Linkage mechanisms

- Machines are used to convert energy into different forms and to transmit energy.
- Machines are composed of different types of mechanisms.
- A mechanism is a device that converts input motion and force into a desired output motion and force.
- Linkages, cams, gears, and pulleys are examples for common mechanisms.

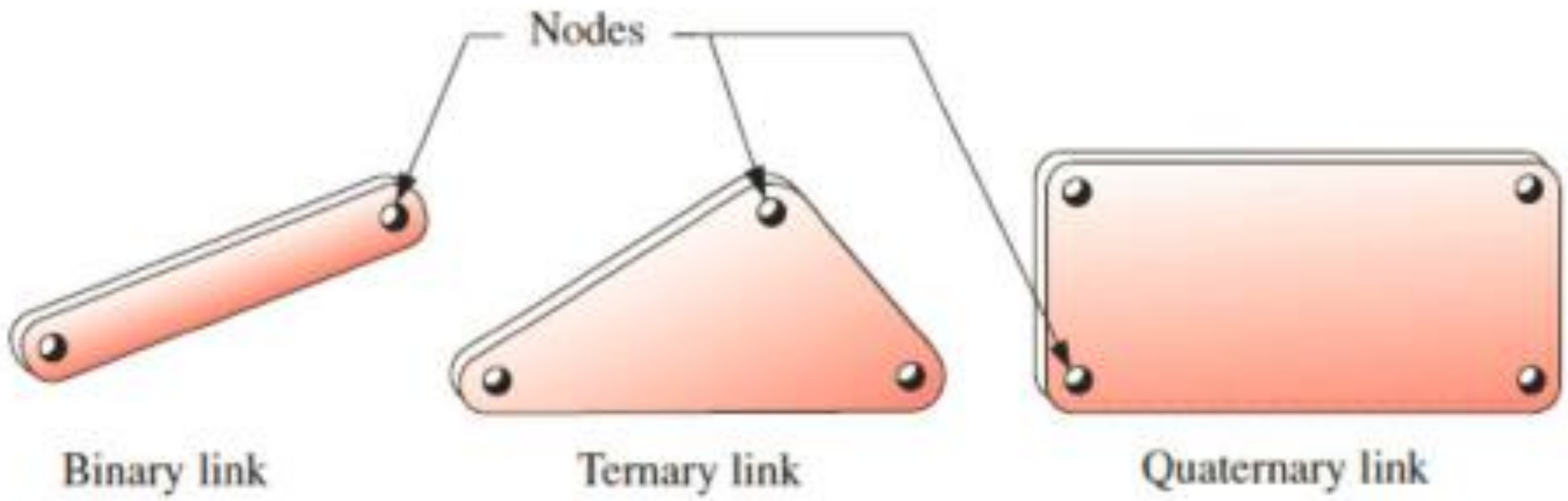
- **Link**

A rigid body having two or more pairing elements which connect to other bodies for the purpose of transmitting force or motion.

- **Kinematic link**

A resistant body in a machine which moves relative to another resistant body.

Types of link.



- **Joint / Kinematic pair**

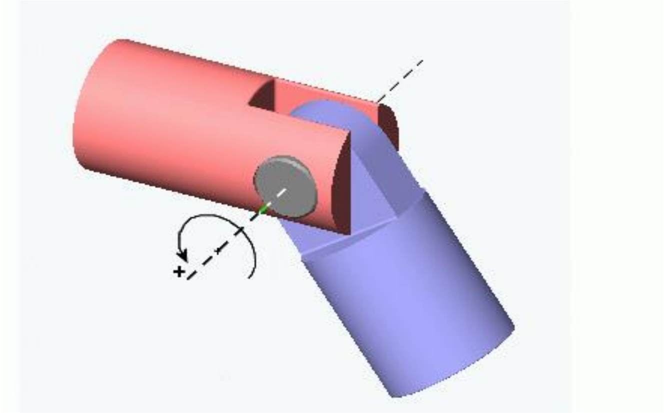
Provides the connection between links. Two links of a machine when in contact with each other, are said to form a pair.

Kinematic pairs are classified using various aspects such as

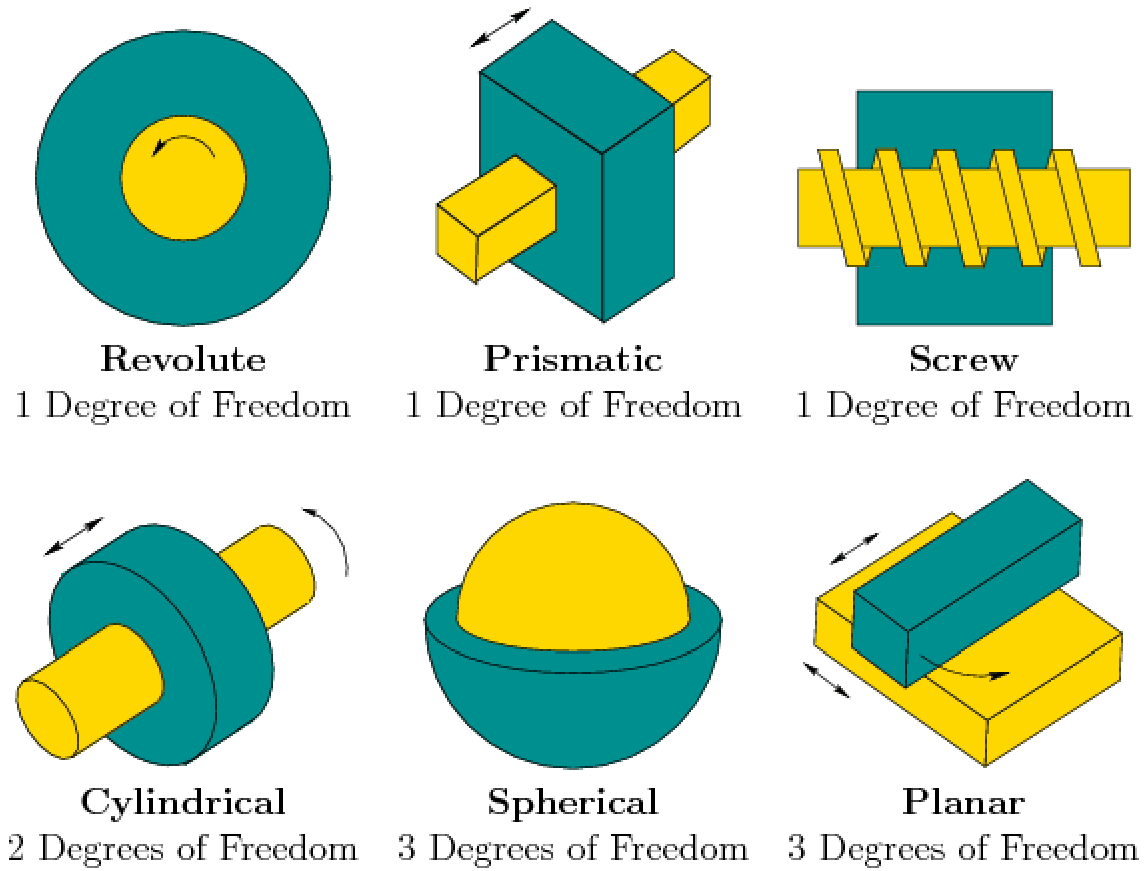
- motion between links
- contact area between links
- closure of links

In the classification of contact area between links, there are two types of kinematic pairs:

- **Lower pair:** have surface contact between the links.

