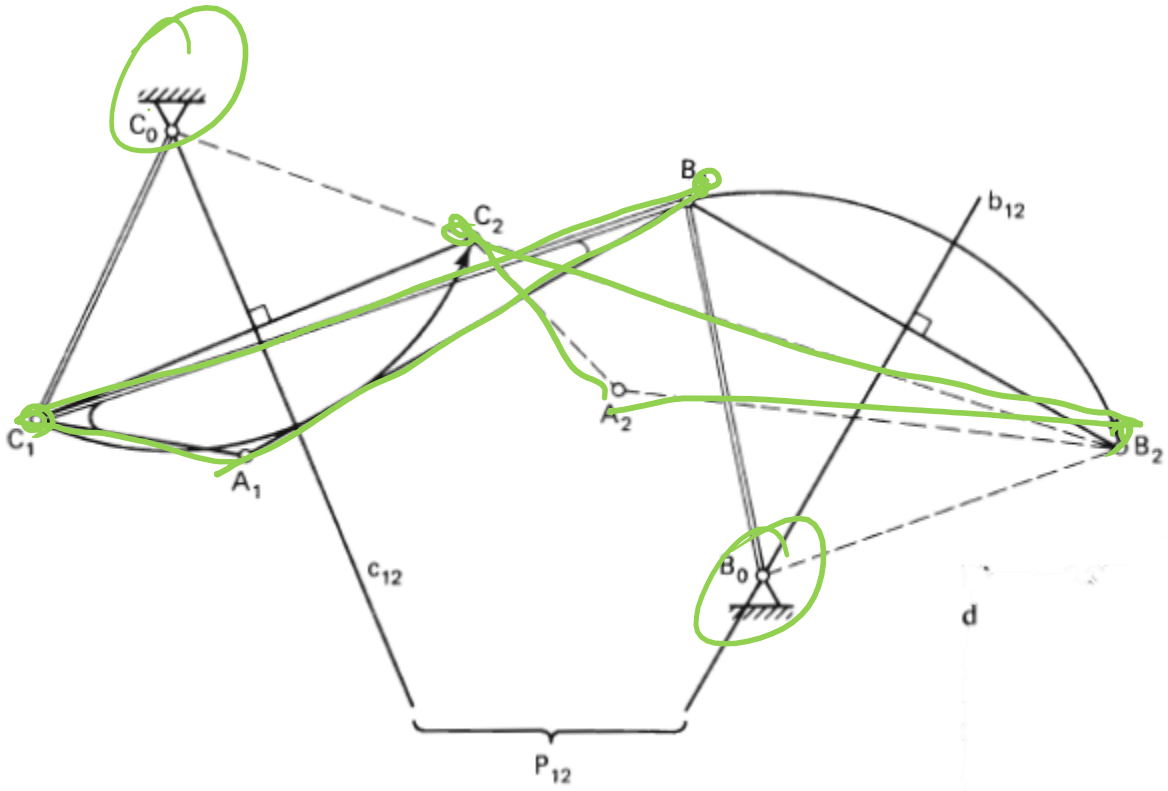
Graphical Synthesis - Motion generation: 2 prescribed position

