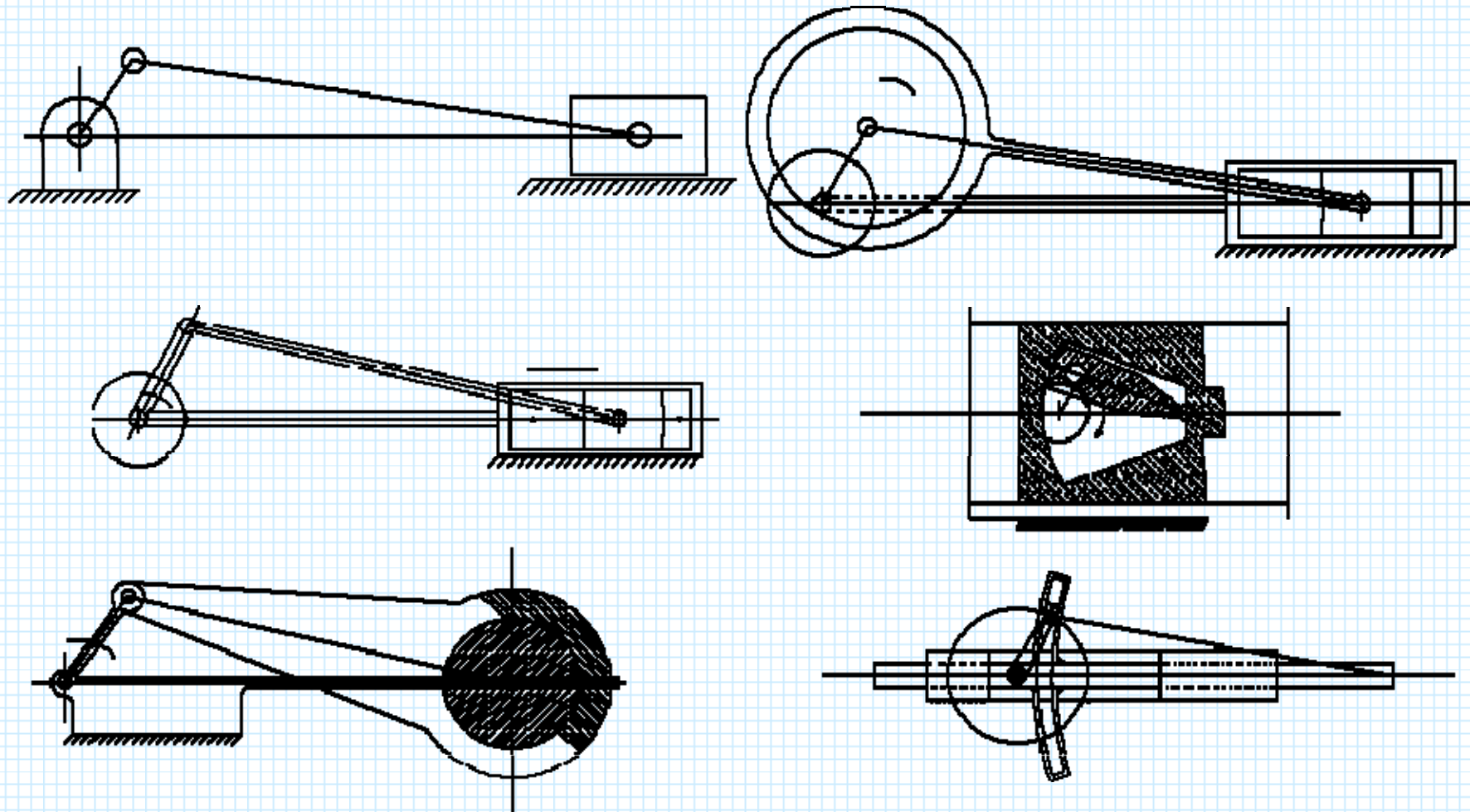
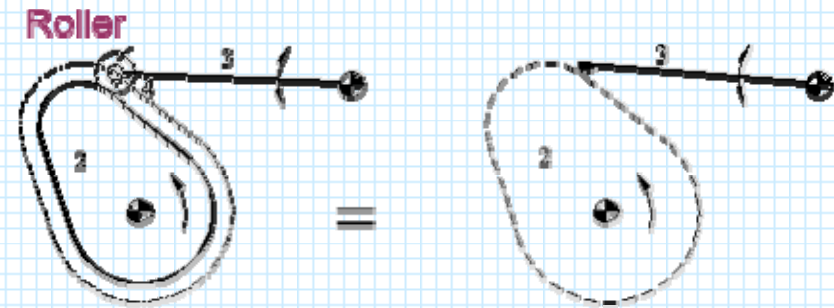
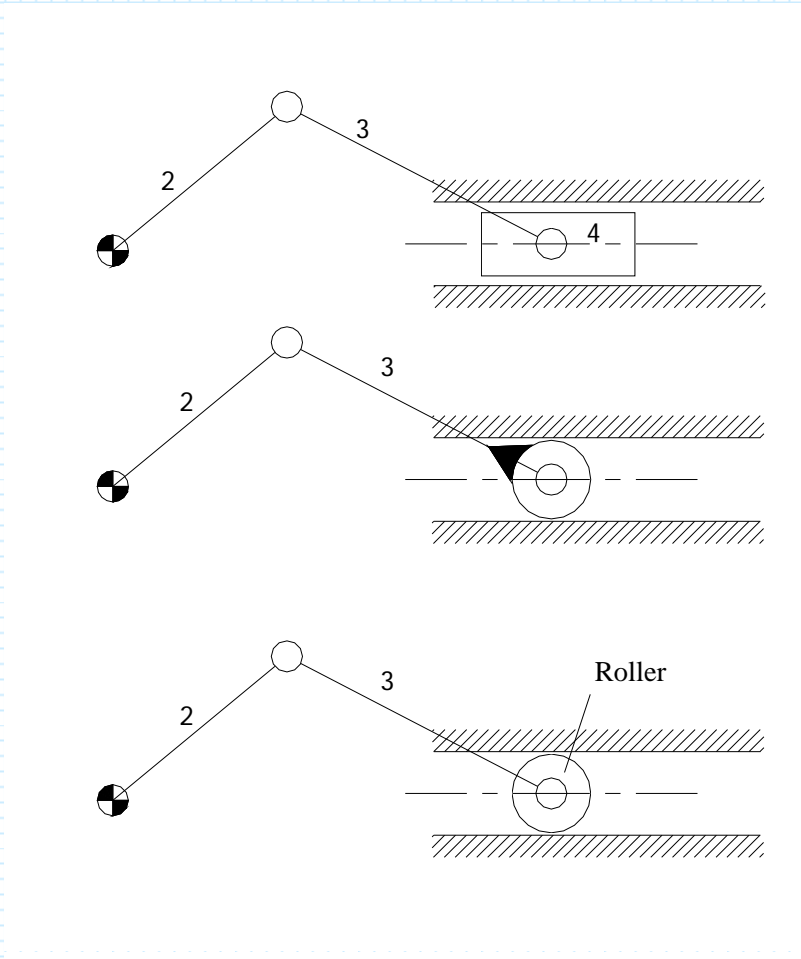