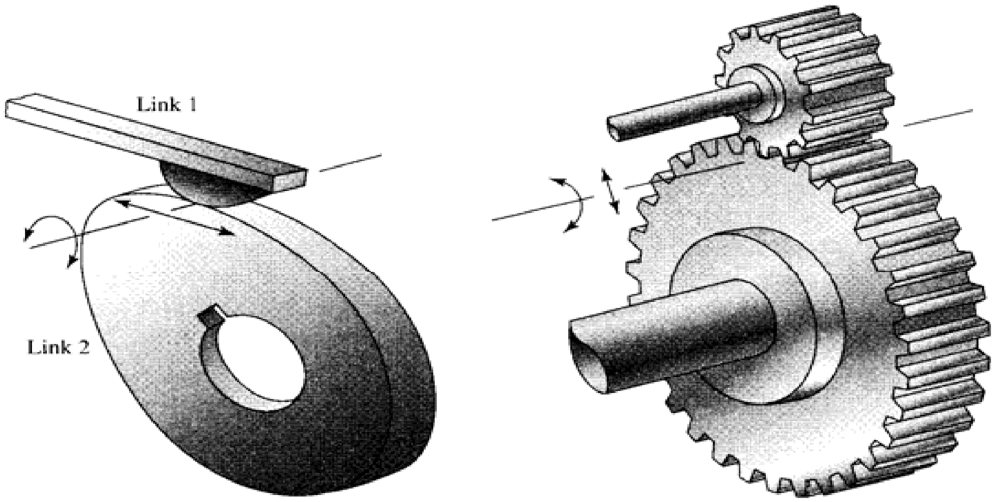


Classification of Kinematic pairs

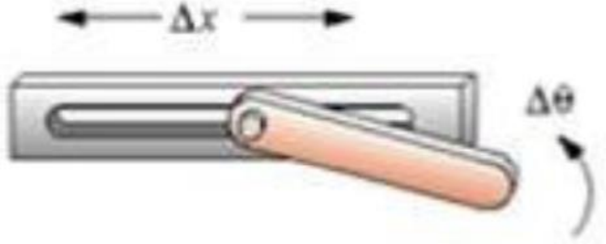


Surface contact

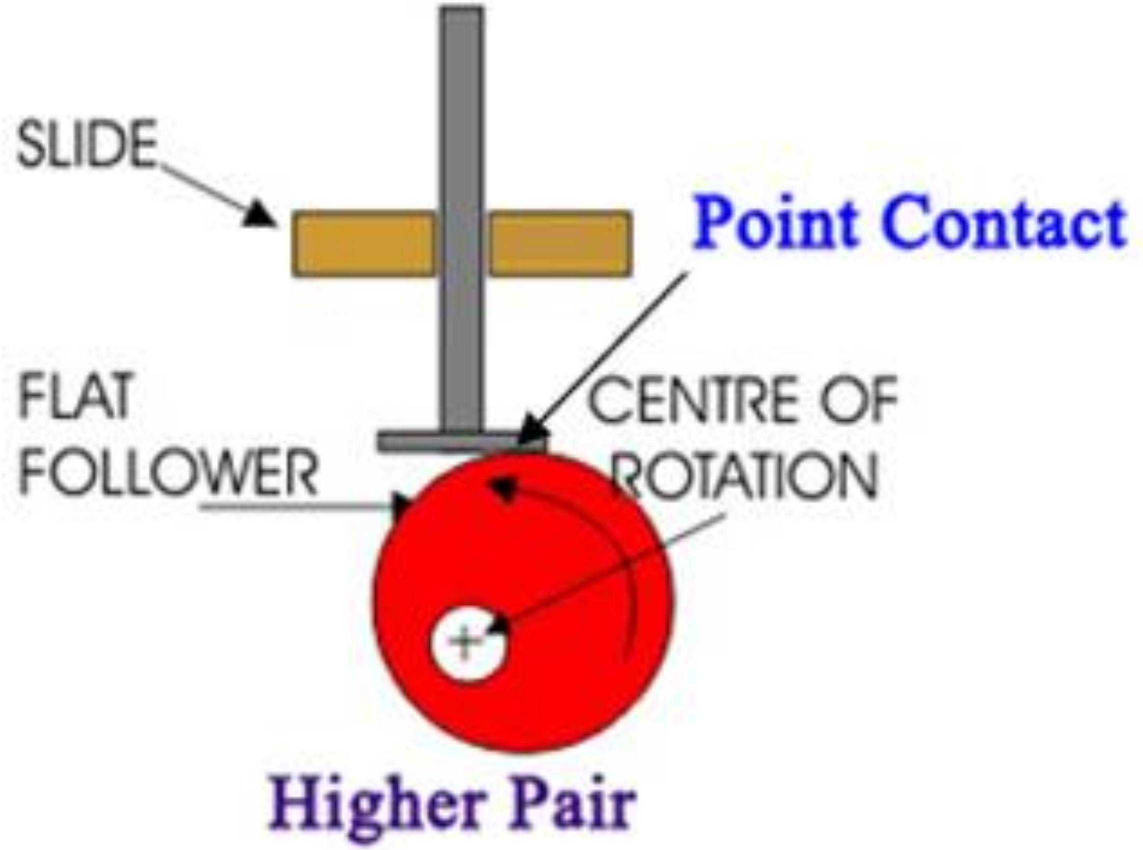
- **Higher pair:** have line / point contact between the links



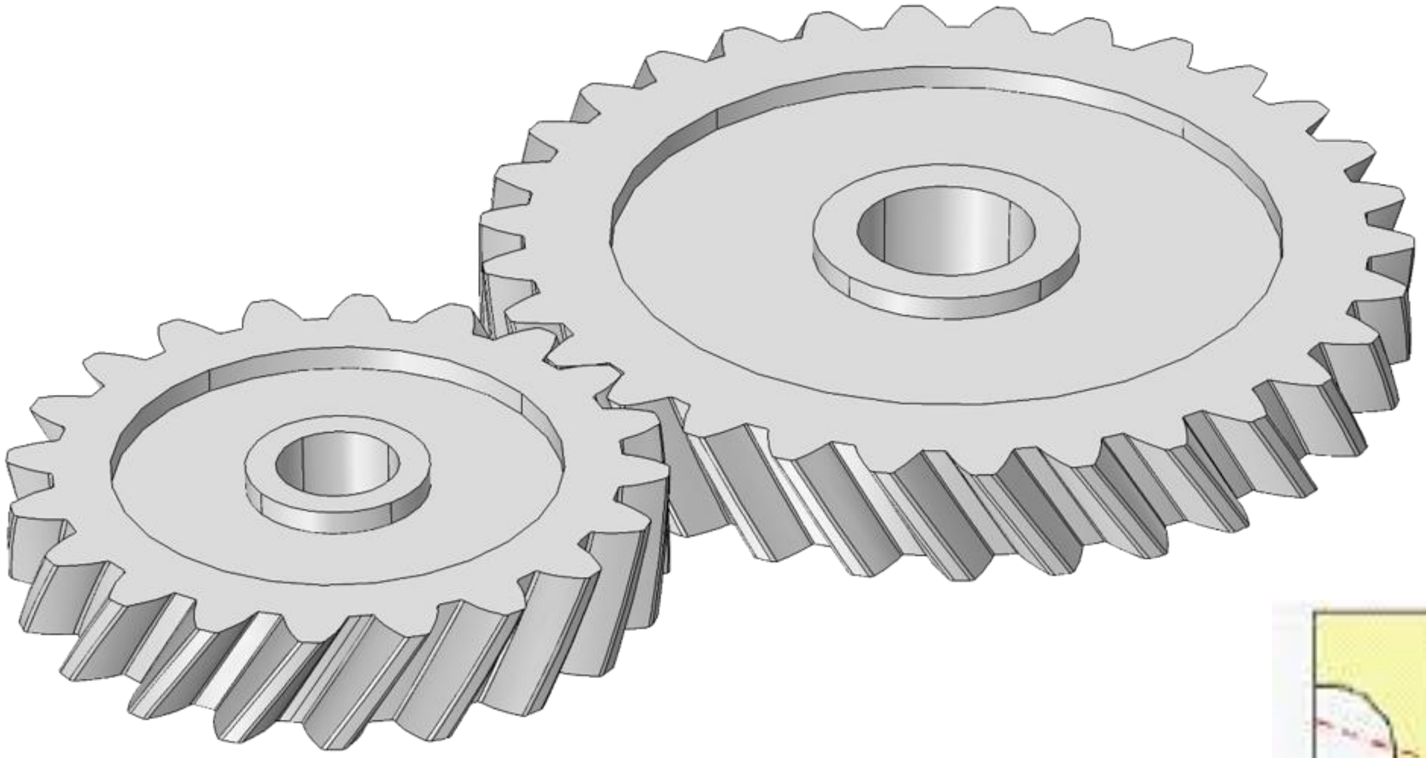
(a) Cam joint (b) Gear joint



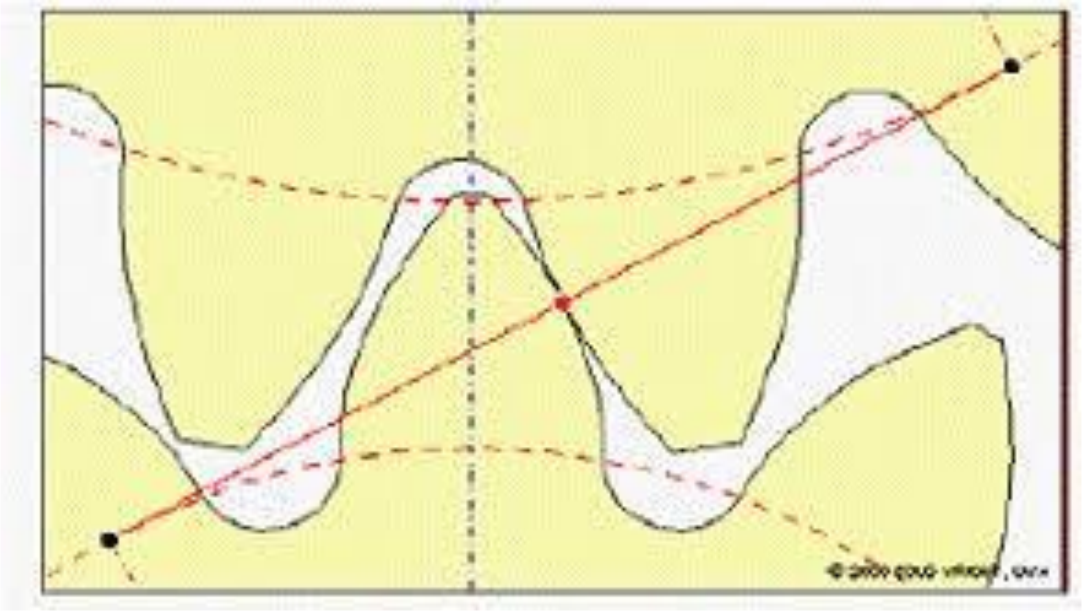
Pin in slot



Point contact



Line contact



- **Kinematic chain** is a combination of links and pairs without a fixed link.

- **Mechanism** is a kinematic chain in which at least one link is a fixed link.

- **Degree of Freedom** is number of independent movements a rigid body has in a plane / space.

For a planar mechanism, the degree of freedom (mobility) is given by **Gruebler's Equation:**

$$\mathbf{DoF = 3(n\text{-}1) - 2L - H}$$

n : Total number of links (including a fixed or single grounded link)

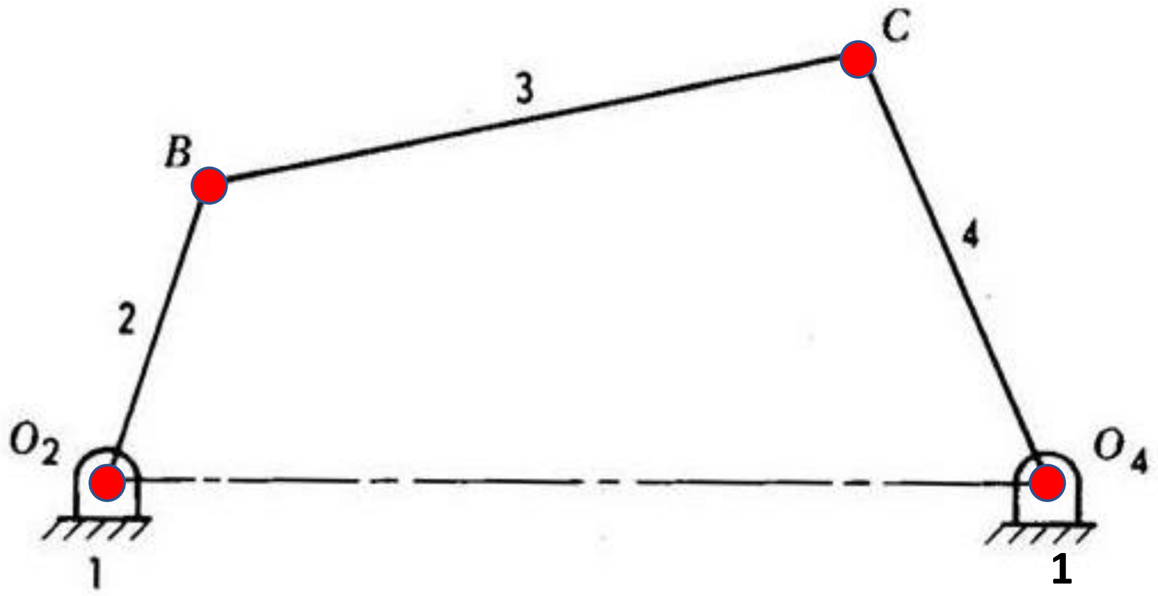
L : Total number of lower pairs

H : Total number of higher pairs

Total no. of links, $n = 4$
No. of lower pair, $L = 4$
No. of higher pair, $\mathrm{H} = 0$