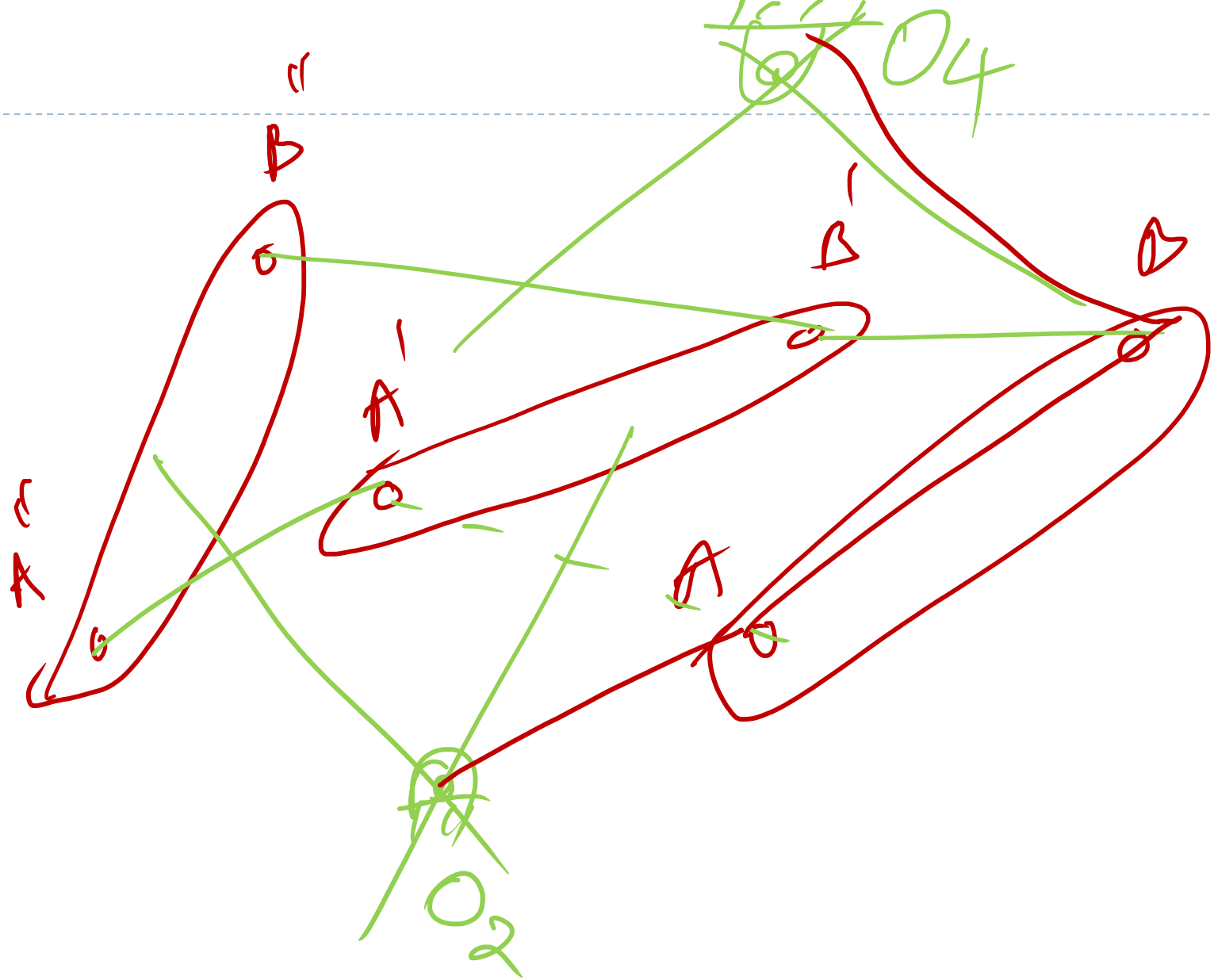


Graphical Synthesis - Motion generation: 2 prescribed position

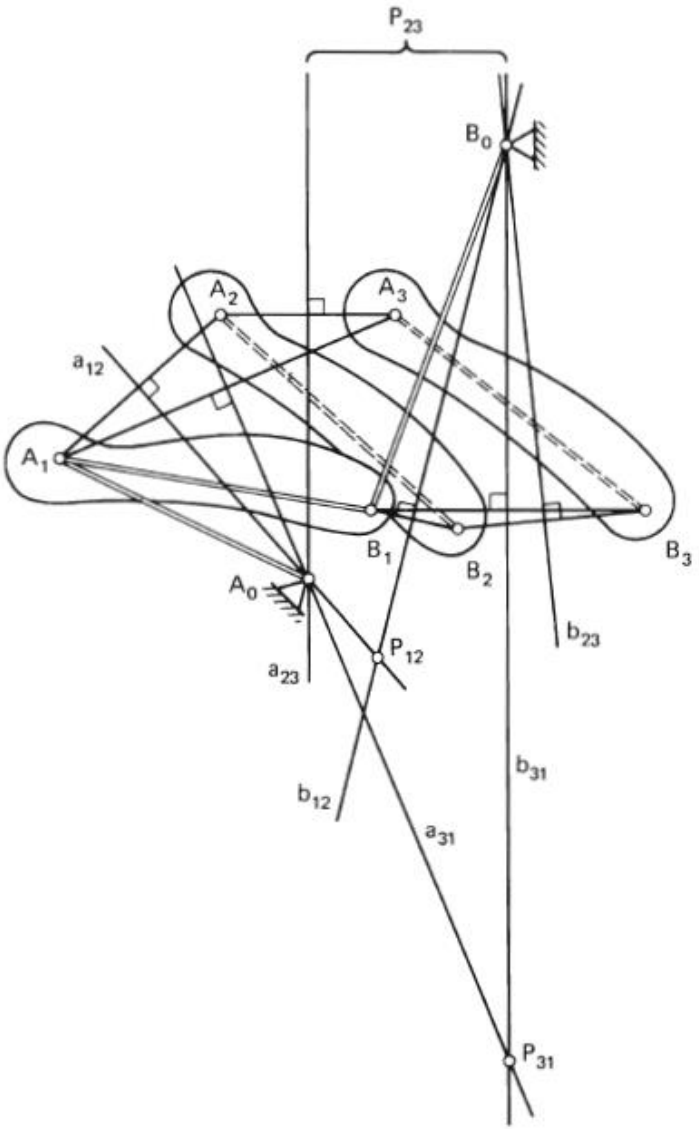


Graphical Synthesis - Motion generation: 2 prescribed position

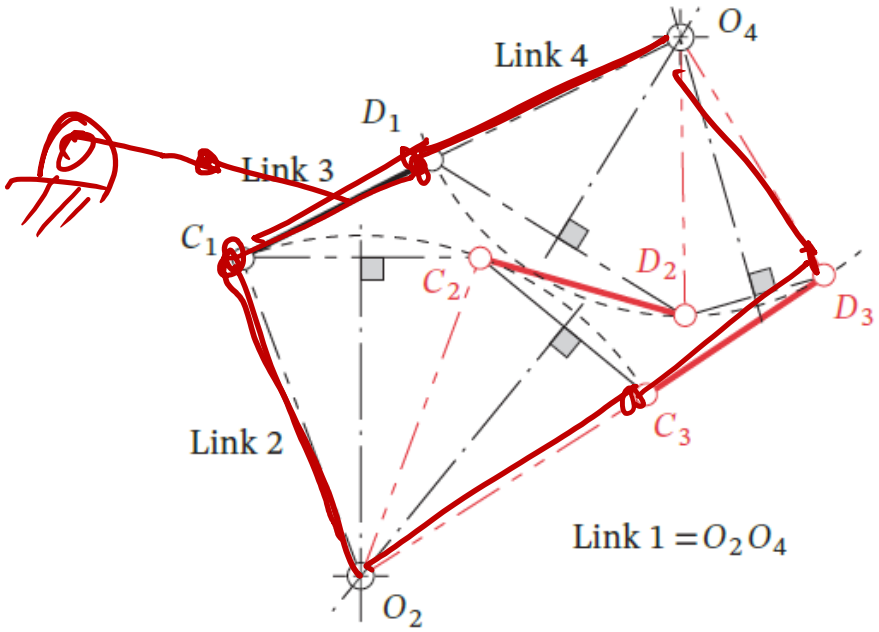



