Design and Production Engineering Department

Chapter 1
Mechanisms

MCT 251

Asst. Prof. Mohammed M. Hedaya

1.1. Definitions

- **Reference frame**

  The coordinates frame considered as a reference.

- **Ground**

  The link which is fixed (no-moving) with respect to reference frame.

  - The reference frame may be moving (e.g. automobile chassis of a crane).

- **Link**

  A rigid body, which is the primary element of a mechanism.

- **Kinematic pair (pair)**

  A joint between links in contact to enable a relative motion between these links.

- **Kinematic chain**

  A of links connected through kinematic pairs.

1.1. Definitions (cont.)

- **Closed kinematic chain**

  A kinematic chain in which the links form a loop.

- **Mechanism**

  A closed kinematic chain with one fixed link.

- **Machine**

  A mechanism used to modify energy or do a useful work.

- **Degrees of freedom (D.O.F.) of a link**

  The number of independent coordinates necessary to determine its position.

  - No. of D.O.F. of a link in space = 6
  - No. of D.O.F. of a link in plane = 3

1.1. Definitions (cont.)

- **Degrees of freedom (D.O.F.) of a chain**

  The number of independent coordinates necessary to determine the positions of its links.

- **Crank**

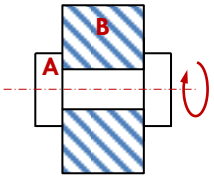
  The link which is pivoted to ground, and makes a complete revolution.

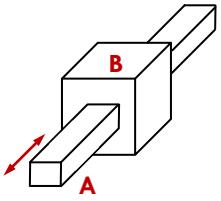
- **Lever (rocker)**

  The link which is pivoted to ground, and makes an oscillatory motion (back and forth).

1.2. Kinematic pairs

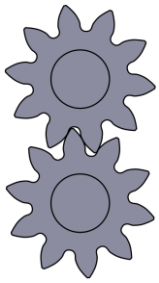
- Types of pairs
  - Lower pair
    - The kinematic pair enables a relative motion which is defined by one coordinate (e.g. turning and sliding pairs).
      - Turning pair
      - Sliding pair

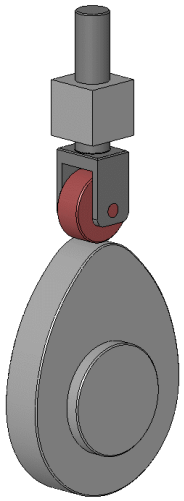




1.2. Kinematic pairs (cont.)

- Types of pairs
  - Higher pair
    - The kinematic pair enables a relative motion which is defined by two independent coordinates in case of plane chains. (cam and gear pairs).





1.2. Kinematic pairs (cont.)

- Degrees of freedom lost by pairing
  - Lower pair

Turning pair

- No. of D.O.F. before pairing

$2\times3 = 6$

- Condition imposed by pairing

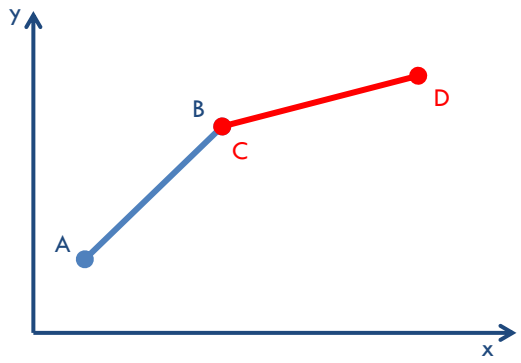
$x_B = x_C$, $y_B = y_C$

- No. of D.O.F. lost by pairing

2

- No. of D.O.F. after pairing

4



1.2. Kinematic pairs (cont.)

- Degrees of freedom lost by pairing
  - Lower pair

Sliding pair

- No. of D.O.F. before pairing

$2\times3 = 6$

- Condition imposed by pairing

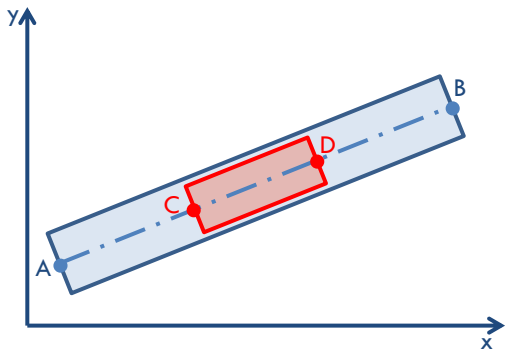
C on AB, D on AB

- No. of D.O.F. lost by pairing

2

- No. of D.O.F. after pairing

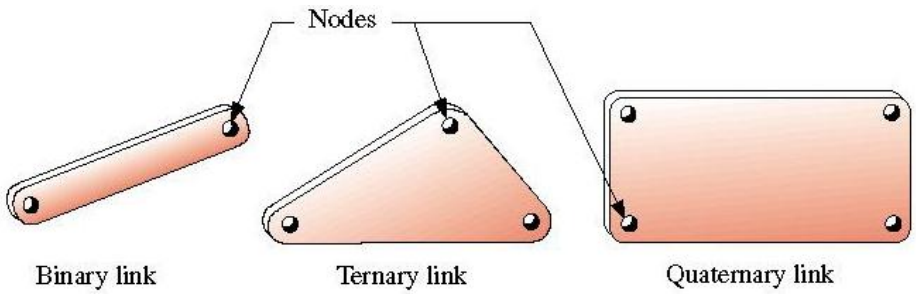
4



1.2. Kinematic pairs (cont.)

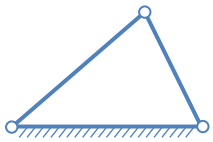
- Degrees of freedom lost by pairing
  - Lower pair = 2
  - Higher pair = 1

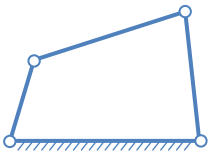
1.3. Types of links



1.4. Degrees of freedom of a mechanism

- Examples





D.O.F. before pairing	3×3 = 9	4×3 = 12
D.O.F. after grounding	9-3 = 6	12-3 = 9
D.O.F. lost by pairing	3×2 = 6	4×2 = 8
D.O.F. after pairing	6-6 = 0	9-8 = 1
	Locked mechanism (Structure)	Mechanism with single input

1.4. Degrees of freedom of a mechanism (cont.)

- Grübler Equation

$$N = 3(L-1) - 2P_l - P_h$$

L: No. of links

P_l: No. of lower pairs

P_h: No. of higher pair

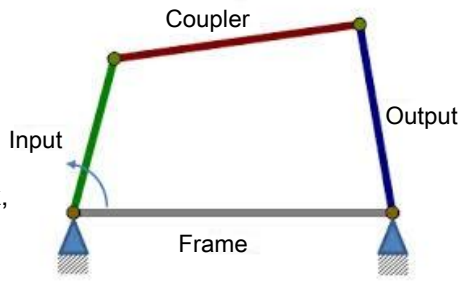
1.5. Four-bar mechanism

- Types of four-bar mechanism
  - Double-crank

    Both input and output links are cranks
  - Crank-lever (crank-rocker)

    One of the input or output links is crank, whereas the other is lever
  - Double-crank

    Both input and output links are levers



1.5. Four-bar mechanism (cont.)

- Grashof's condition
  - If S+L > P+Q, the mechanism is double-rocker
  - If S+L ≤ P+Q, it depends on which link is grounded

Fixed link	Mechanism Type
Shortest link	Double-crank
Adjacent to shortest	Crank-lever
Opposite to shortest	Double-lever