Pin joint, Lower pair

$$\begin{aligned} DoF &= 3(n-1) - 2L - H \\ &= 3(4-1) - 2 \times 4 - 0 \\ &= 1 \end{aligned}$$



Total no. of links, $n = 6$

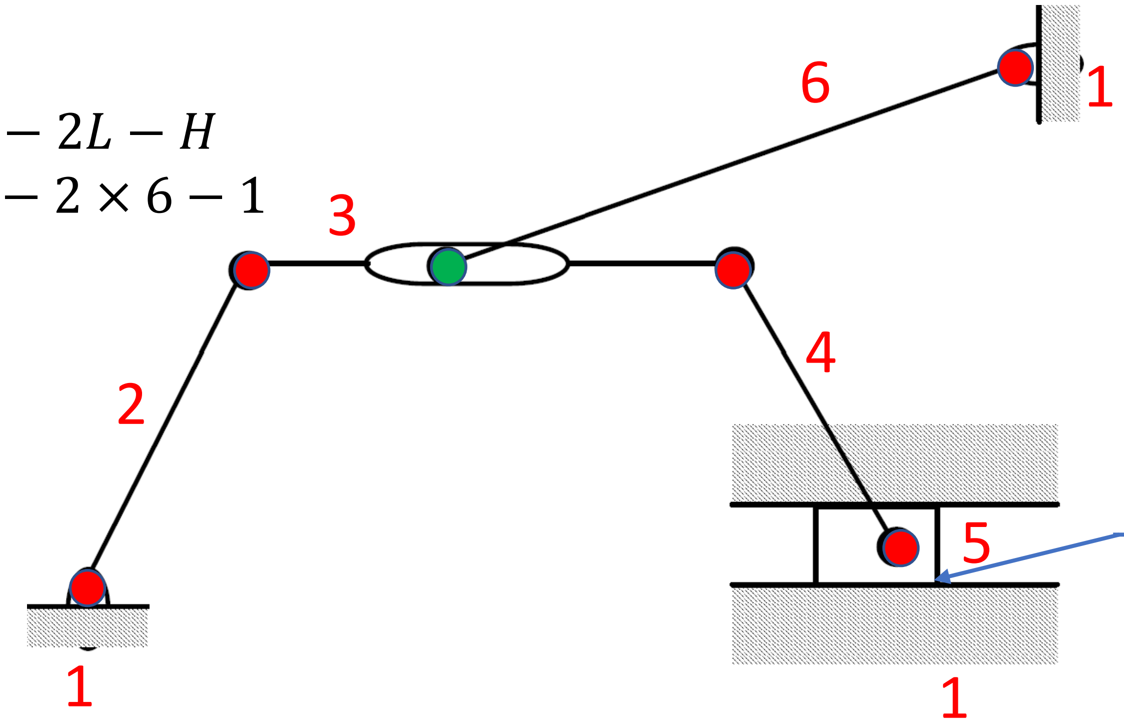
No. of lower pair, $L = 6$

No. of higher pair, $\mathrm{H} = 1$

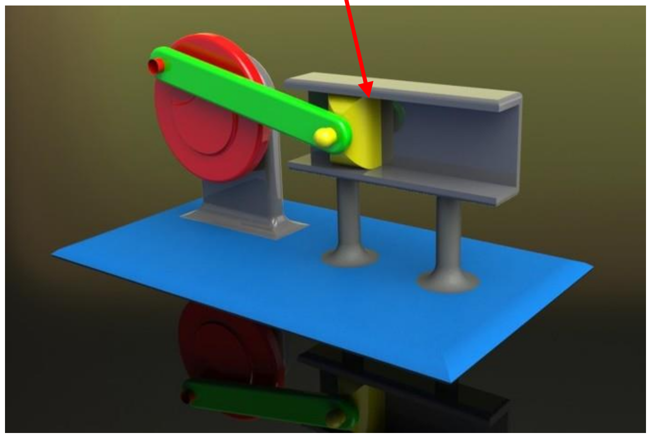
$$
\begin{aligned}
DoF &= 3(n-1) - 2L - H \\
&= 3(6-1) - 2 \times 6 - 1 \\
&= 2
\end{aligned}
$$

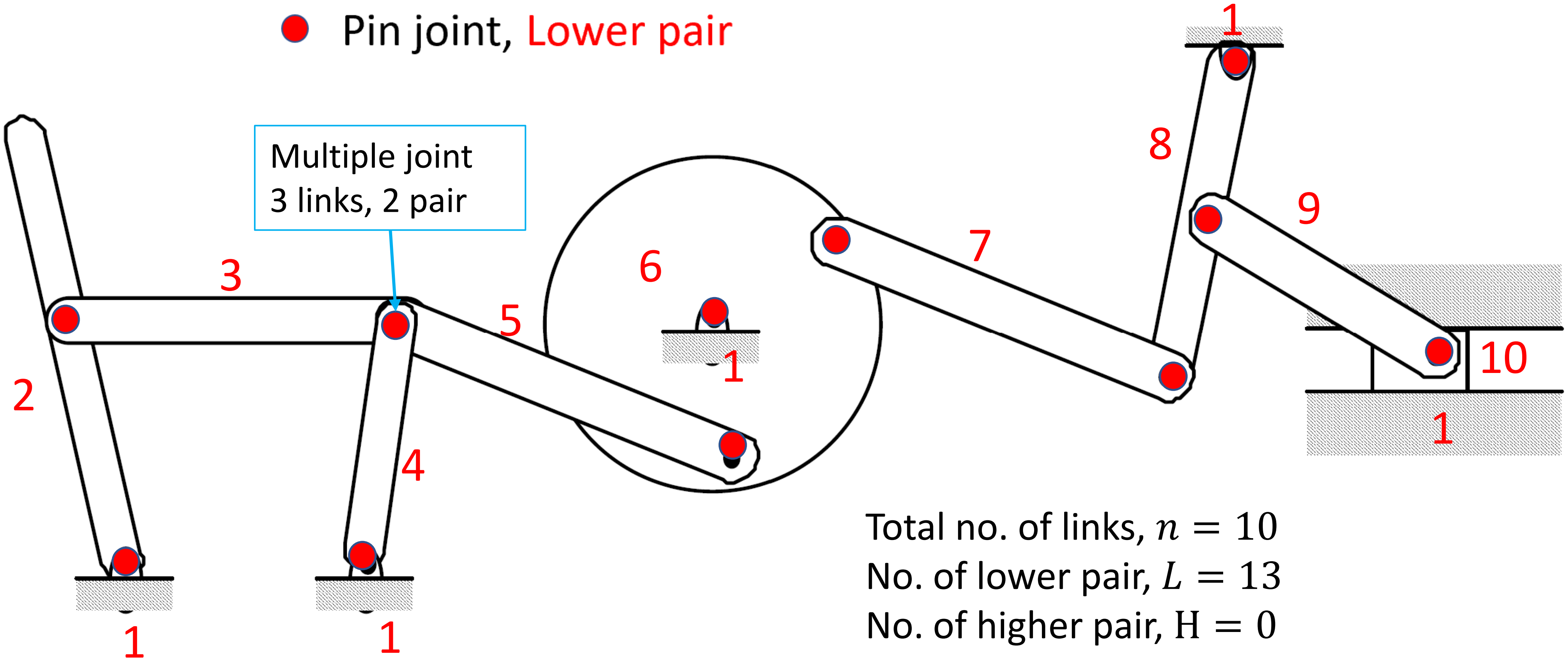
● Pin joint, Lower pair

● Slotted pin, Higher pair



Surface contact



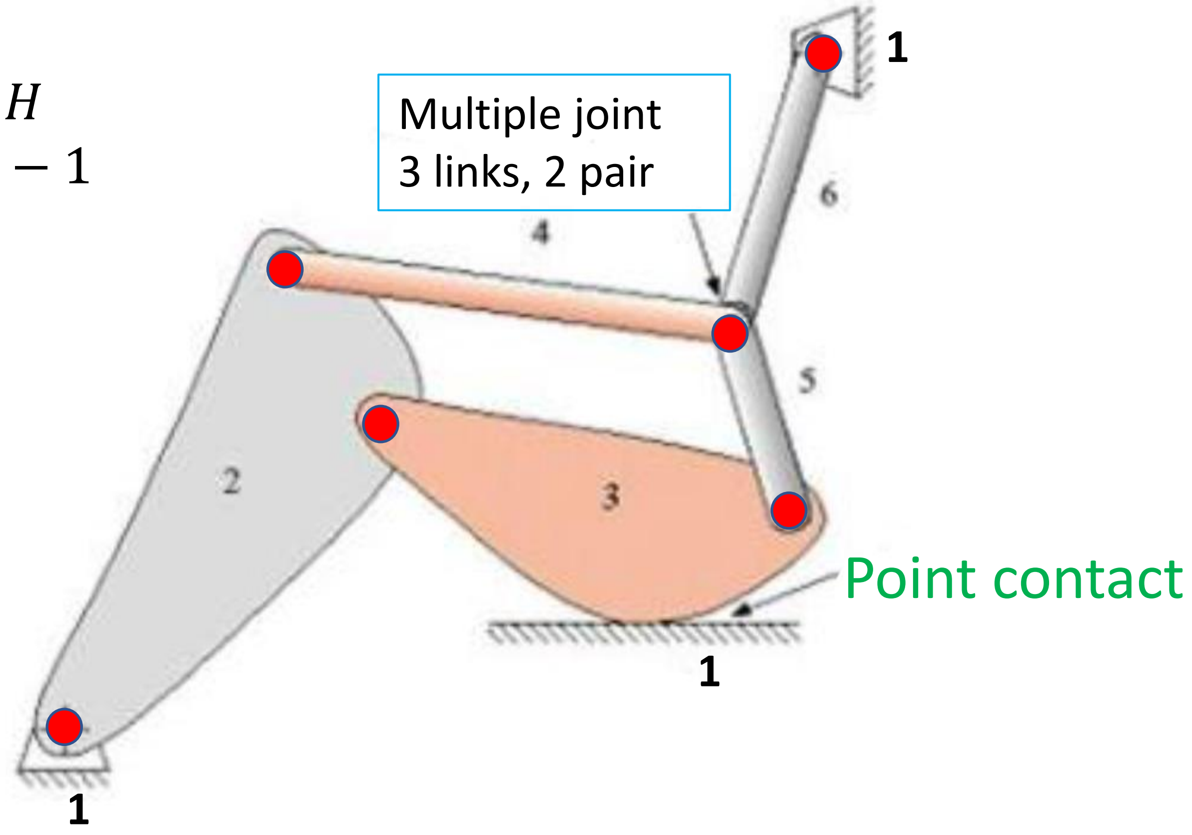


Total no. of links, $n = 10$
No. of lower pair, $L = 13$
No. of higher pair, $\mathrm{H} = 0$

$$
\begin{aligned}
DoF &= 3(n-1) - 2L - H \\
&= 3(10-1) - 2 \times 13 - 0 \\
&= 1
\end{aligned}
$$

