Design and Production Engineering Department

Chapter 2
Graphical Synthesis of Mechanisms

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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

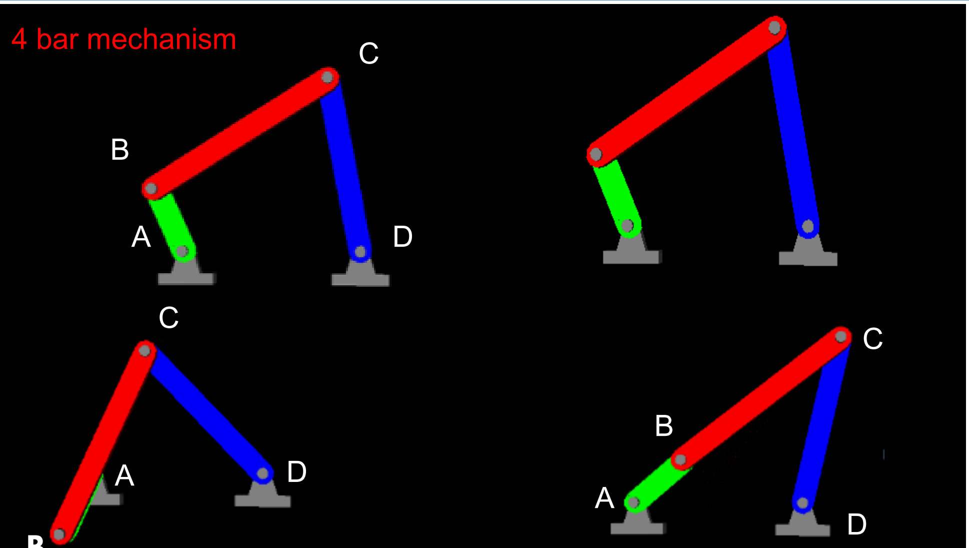
- Motion generation

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



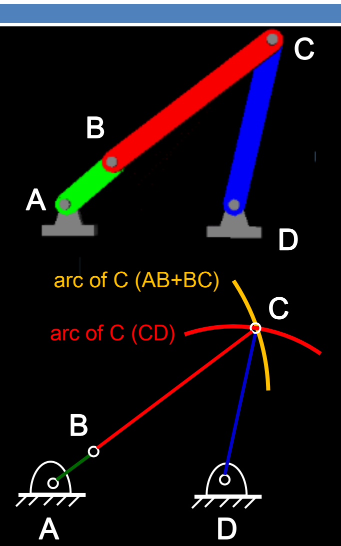
2.2. Extreme positions (cont.)

- From A

Open the compass with length AB+BC

- From D

Open the compass with length DC



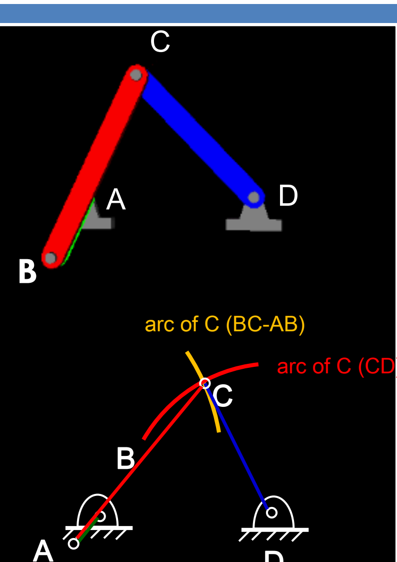
2.2. Extreme positions (cont.)