O4
O2

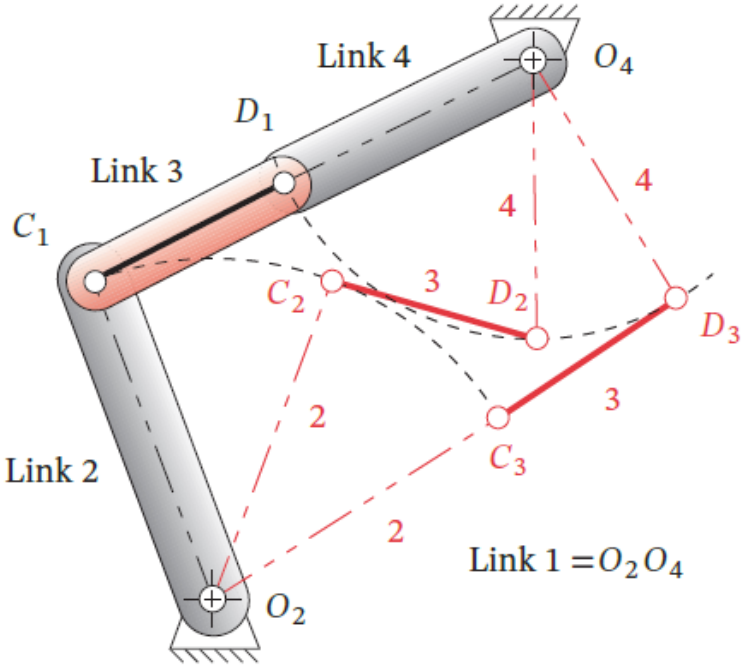
Graphical Synthesis - Motion generation: 3 prescribed position



Coupler Output - 3 Positions with Complex Displacement. (Motion Generation)

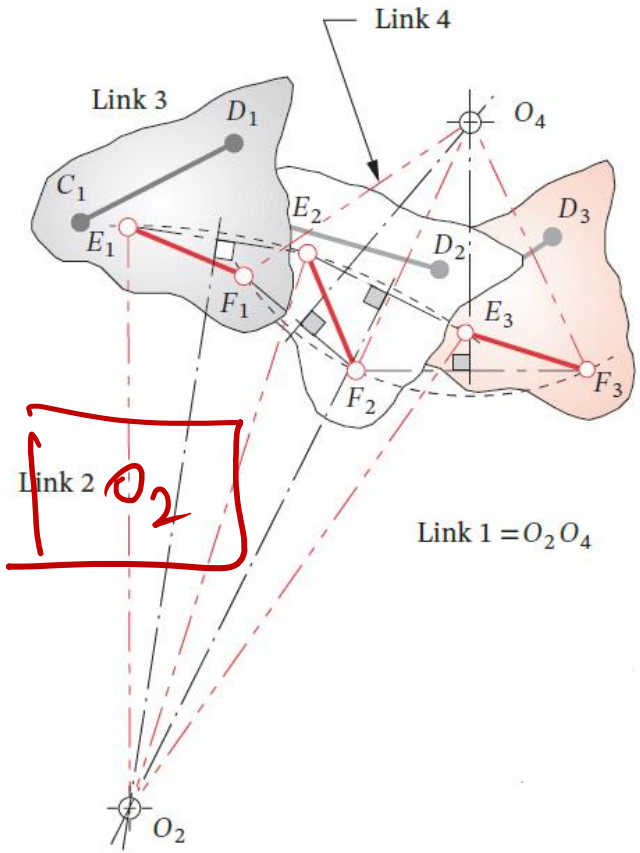


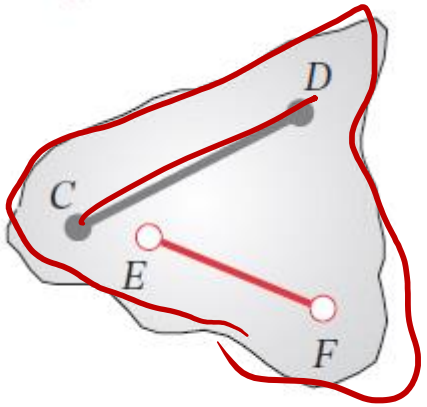
(a) Construction method



(b) Finished non-Grashof fourbar

Coupler Output - Three Positions with Complex Displacement - Alternate Attachment Points for Moving Pivots. (Motion Generation)





