# Lecture 6

# Linkage Synthesis II

ME 370 - Mechanical Design 1

*“Colibri” by Derek Hugger*

** www.youtube.com/watch?v=1scj5sotD-E*

# Topic 2: Graphical Linkage Synthesis

- Graphical synthesis types and general strategies
  - Generation types and strategies
- Two-position synthesis
  - Rocker output
  - Coupler output
  - Rotopoles
- Dyad drivers
- Quick return mechanisms
- Three-position synthesis
  - Specified moving points
  - Alternate moving points
  - Specified moving points & fixed points (video lecture with Jupiter notebook)
- Path Synthesis
  - Atlas of curves

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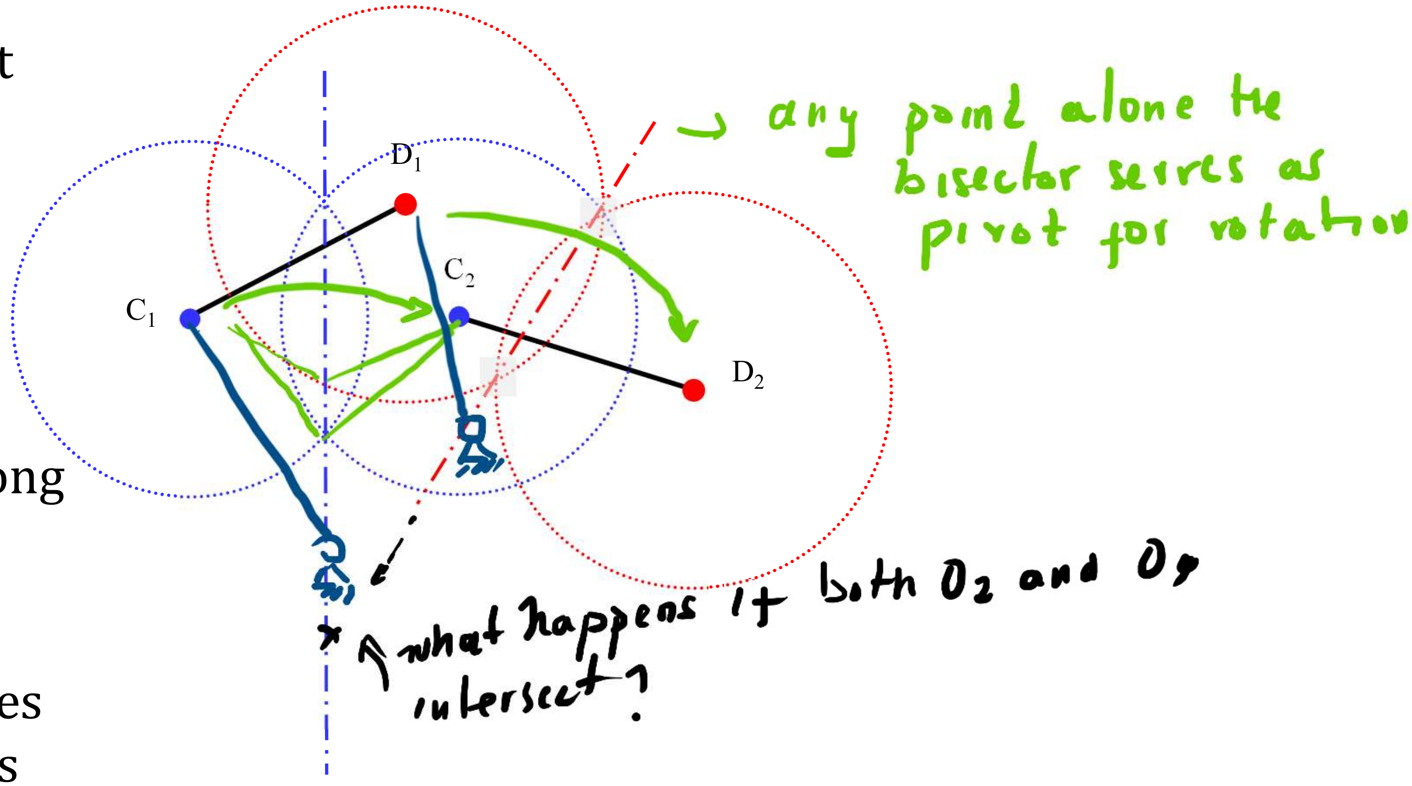
# Recall: Lots of design freedom with 2-position synthesis