ME301 THEORY OF MACHINES 1- MECHANISMS

A Mechanism Link can be of any Shape



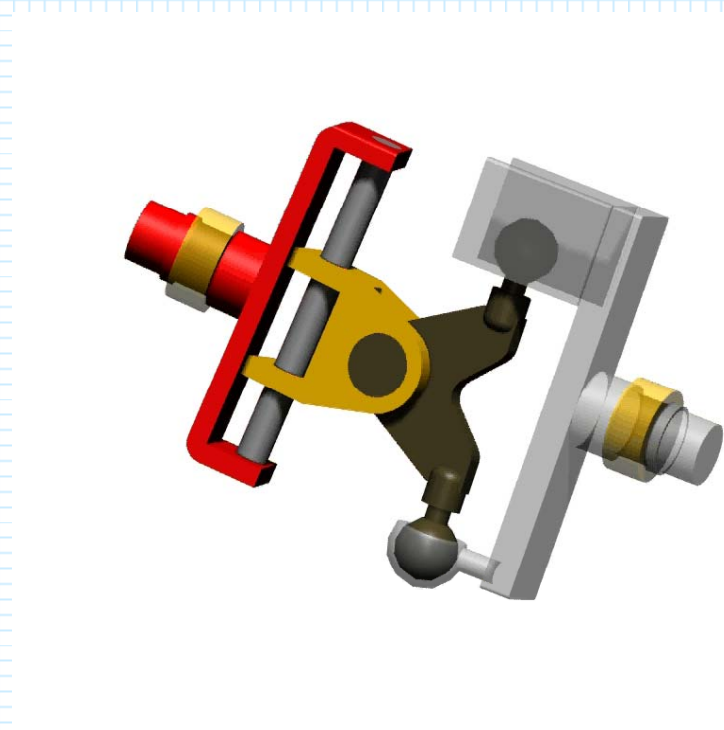
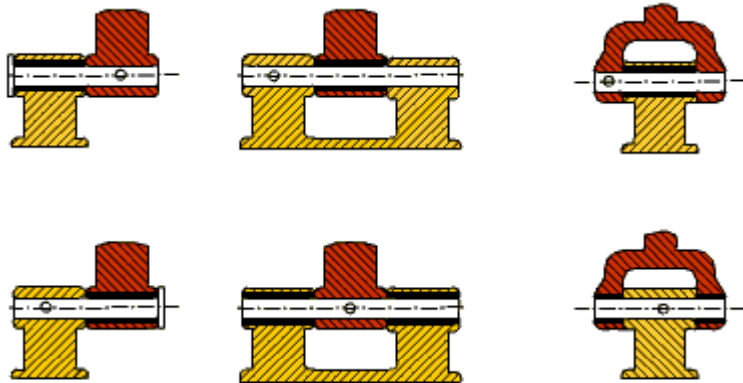
Case of a roller