- From A

Open the compass with length BC - AB

- From D

Open the compass with length DC



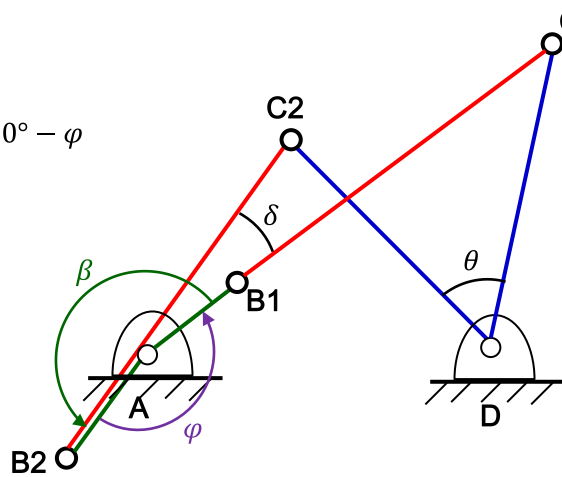
2.2. Extreme positions (cont.)

- From 1 to 2 : β
- From 2 to 1 : φ

$\delta = \beta - 180° =, \delta = 180° - \varphi$

$\delta = 180° - \varphi$

$2\delta = \beta - \varphi$



2.3. Synthesis of four-bar mechanism

2.3.1. Rocker-output

2.3.1.1. Equal time for go and return

Angular displacements

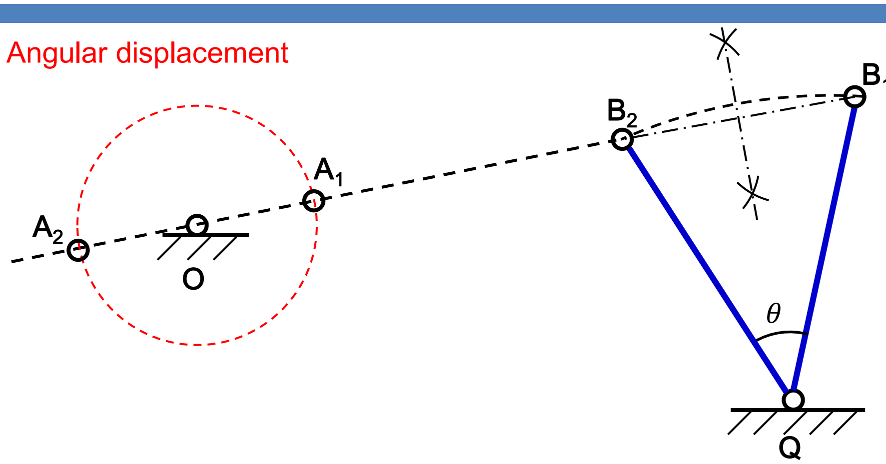
Complex motion

2.3.1.2. Quick return

2.3.2. Coupler-output

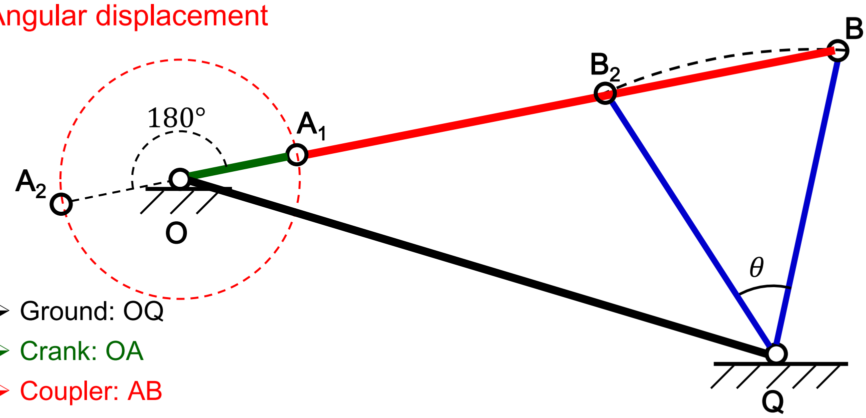
2.3.1.1. Rocker-output, equal time for go and return