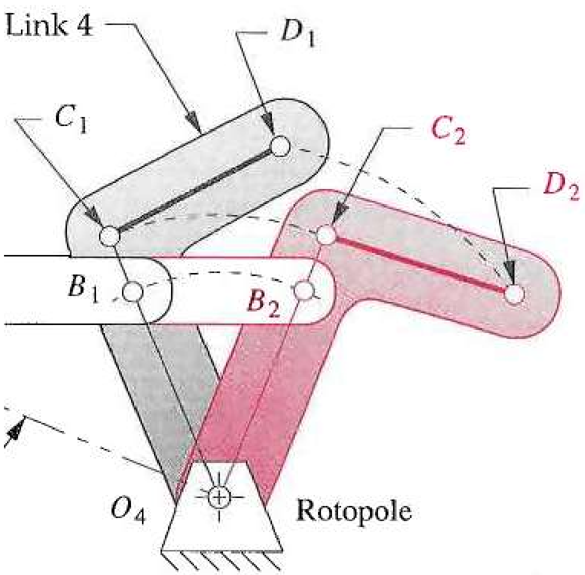
- The pin-joint of the first link can be located ANYWHERE along the bisecting line.
- The pin-joint of the second link can be located located ANYWHERE along the bisecting line.
- There are an unlimited number of 4-bar linkages that can accomplish this movement

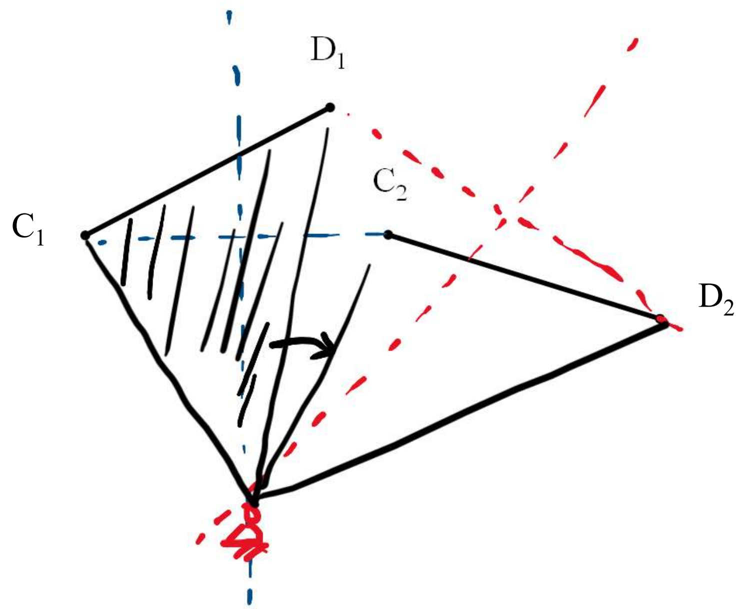


# Two-position synthesis: Rotopole

**Rotopole**: common ground rotation point – converts two-position **coupler output** motion to two-position **rocker output**.
Then treat as crank-rocker.

Advantage: simpler & stronger mechanism
Disadvantage: more specific




Given 2 poses of a line in the plane there is allways a rotation that takes one to the other!