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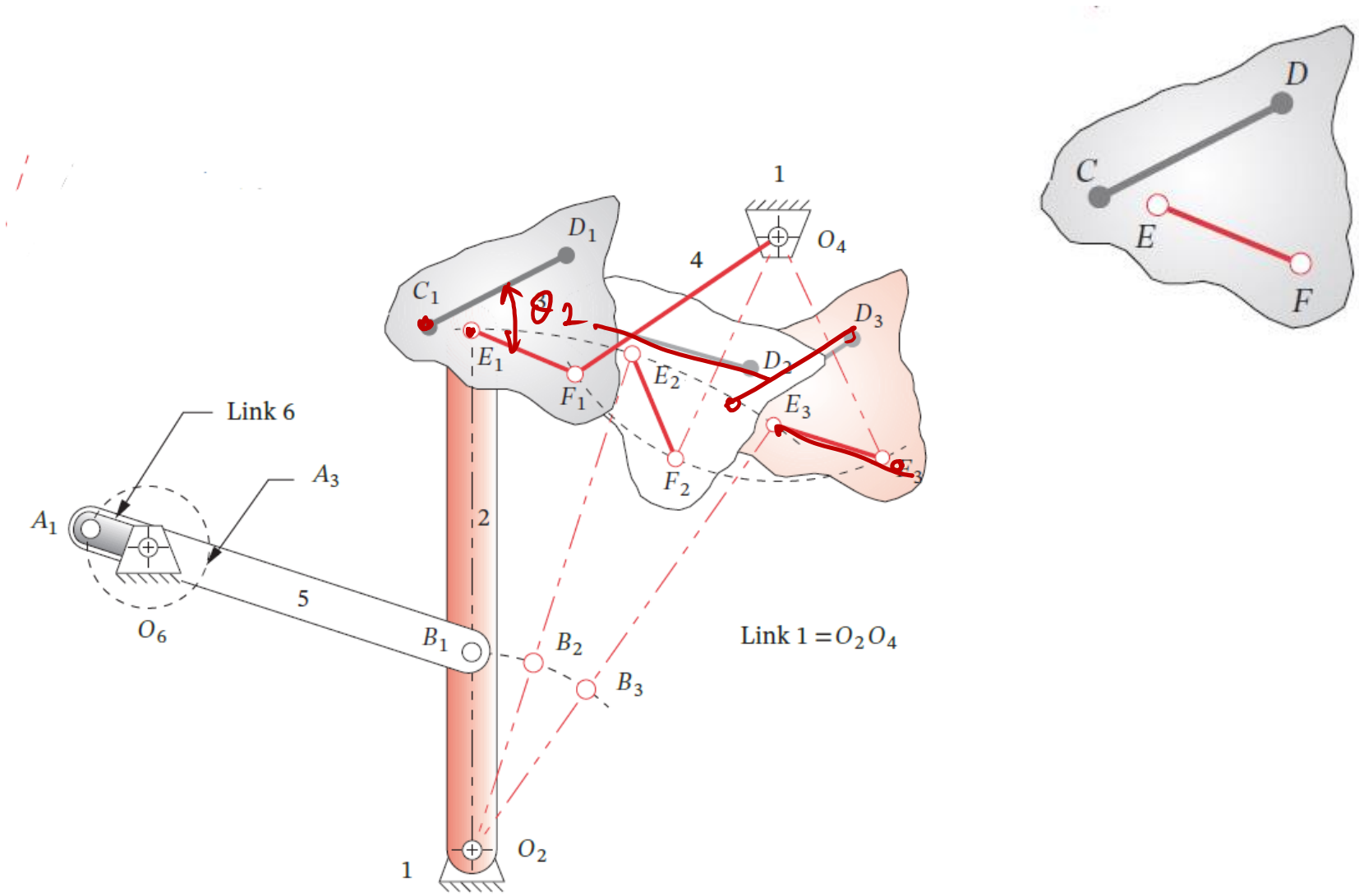