Total no. of links, $n = 6$
No. of lower pair, $L = 7$
No. of higher pair, $\mathrm{H} = 1$

$$\begin{aligned} DoF &= 3(n-1) - 2L - H \\ &= 3(6-1) - 2 \times 7 - 1 \\ &= 0 \end{aligned}$$



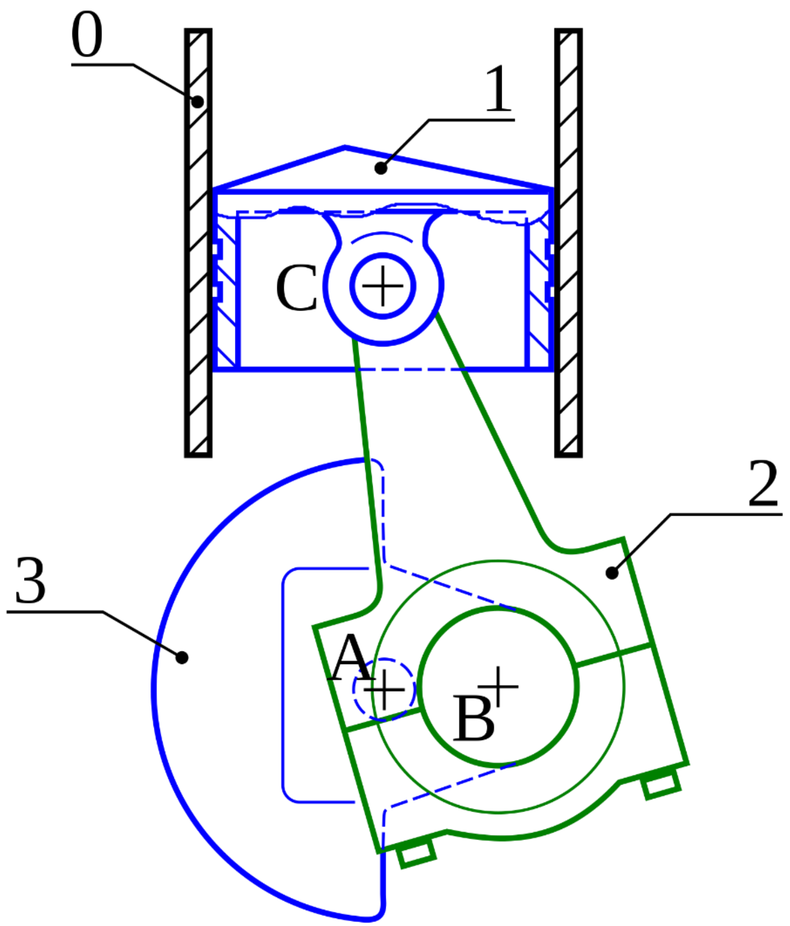
Kinematic diagram

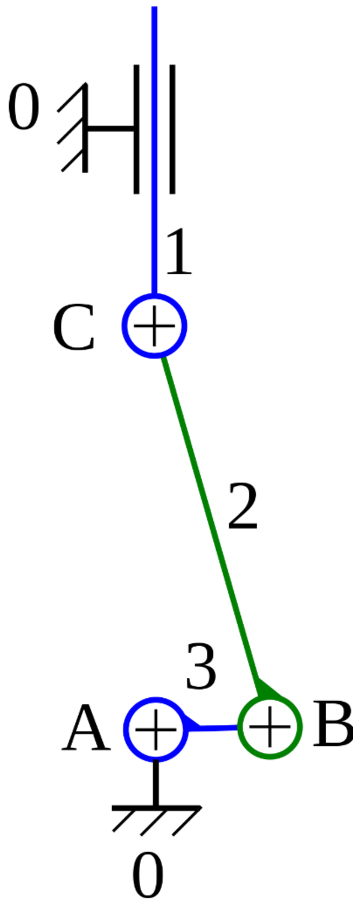
- A **kinematic diagram** or **kinematic scheme** (also called a **joint map** or **skeleton diagram**) illustrates the connectivity of links and joints of a mechanism or machine rather than the dimensions or shape of the parts.

- Often links are presented as geometric objects, such as lines, triangles or squares, that support schematic versions of the joints of the mechanism or machine.