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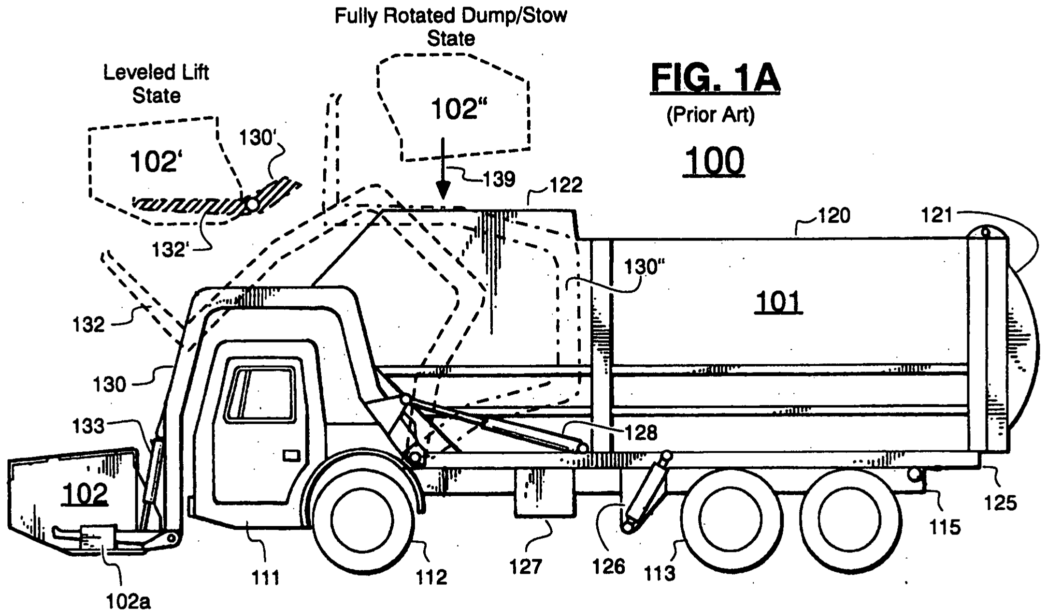
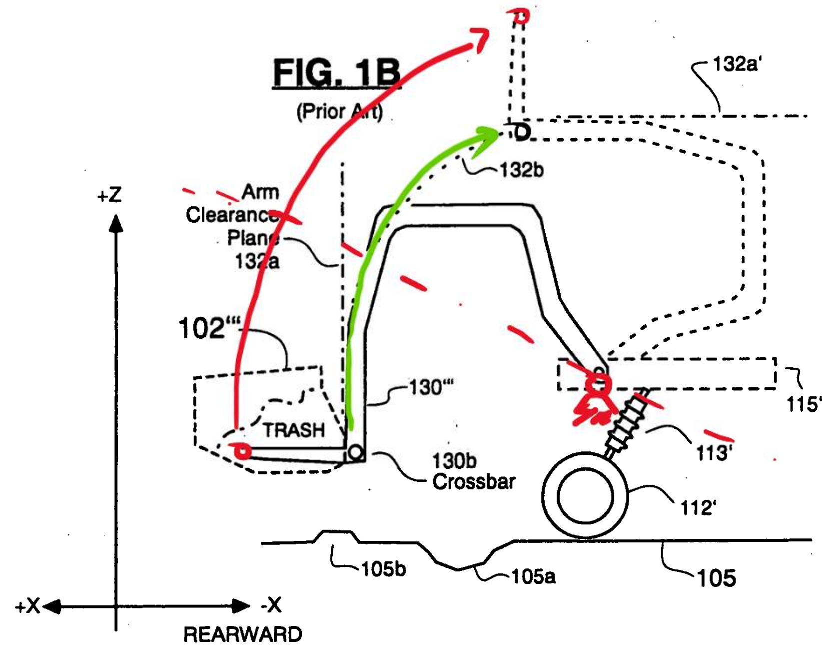
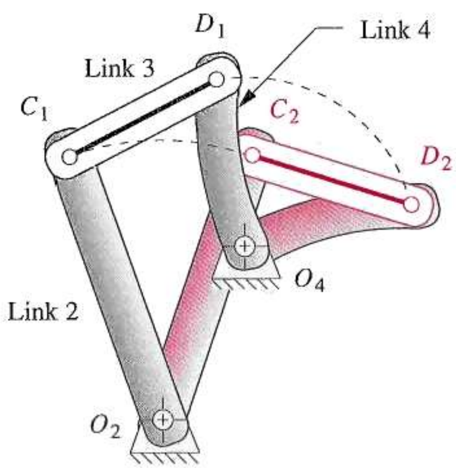
# Rotopole example: Garbage truck