Some Important Points about Degree-of-Freedom of Mechanisms

1. The number of supports or contact points between two rigid bodies does not mean there are several joints between them:

In between two rigid bodies we can have only one joint



Case of Planetary Gear Trains

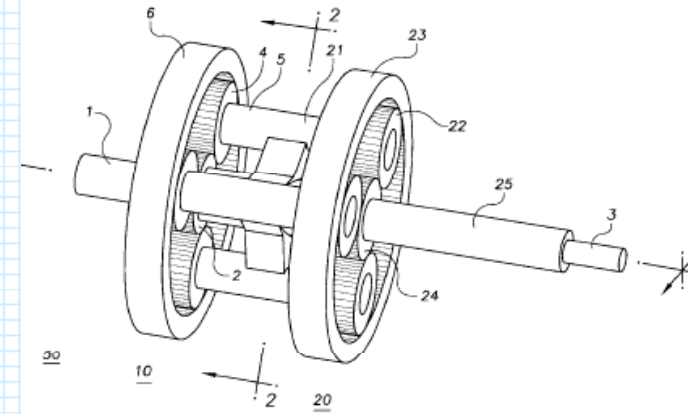
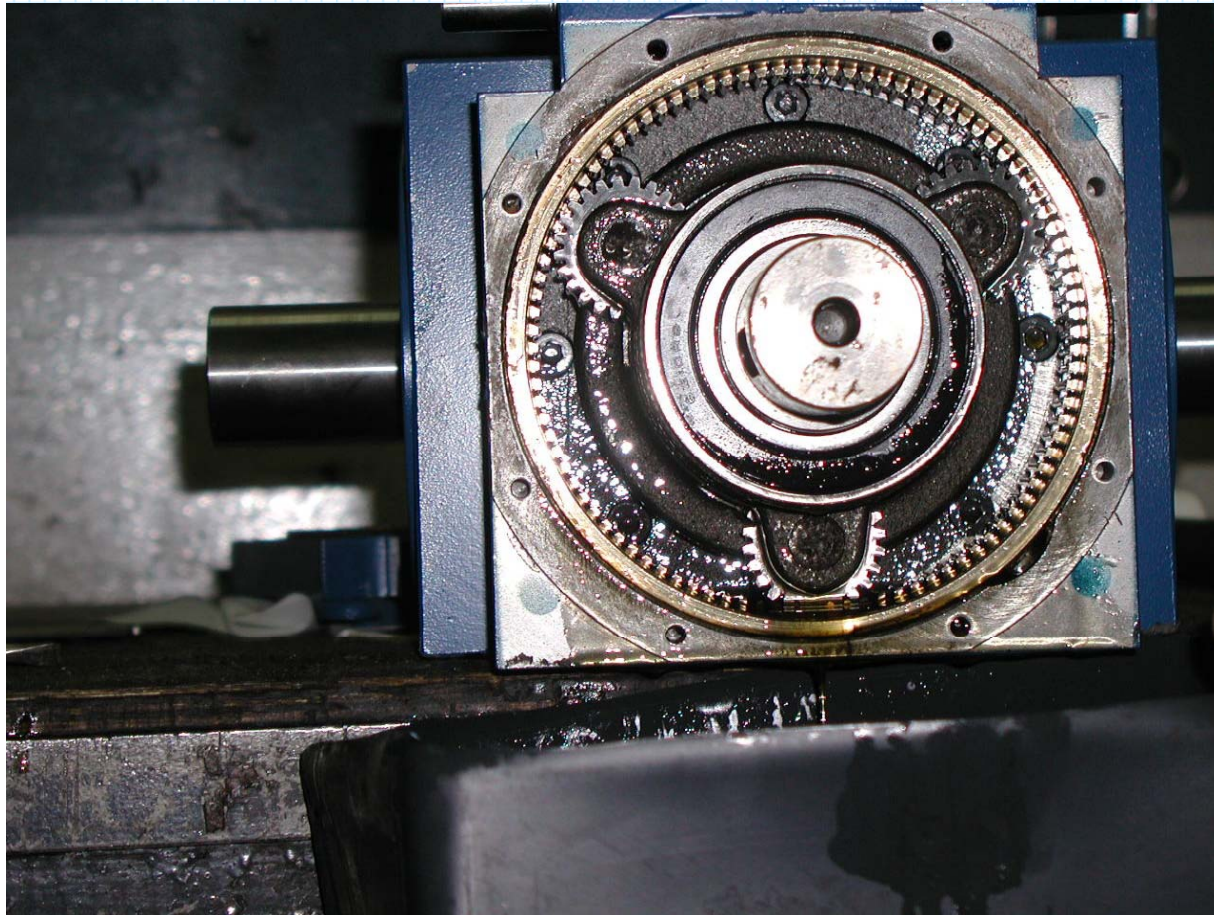