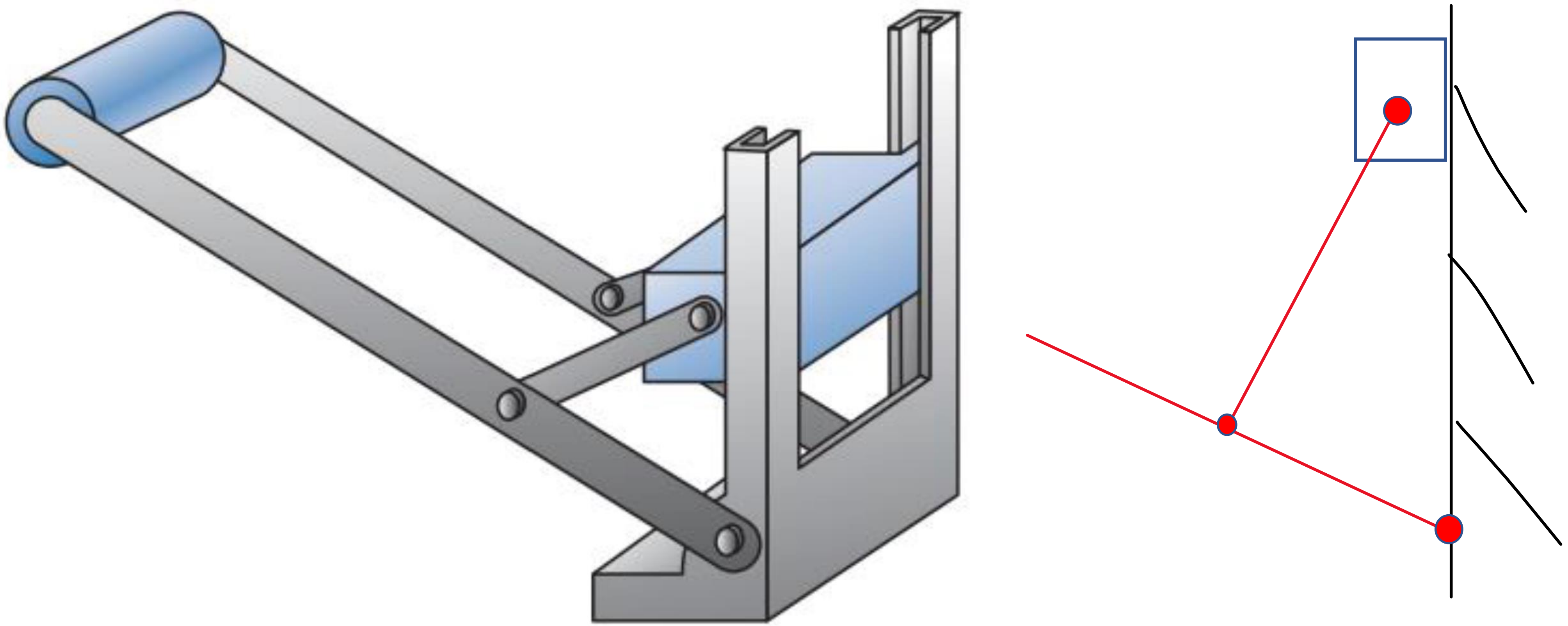
Kinematic diagram - Wikipedia

Kinematic diagram

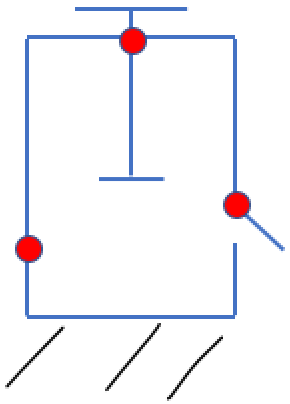




Can crusher

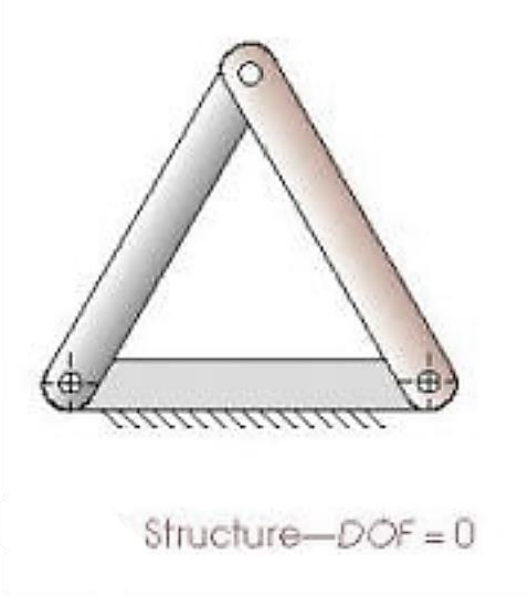


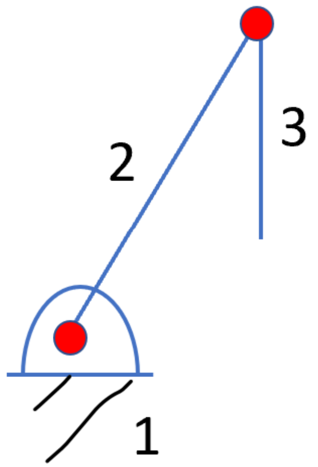
Bench yoke vise mechanism



Simple mechanisms

For 3 links



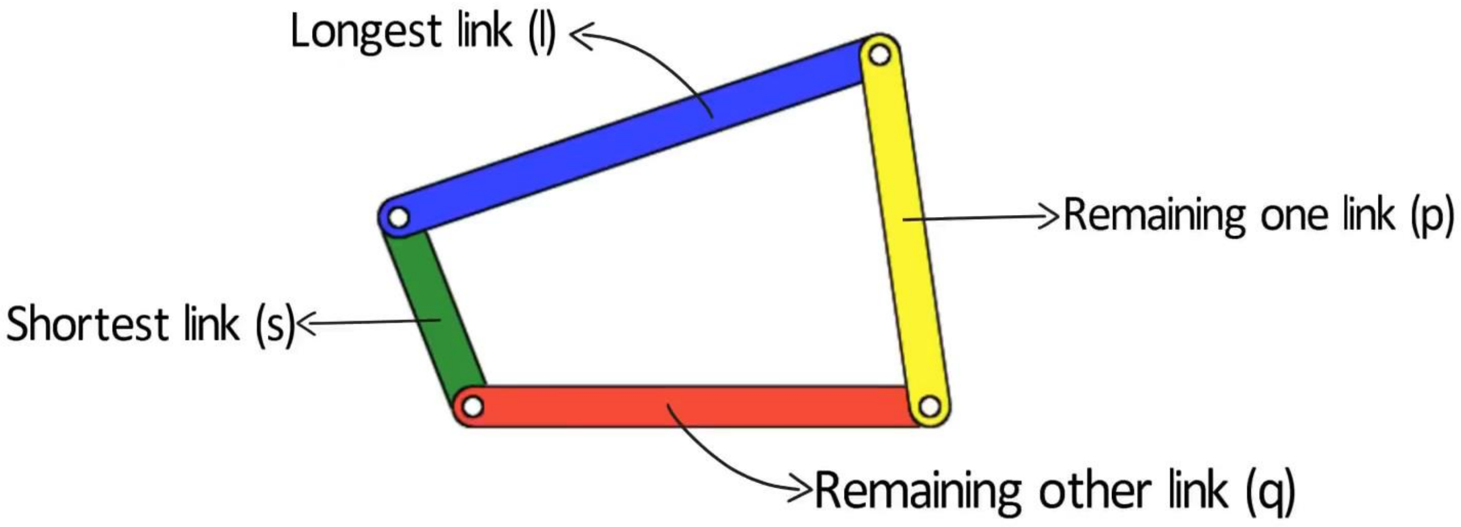


$$
\begin{aligned}
DoF &= 3(n-1) - 2L - H \\
&= 3(3-1) - 2 \times 2 - 0 \\
&= 2
\end{aligned}
$$

Free movement of links 2 & 3. No desired output.

Simple mechanisms

The simplest linkage that allows relative motion is called a four bar linkage.



Grashof's theorem

A four bar mechanism has at least one revolving link (rotate in circle), if

$$s + l \leq p + q$$

The three nonfixed links will merely rock, if

$$s + l > p + q$$

s : Length of the shortest link

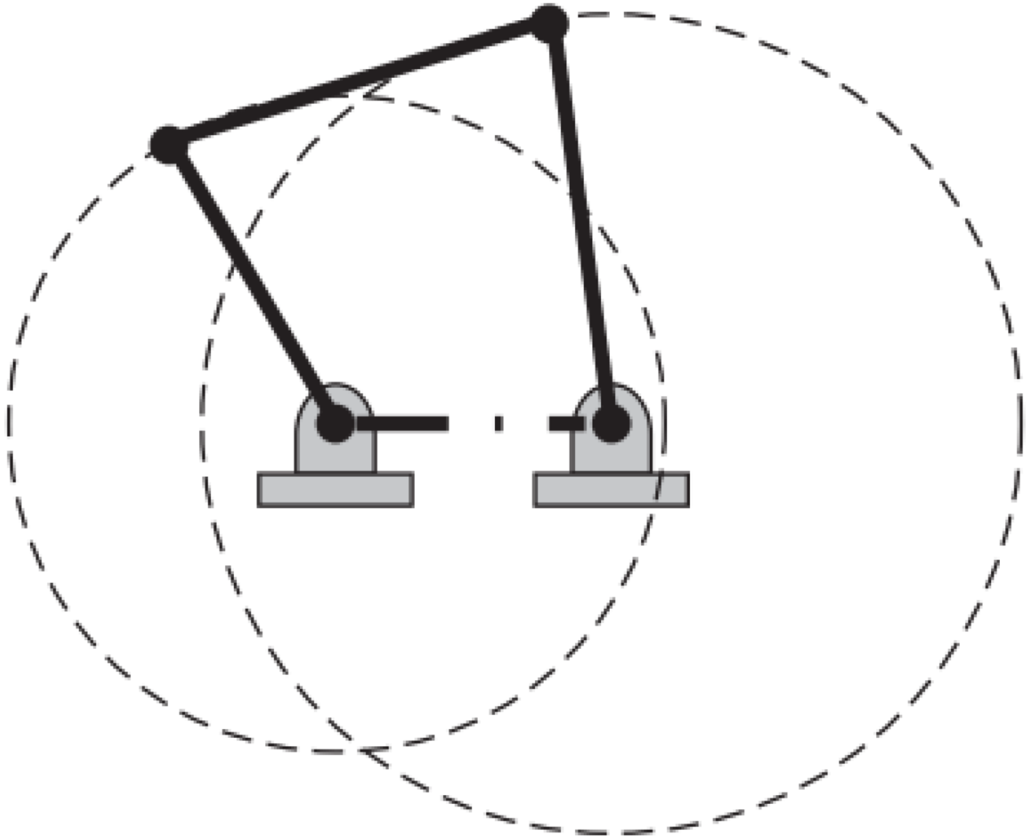
l : Length of the longest link

p and q : Lengths of the other links

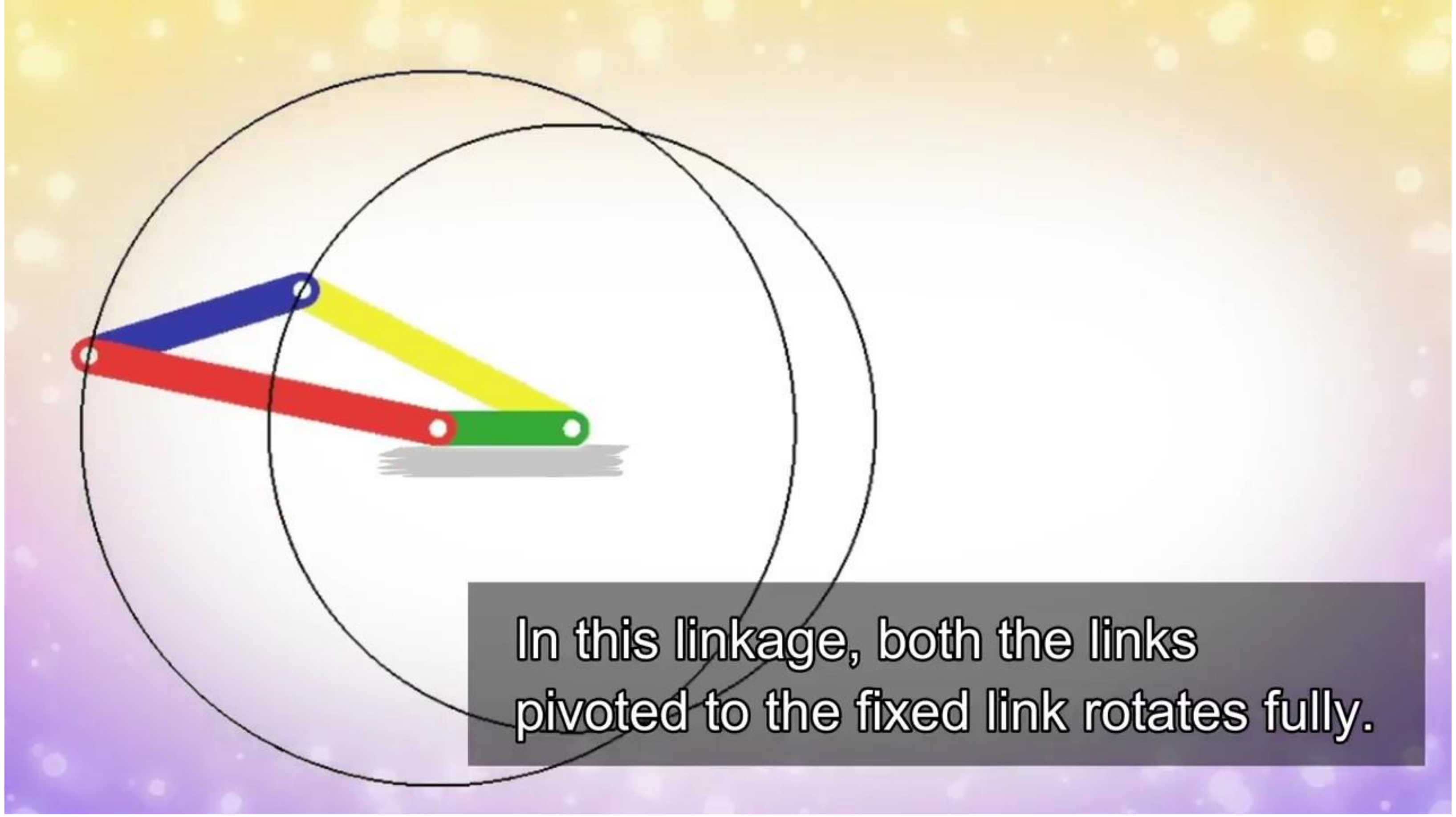
Categories of four bar mechanisms

Case	Criteria	Shortest Link	Category
1	$s + l < p + q$	Frame	Double crank
2	$s + l < p + q$	Side	Crank-rocker
3	$s + l < p + q$	Coupler	Double rocker
4	$s + l = p + q$	Any	Change point
5	$s + l > p + q$	Any	Triple rocker

