2.1. Types of Synthesis of Mechanisms

- Function generation
  The correlation of an input motion with an output motion.
  \[ \theta = f(\beta) \]
  - Mechanical analog computers
  - Mechanical function generators applications
    - Artillery rangefinders and shipboard gun aiming system

- Path generation
  The control of a point in the plane such that it follows some prescribed path.
2.1. Types of Synthesis

- **Motion generation**

  The control of a line in the plane such that it passes some prescribed set of sequential positions. Orientation of the link containing the line is important.

---

The course scope: Motion Two Position Synthesis

---

2.2. Extreme positions

- **4 bar mechanism**

---

Theory of machines and multibody (MCT251) – Chapter 2: Graphical Linkage Synthesis

Hedaya, M.
2.2. Extreme positions (cont.)

- From A
  Open the compass with length $AB + BC$

- From D
  Open the compass with length $DC$

---

2.2. Extreme positions (cont.)

- From A
  Open the compass with length $BC - AB$

- From D
  Open the compass with length $DC$
2.2. Extreme positions (cont.)

- From 1 to 2: $\beta$
- From 2 to 1: $\varphi$

\[
\delta = \beta - 180^\circ =, \delta = 180^\circ - \varphi \\
\delta = 180^\circ - \varphi \\
2\delta = \beta - \varphi
\]

2.3. Synthesis of four-bar mechanism

2.3.1. Rocker-output

2.3.1.1. Equal time for go and return

Angular displacements

Complex motion

2.3.1.2. Quick return

2.3.2. Coupler-output
2.3.1.1. Rocker-output, equal time for go and return

- Angular displacement

![Diagram](image)

- Ground: OQ
- Crank: OA
- Coupler: AB
- Output: QB
2.3.1.1. Rocker-output, equal time for go and return (cont.)

- **Angular displacement**
  - **Given**
    - Angle
  - **Steps**
    1. Draw the output link in both extreme positions, in any convenient location.
    2. Draw the chord $B_1B_2$ and extend it in any convenient direction.
    3. Select a convenient point $O$ on line $B_1B_2$ extended.
    4. Bisect line segment $B_1B_2$, and draw a circle of that radius about $O$.
    5. Label the two intersections of the circle and $B_1B_2$ extended, $A_1$ and $A_2$.
    6. Measure the length of the coupler as $A_1$ to $B_1$ or $A_2$ to $B_2$.
    7. Measure ground length, crank length, and rocker length.

"Theory of Machines and Multi-body (MCT251) - Chapter 2: Graphical Synthesis of Mechanisms" by Hedaya, M.
2.3.1.1. Rocker-output, equal time for go and return (cont.)

- **Complex motion**
  - Ground: OQ, specific position of Q
  - Crank: OA
  - Coupler: AB
  - Output: QBDC (specific shape)

---

- **Given**
  - Two positions of a line

- **Steps**
  1. Draw line from point $D_1$ to $D_2$ and bisect it.
  2. Draw line from point $C_1$ to $C_2$ and bisect it.
  3. Set the intersection of the bisectors as a grounded pair of the rocker.
  4. Construct the rocker.
  5. Draw arc of a suitable radius to determine a connection point B.
  6. Draw the output link in both extreme positions, in any convenient location.
2.3.1.1. Rocker-output, equal time for go and return (cont.)

- Complex motion
  - Given
    - Two positions of a line
  - Steps (cont.)
    7. Draw the chord $B_1B_2$ and extend it in any convenient direction.
    8. Select a convenient point $O$ on line $B_1B_2$ extended.
    9. Bisect line segment $B_1B_2$, and draw a circle of that radius about $O$.
    10. Label the two intersections of the circle and $B_1B_2$ extended, $A_1$ and $A_2$.
    11. Measure the length of the coupler as $A_1$ to $B_1$ or $A_2$ to $B_2$.
    12. Measure ground length, crank length, and rocker length.

2.3.1.2. Rocker-output, quick return

- Angular displacement
2.3.1.2. Rocker-output, quick return (cont.)

- **Angular displacement**
  - Given
    - Angle
  - Steps
    1. Draw the output link in both extreme positions, in any convenient location.
    2. Construct a line through a point $B_1$ in any convenient angle.
    3. Construct a line through a point $B_2$ at angle $\delta$ with the previous line.
    4. Label the intersection of the two lines $O$.
    5. Draw a circle with centre $O$ and radius equal crank length $= (OB_1 - OB_2)/2$.
    6. Label the intersections of the circle and $OB_1$ and with $OB_2$ extension as $A_1$ and $A_2$.
    7. Measure the length of the coupler as $A_1$ to $B_1$ or $A_2$ to $B_2$.
    8. Measure ground length and rocker length.
2.3.2. Coupler-output

- Complex motion

![Diagram](image_url)

- Ground: OQ
- Rockers: OC, QD
- Coupler/Output: CD

---

2.3.2. Coupler-output (cont.)

- Complex motion (cont.)

![Diagram](image_url)
2.3.2. Coupler-output (cont.)

- Complex motion
  - Given
    - Two positions of a line
  - Steps
    1. Draw line from point $D_1$ to $D_2$ and bisect it.
    2. Draw line from point $C_1$ to $C_2$ and bisect it.
    3. Select suitable positions for grounded pairs $O$ and $Q$.
    4. Measure the length of the rockers $OC$ and $QD$
    5. Measure ground length.
    6. Check that the mechanism is double-lever. If not repeat steps from step 3.

2.4. Solved examples

- Design a four-bar mechanism to produce 30° rocking angle of the output.
2.4. Solved examples

- Design a four-bar mechanism to produce 30° rocking angle of the output, where the ratio between forward and return times is 1.5:1.

- Design a four-bar mechanism to transfer the shown box between the shown positions, where the ratio between forward and return times is 1.5:1.
2.4. Solved examples

- Design a four-bar mechanism to transfer the shown box between the shown positions. Use the coupler as an output link.