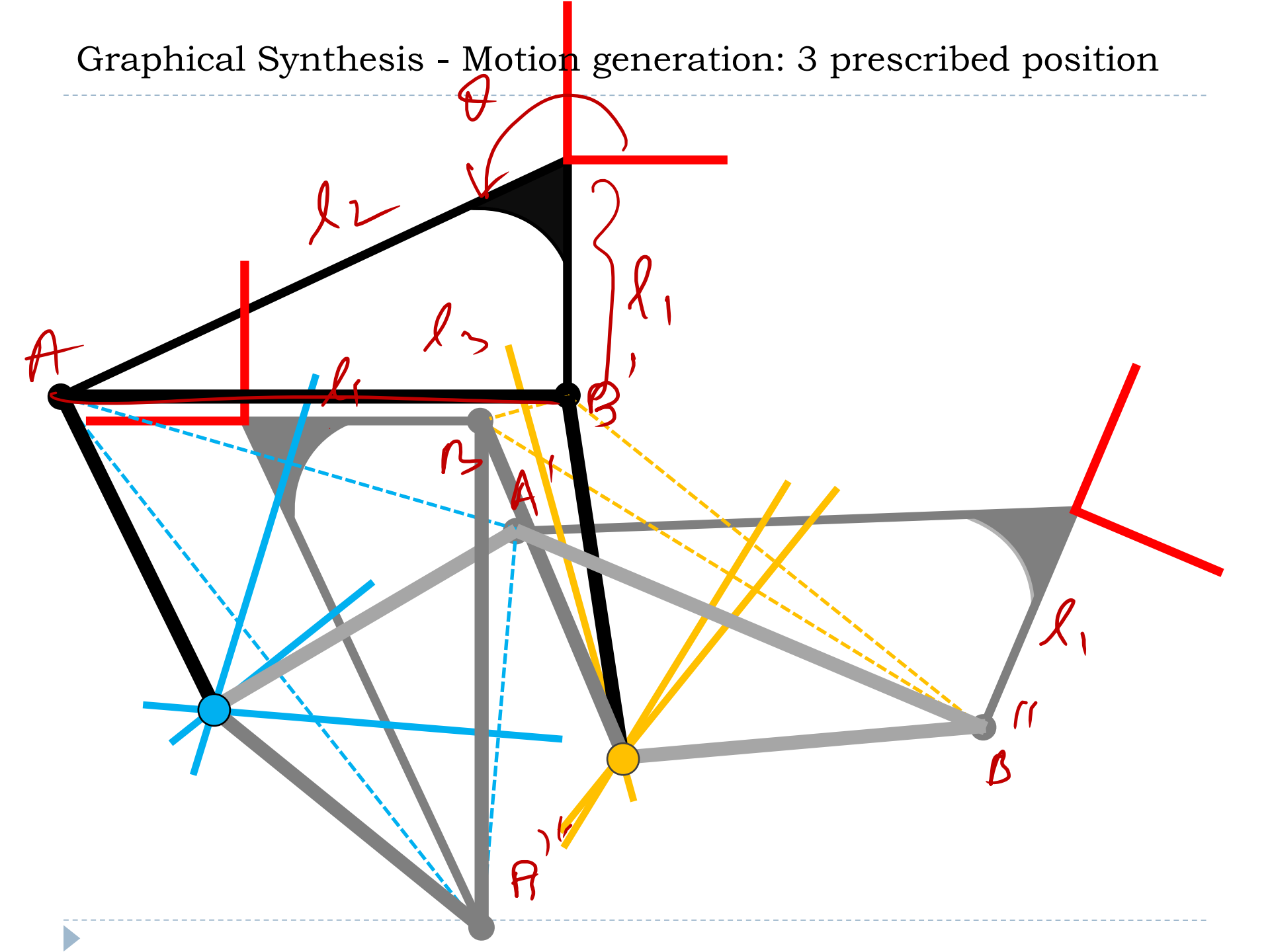
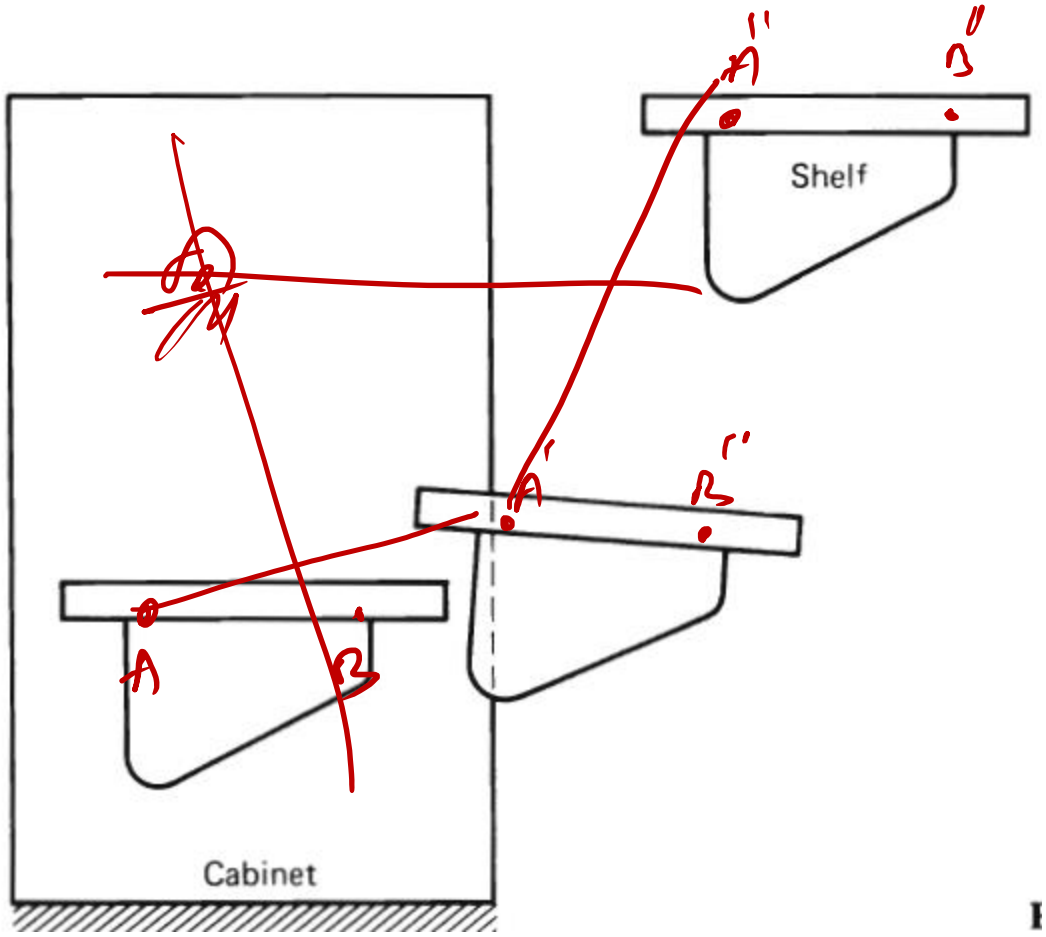