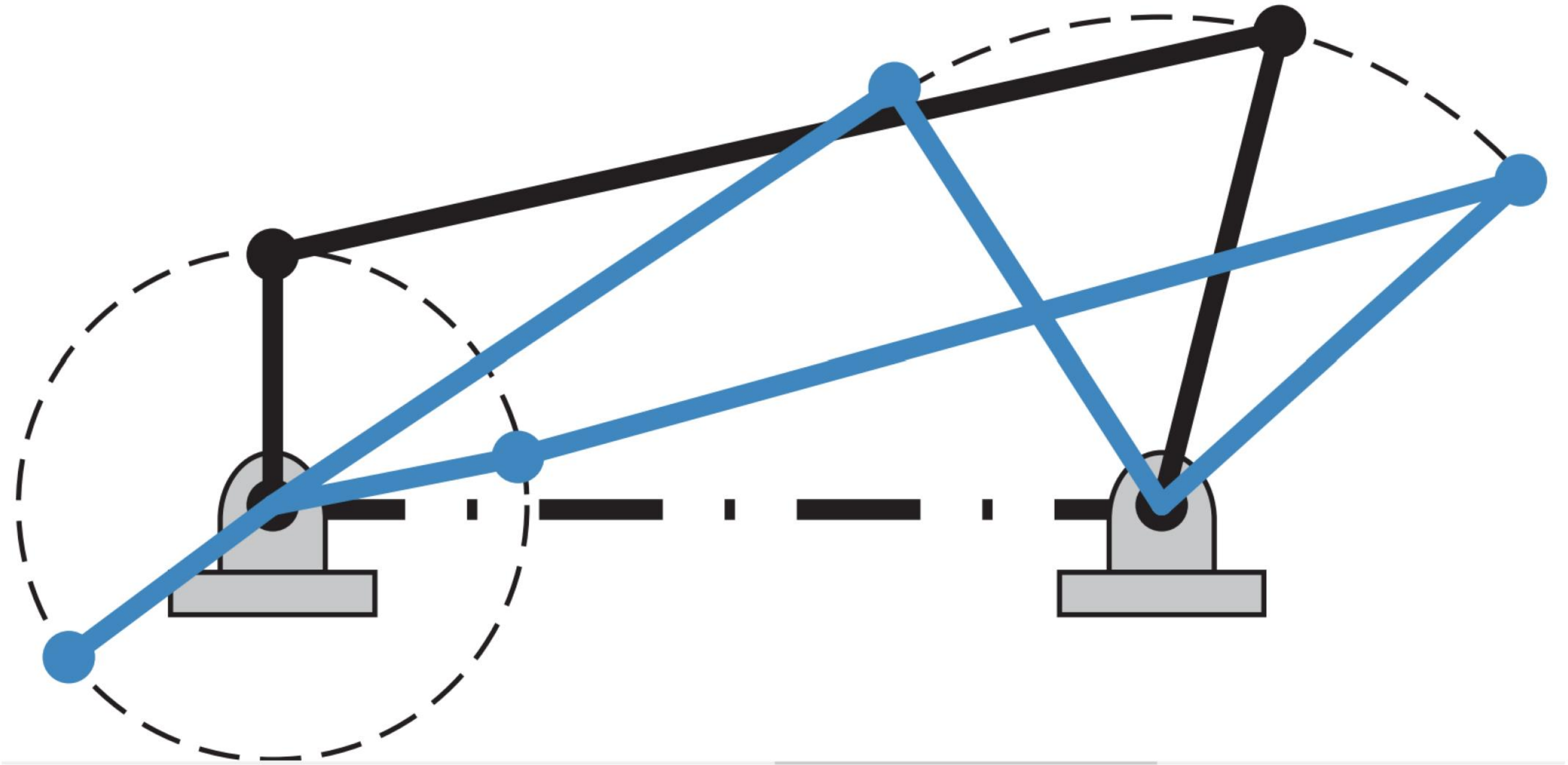
Double crank $s + l < p + q$; s = frame



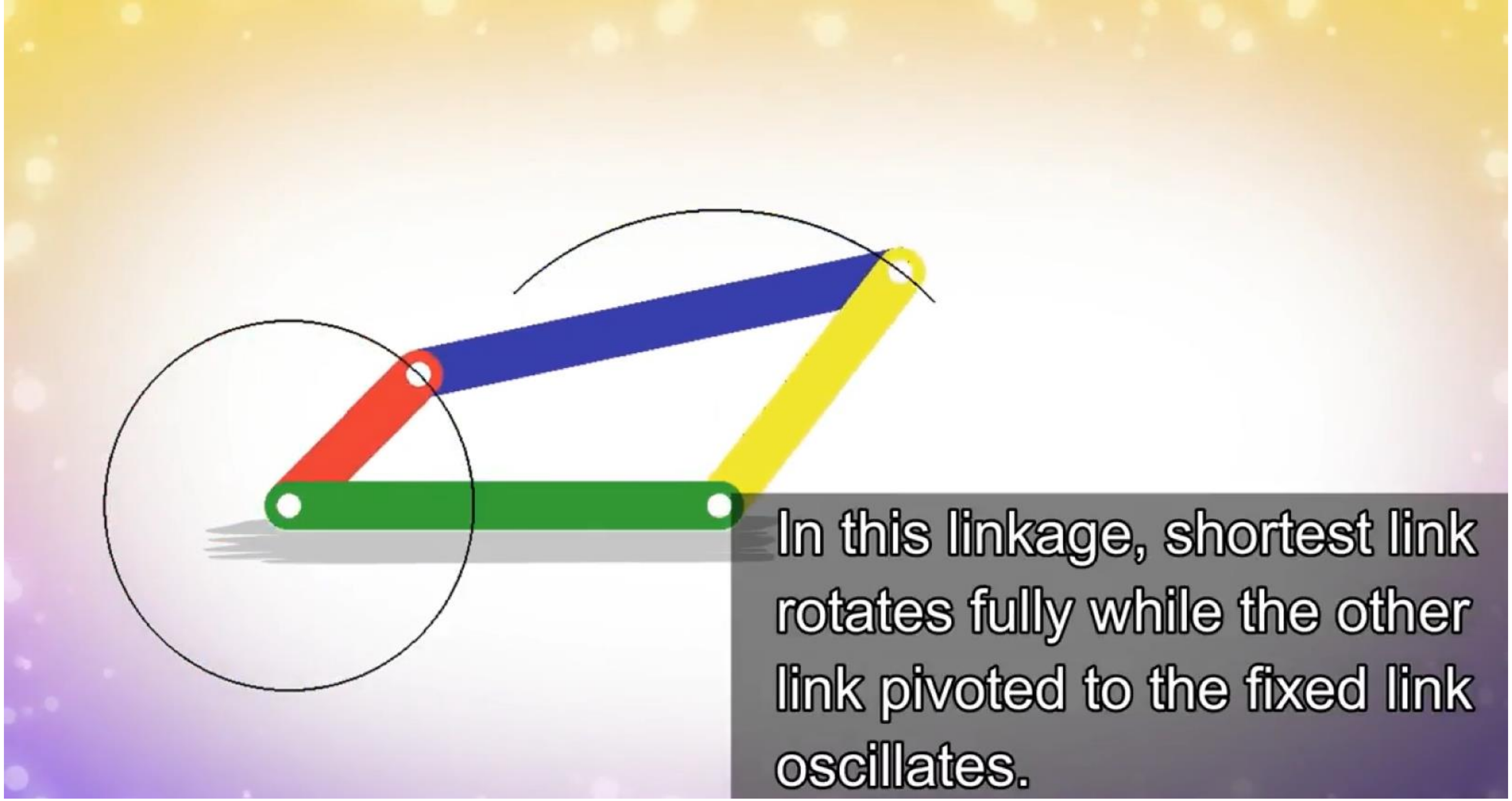
Double crank mechanism



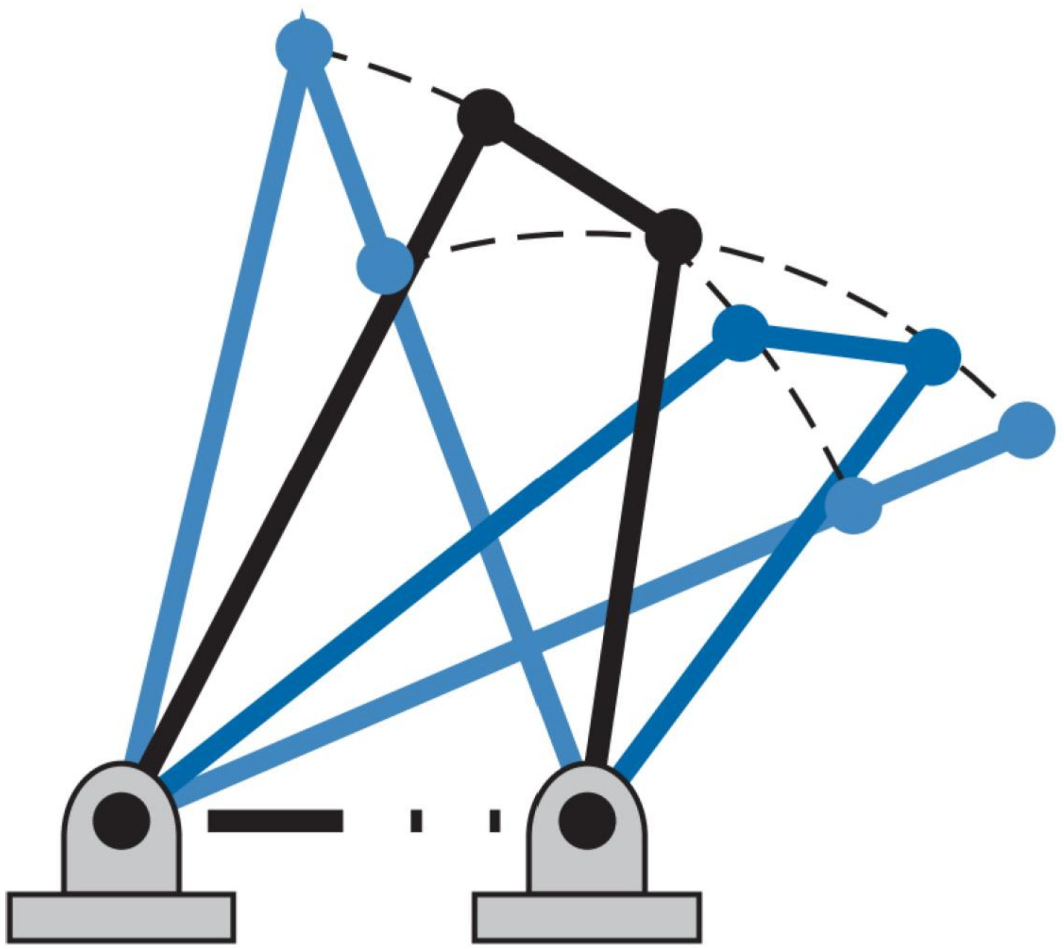
Crank rocker $\boldsymbol{s + l < p + q}$; $\mathbf{s}$=$\mathbf{side}$