- Angular displacement



2.3.1.1. Rocker-output, equal time for go and return (cont.)

- Angular displacement



- Ground: OQ
- Crank: OA
- Coupler: AB
- Output : QB

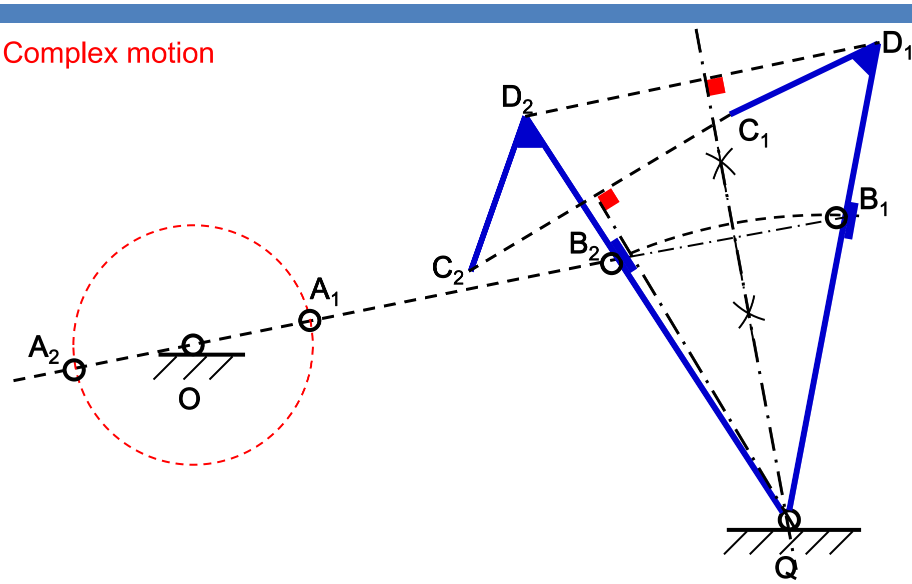
2.3.1.1. Rocker-output, equal time for go and return (cont.)

- 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.

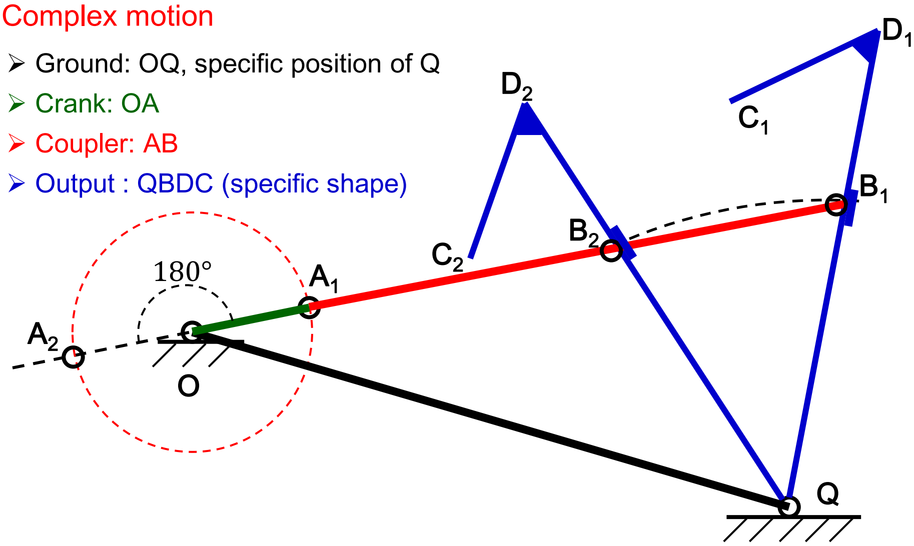
2.3.1.1. Rocker-output, equal time for go and return (cont.)

- Complex motion



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)



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

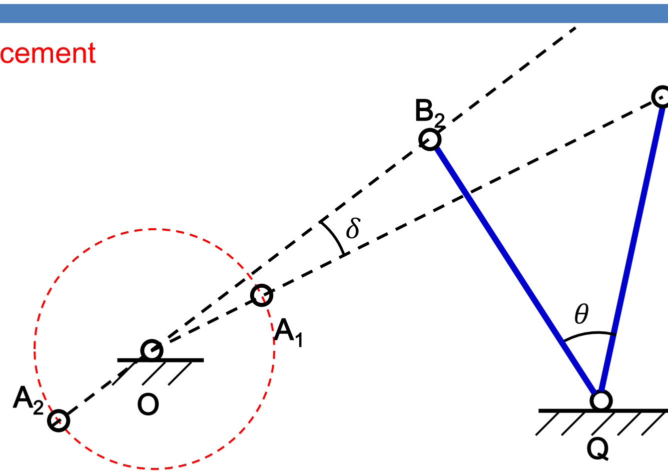
2.3.1.1. Rocker-output, equal time for go and return (cont.)