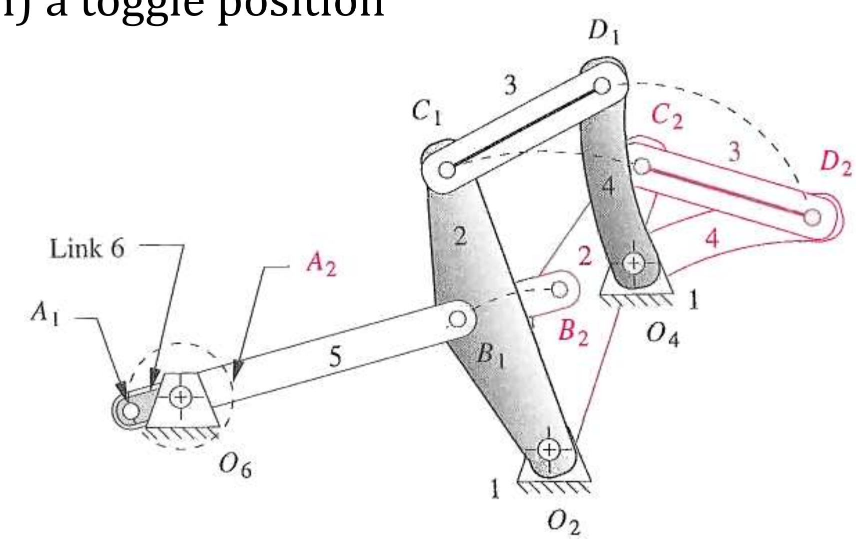


# Dyad drivers

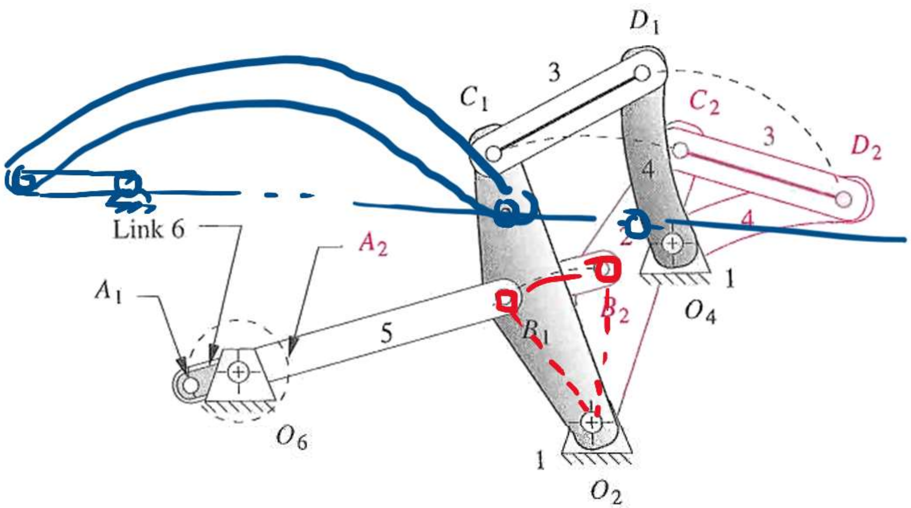
- 2-bar chain added to drive an existing mechanism
- Can be attached to any rocker
- Creates a crank-rocker (Link pinned to the ground)
- Useful for:
    - Adding reciprocating motion to rocker mechanisms
    - Driving a mechanism out of (or through) a toggle position