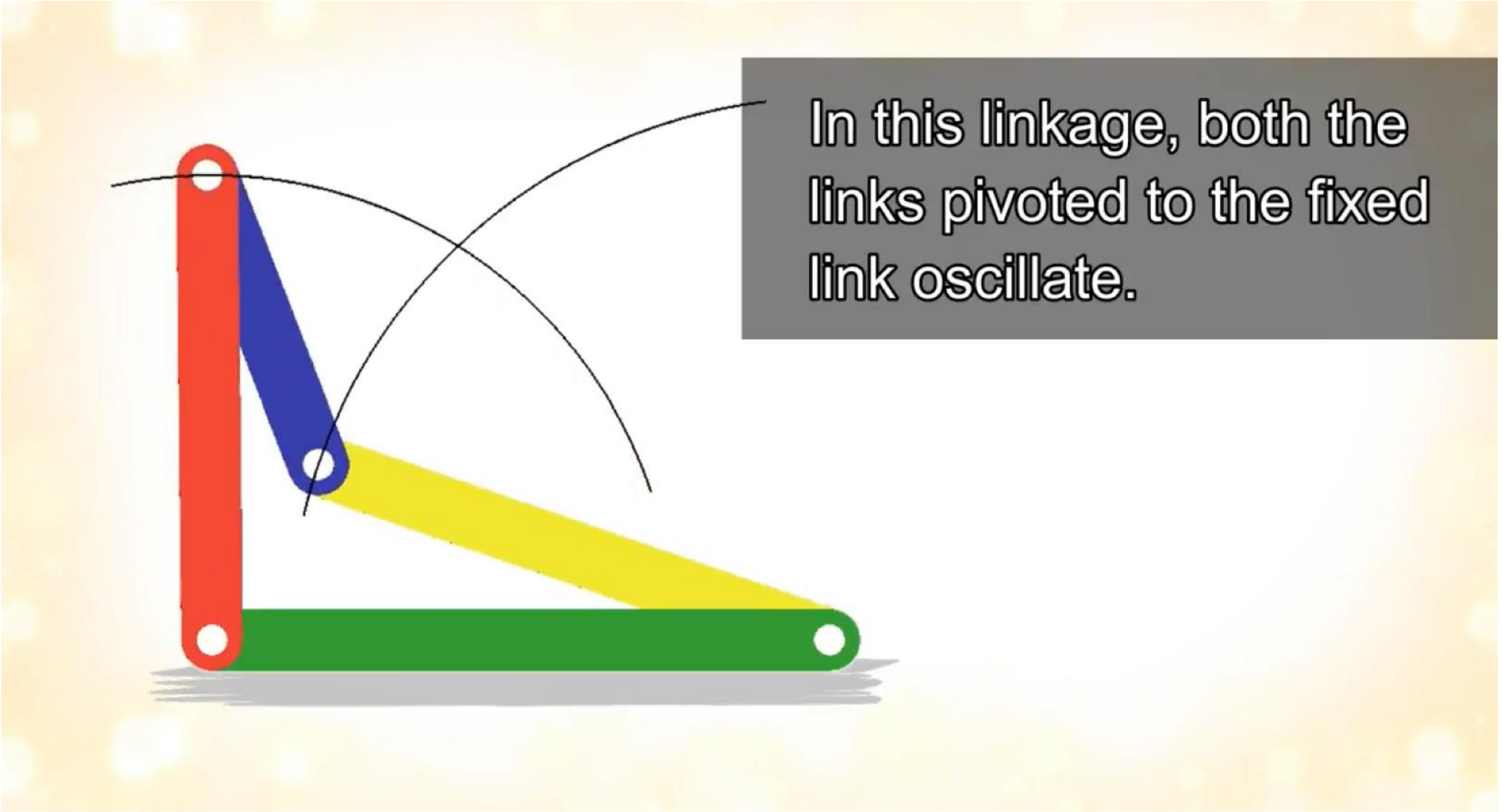
Crank rocker mechanism



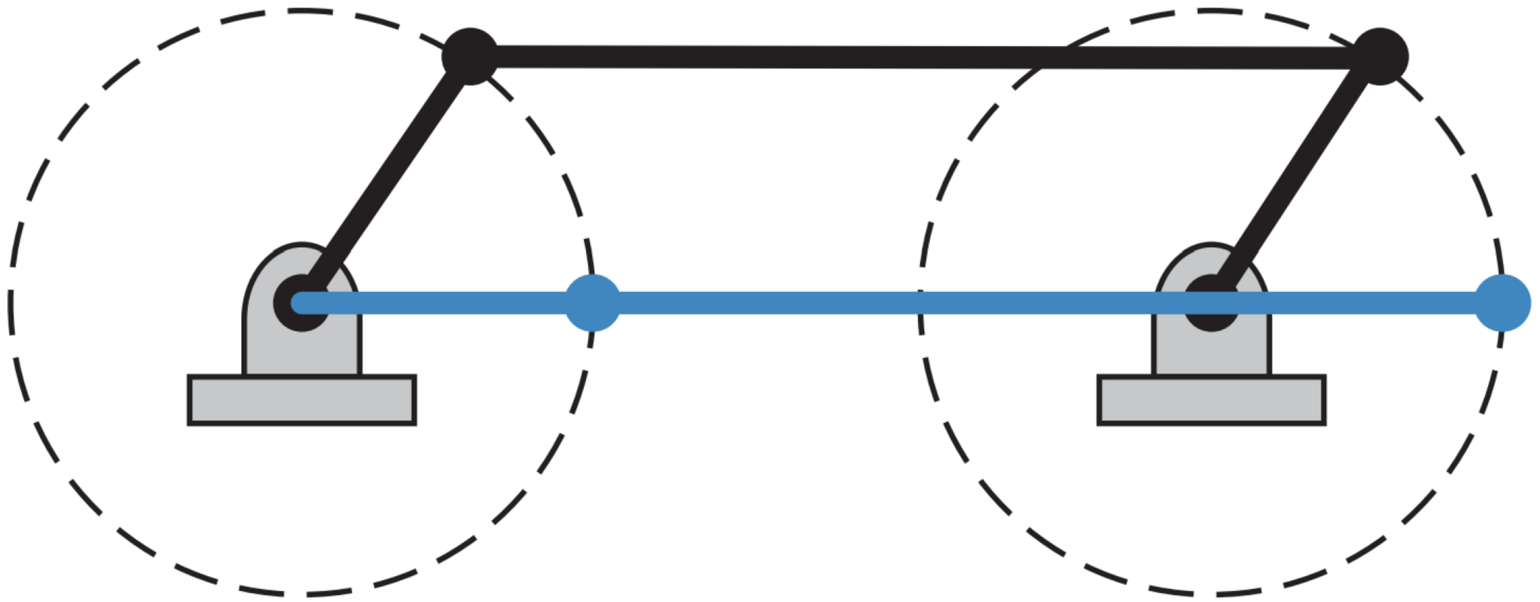
Double rocker $s + l < p + q$; s=$coupler$