- 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.

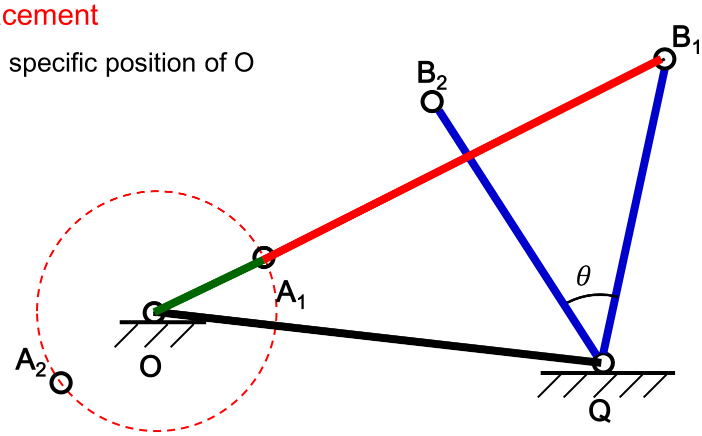
2.3.1.2. Rocker-output, quick return

- Angular displacement



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

- Angular displacement
  - Ground: OQ, specific position of O
  - Crank: OA
  - Coupler: AB
  - Output : QB



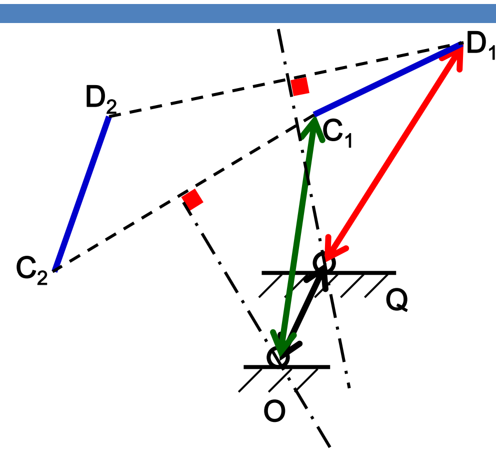
2.3.1.2. Rocker-output, quick return (cont.)

- 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 δ 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.

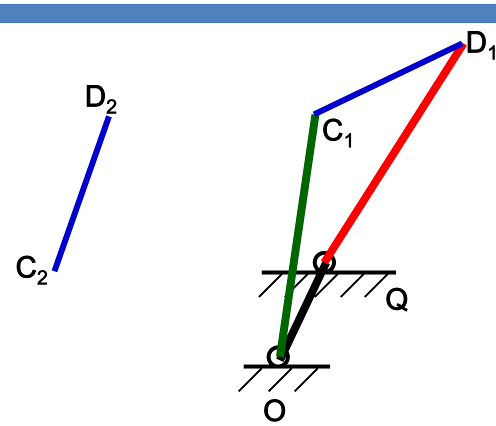
2.3.2. Coupler-output

- Complex motion



2.3.2. Coupler-output (cont.)

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



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

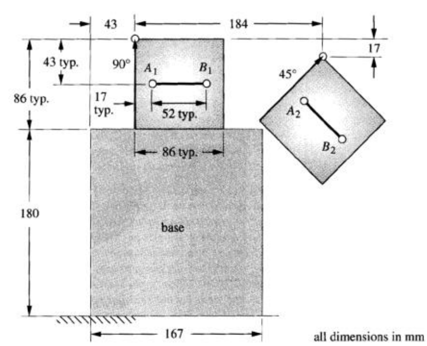
- Design a four-bar mechanism to produce 30° rocking angle of the output.

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.

2.4. Solved examples

- 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.