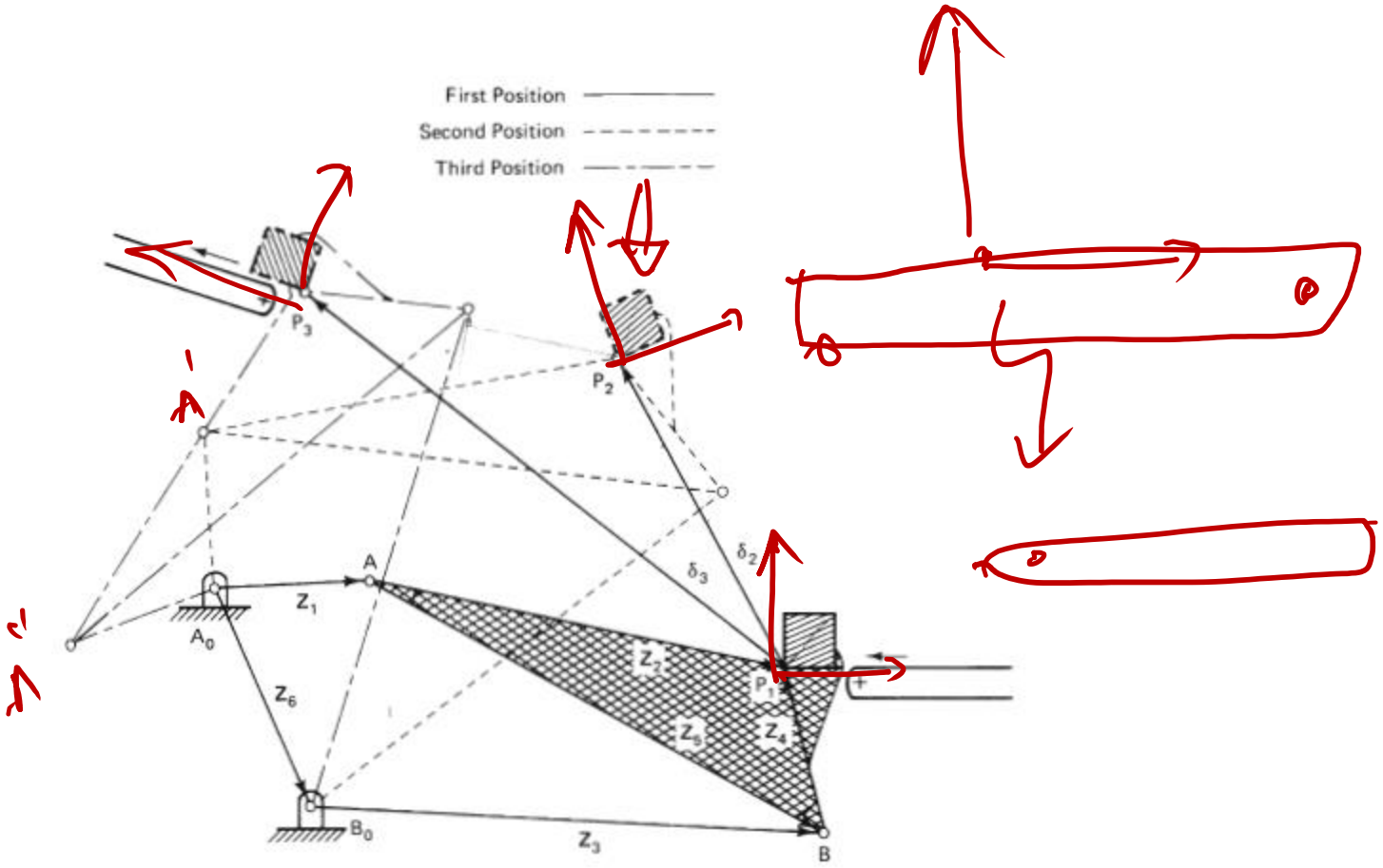


Graphical Synthesis - Motion generation: 3 prescribed position




Shelf
Cabinet


First Position
Second Position
Third Position
P3
P2
P1
A
A0
B
B0
Z1
Z2
Z3
Z4
Z5
Z6
δ2
δ3