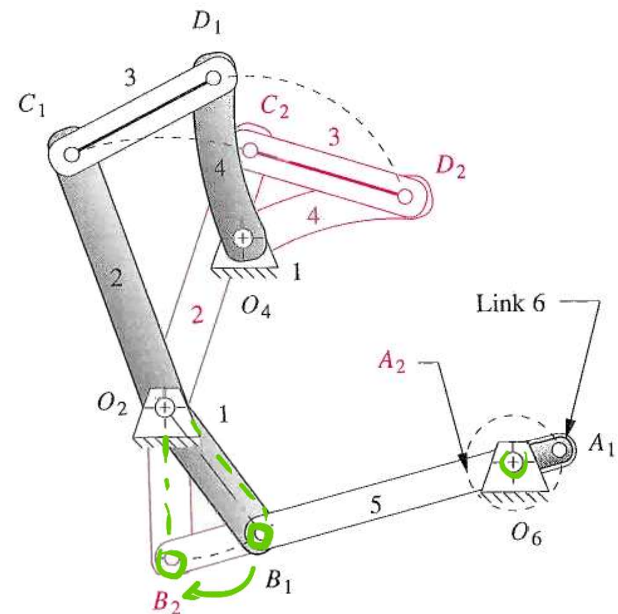


# Possible dyad configurations

- **Important:** Many possible driver designs for a given linkage

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# Dyad synthesis

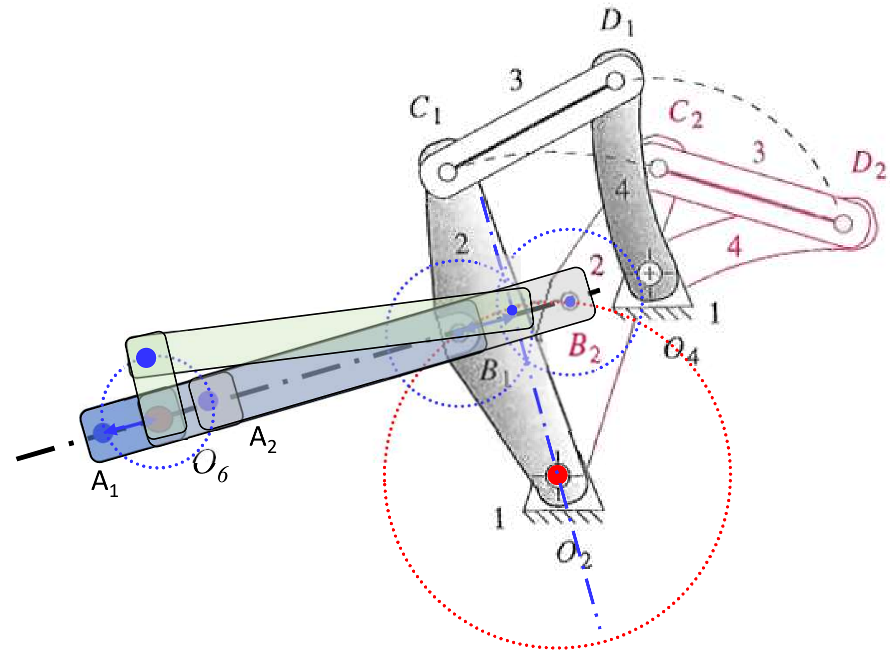
***Add:* 2-bar chain added to drive an existing mechanism.**

Synthesis Steps:

1. Pick $B_1$ anywhere on an existing link (link 2 here)
2. Draw arc about $O_2$ through $B_1$. Note: $B_2$ will be on this arc but in position 2.
3. Complete steps 1-6 for a 2-position rocker output synthesis

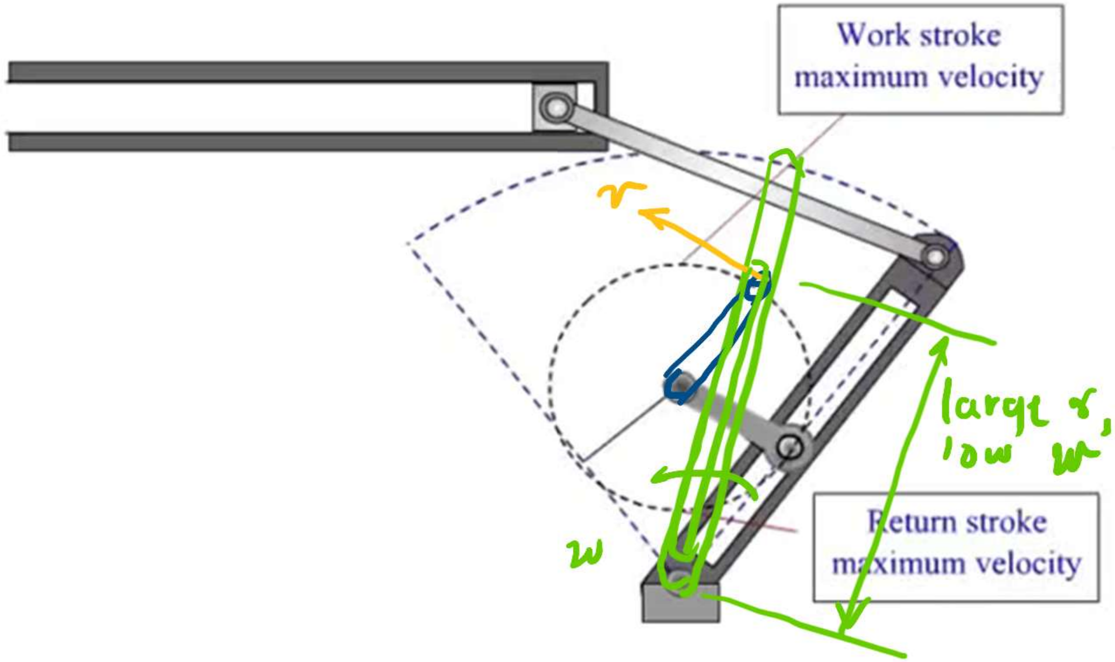
2-position rocker output synthesis steps:

1. Extend $B_1B_2$.
2. Pick $O_6$.
3. Bisect $B_1B_2$. Use distance as radius around $O_6$.
4. Label $A_1$ & $A_2$.
5. Check for Grashof condition with dyad. Measure lengths of links: $O_6A_2$ (dyad crank), $A_2B_2$ (dyad coupler), $B_2O_2$ (dyad rocker), $O_6O_2$ (dyad ground).
6. If non-Grashof, redo 3-6.



# Quick return motion

- Assuming cranks turn at a constant rate, then the **arc swept area** (of the crank rotation) determines the speed ratio between directions.

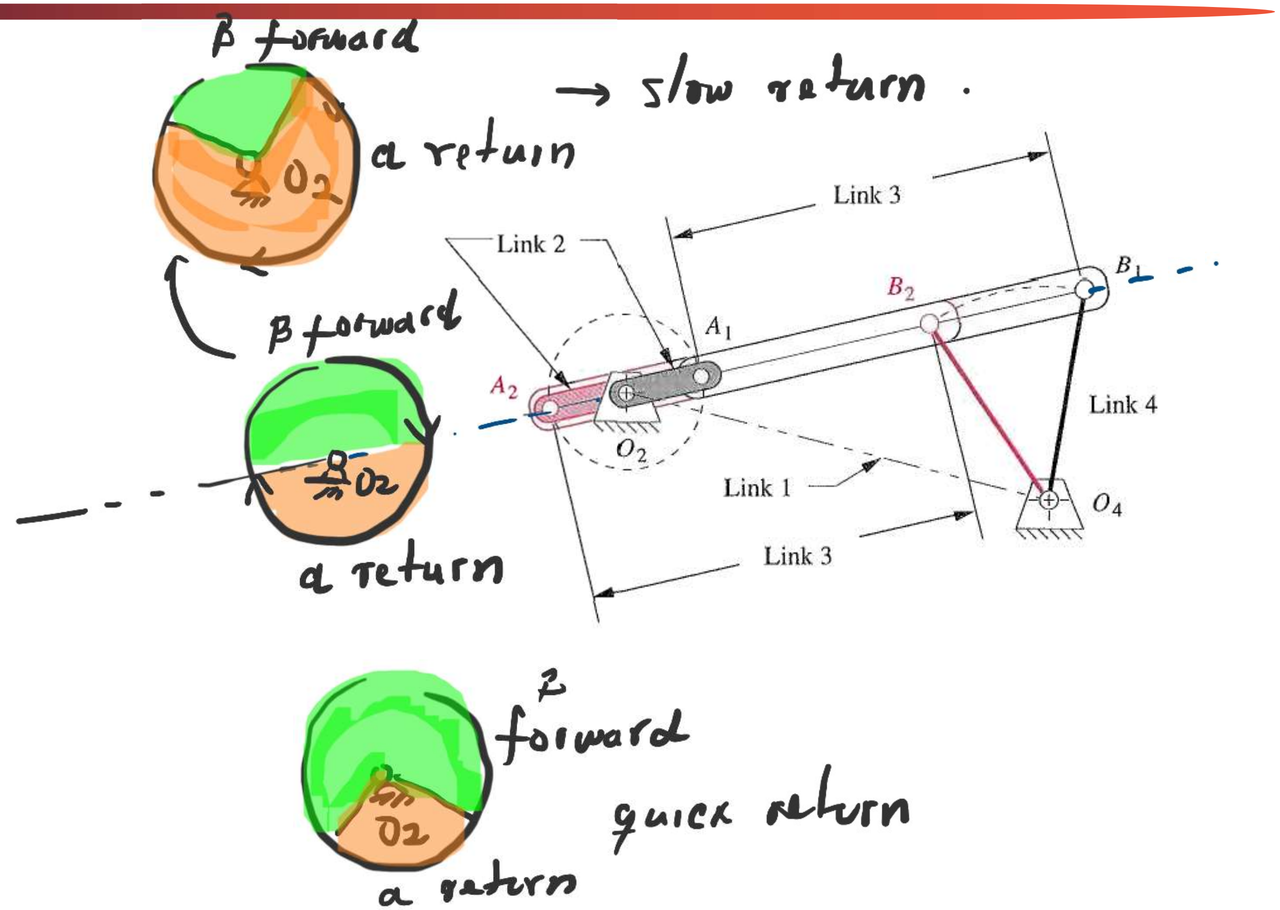