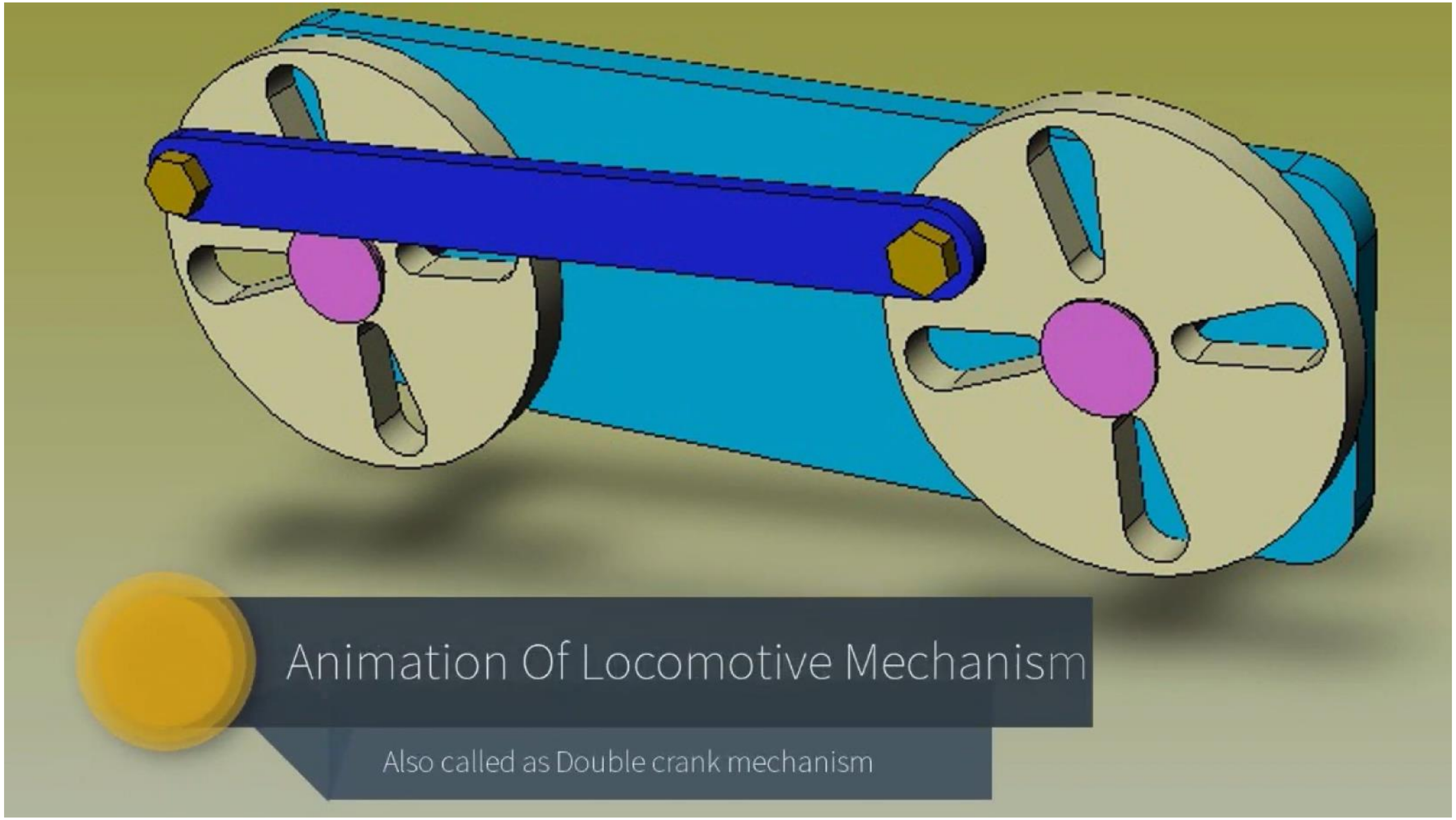


Double rocker mechanism

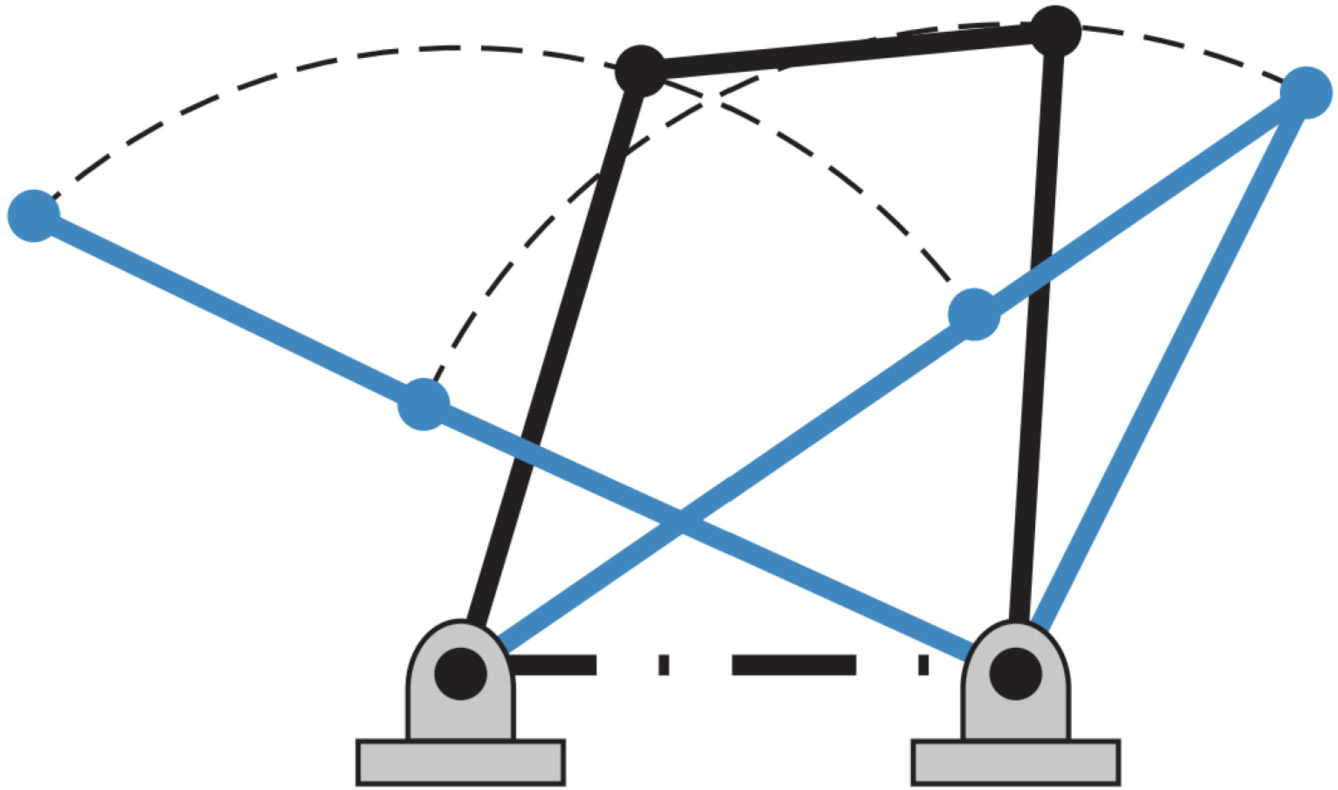


Change point $s + l = p + q$; s=any

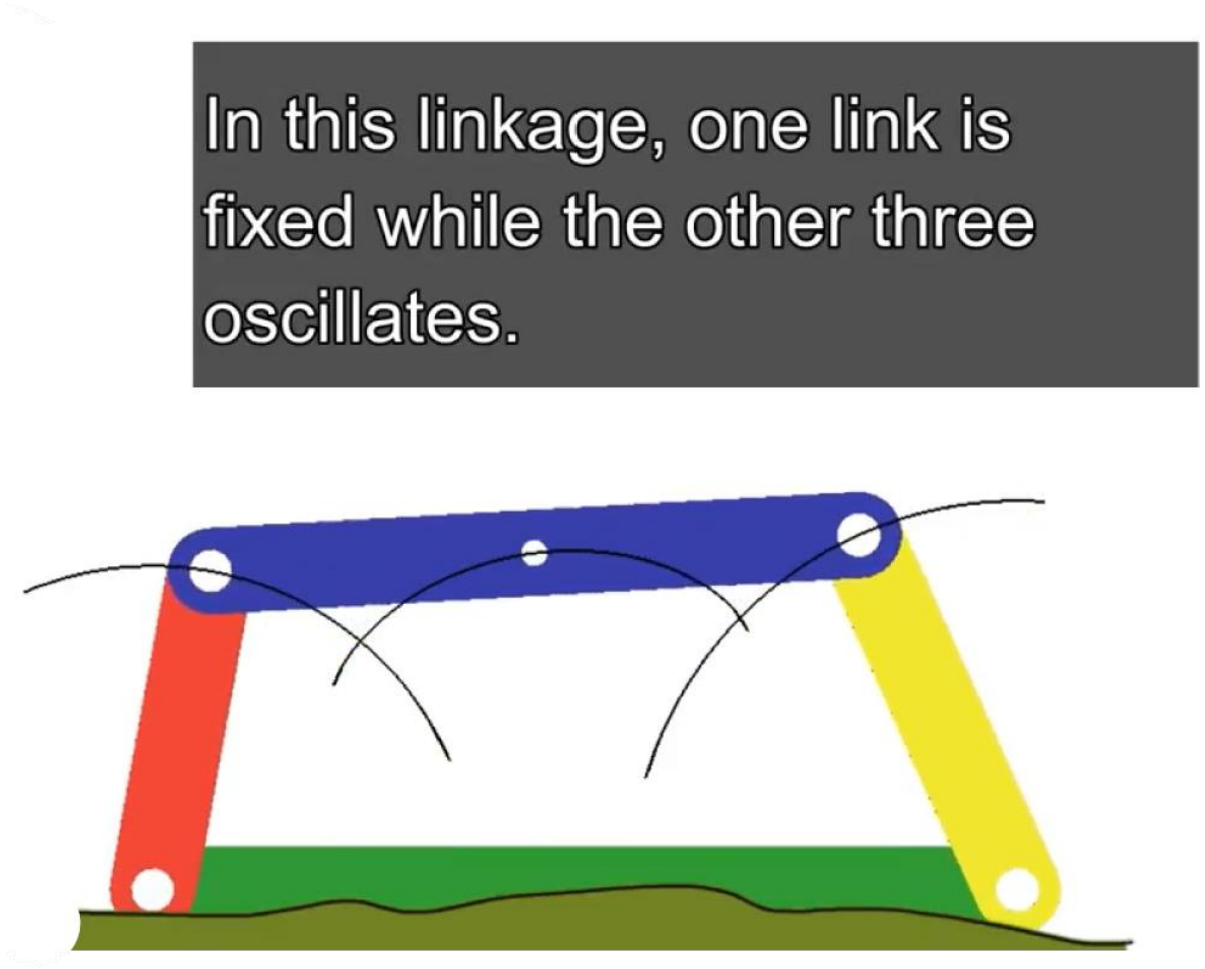



Animation Of Locomotive Mechanism
Also called as Double crank mechanism

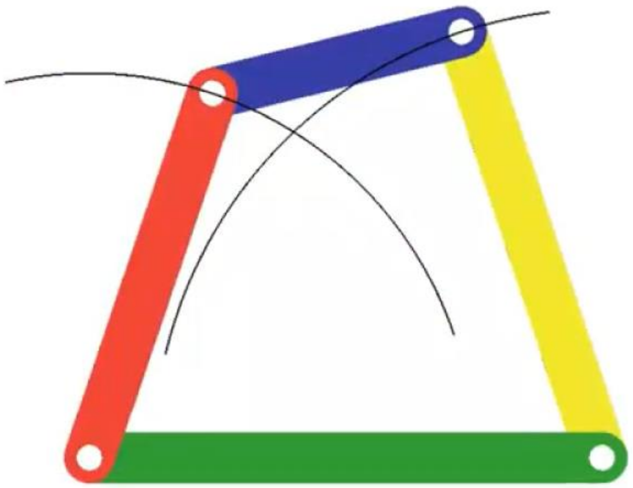
Triple rocker $s + l > p + q$; s=any



Triple rocker mechanism

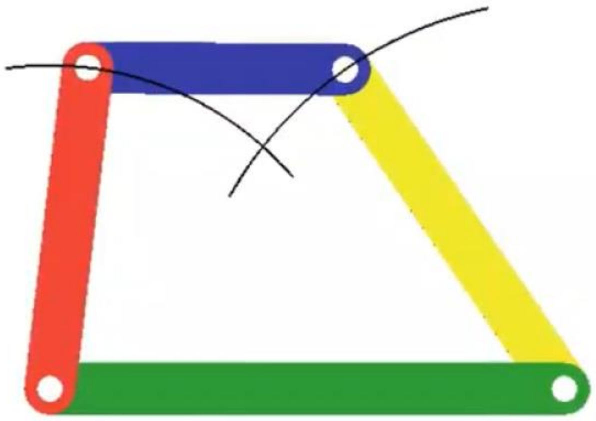


Double Rocker Mechanism



$s + l < p + q$

Triple Rocker Mechanism



$s + l > p + q$