https://www.youtube.com/watch?v=nZCSvbuVU6E

# Quick-return mechanisms

In this mechanism the time back and forth are the same because point $O_2$ is along $B_1B_2$

What happens $O_2$ if is not along $B_1B_2$?

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# Determining quick-return: time ratio $T_R$

1. Determine graphically the arc swept areas between the motions forward and back

$\alpha$: return, $\beta$: forward

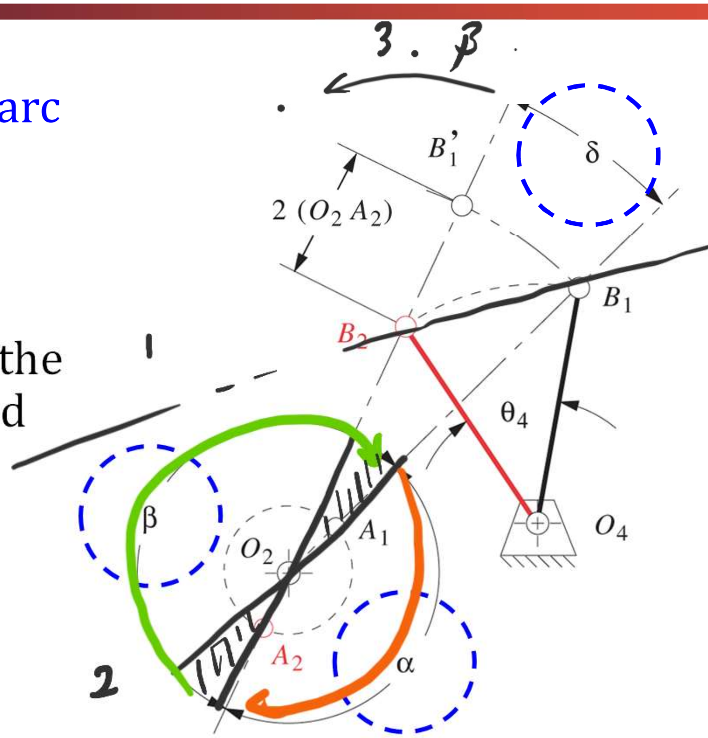
1. Check values knowing δ is the angle between the extended coupler positions:

$$\alpha + \beta = 360$$

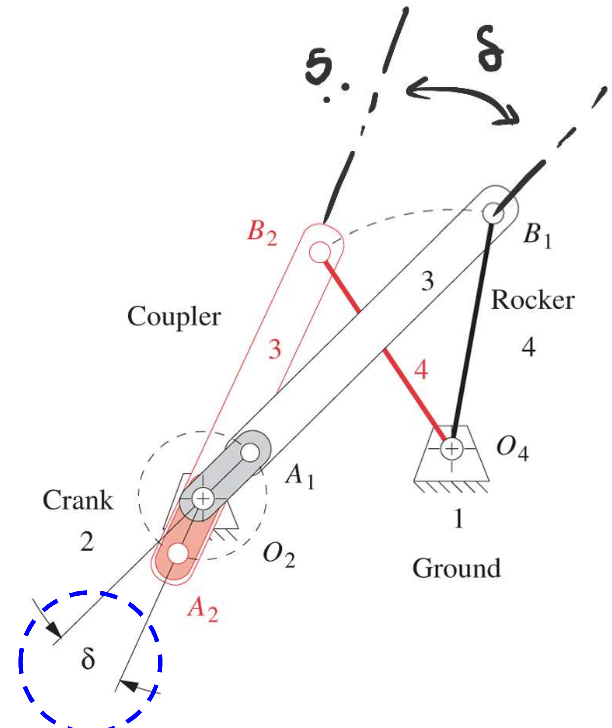
$$\delta = (\beta - \alpha)/2$$

2. Quick return ratio gives the time or speed ratio between motions.

6. $T_R = \alpha / \beta$




4 the relation btw α and β is given by δ

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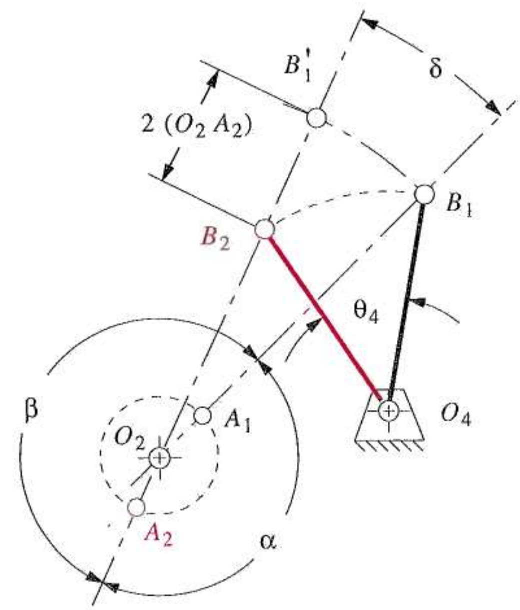
# Synthesizing quick-return mechanisms

1. For a given $T_r$, calculate $\alpha$, $\beta$ and $\delta$
2. Draw a line through point $B_1$ at any convenient angle
3. Draw a line through $B_2$ at angle $\delta$ from the first line, label intersection $O_2$ ($O_2O_4$ defines ground link)
4. Draw an arc centered at $O_2$ from $B_1$ to cut the extended line $O_2B_2$. Label intersection as $B_1$'
5. The length of the crank is 0.5 ($B_2B_1$')
6. Draw an arc centered at $O_2$ with a radius= 0.5 ($B_2B_1$'). Label $A_1$ and $A_2$ along $O_2B_1$ and $O_2B_2$, respectively.
7. Check for Grashof. If non-Grashof, repeat 2-6.




(a) Construction of a quick-return Grashof crank-rocker

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# Example of constructing a quick return

1. For a given TR calculate $\alpha$, $\beta$ and $\delta$
2. Draw a line through point B1 at any convenient angle
3. Draw a line through $B_2$ at angle $\delta$ from the first line, label intersection $O_2$ ($O_2O_4$ defines ground link)
4. Draw an arc centered at $O_2$ from $B_1$ to cut the extended line $O_2B_2$. label intersection $B_1$'
5. The length of the crank is 0.5 $B_2B_1$'
6. Draw an arc centered at O2 with a radius= 0.5 $B_2B_1$'. Label $A_1$ and $A_2$ along $O_2B_1$ and $O_2B_2$, respectively. These points define the extreme positions of the crank rocker.
7. Measure out link lengths. Check for Grashof. If non Grashof repeat 2-6

.1 $Tr = \frac{\alpha}{\beta}$, $\alpha + \beta = 360$ → solve $\alpha, \beta$ → Solve $\delta = (\beta - \alpha)/2$