FIG. 2

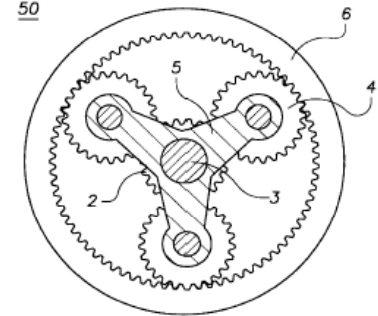
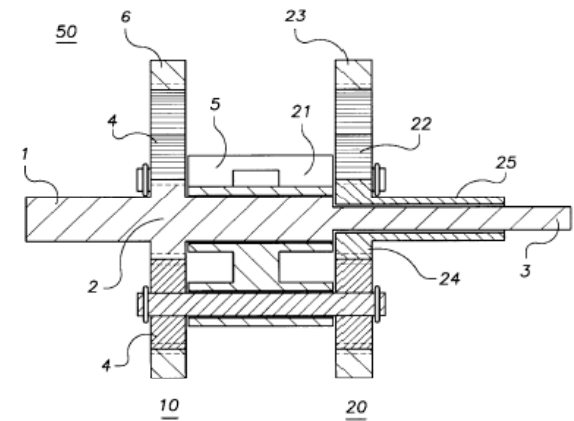
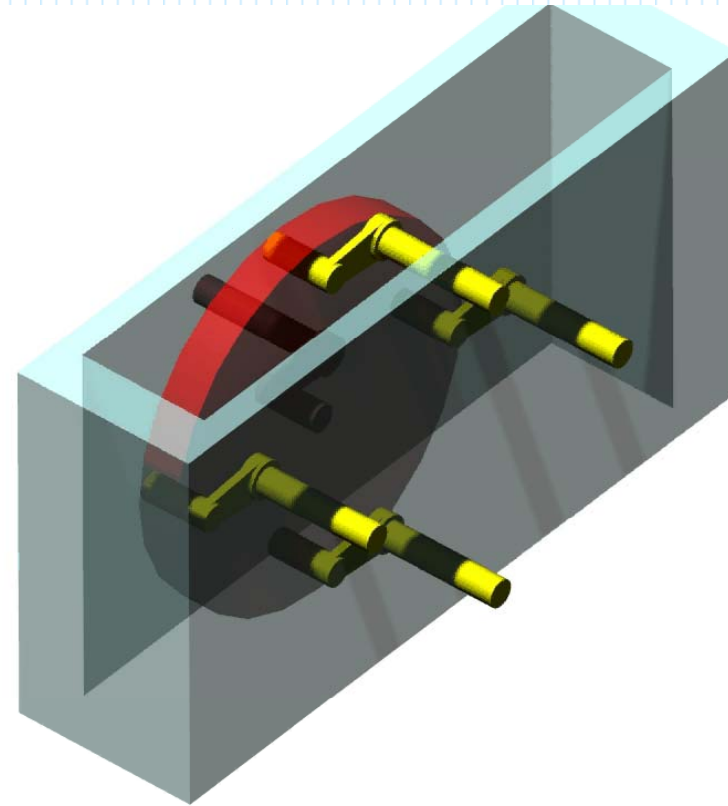
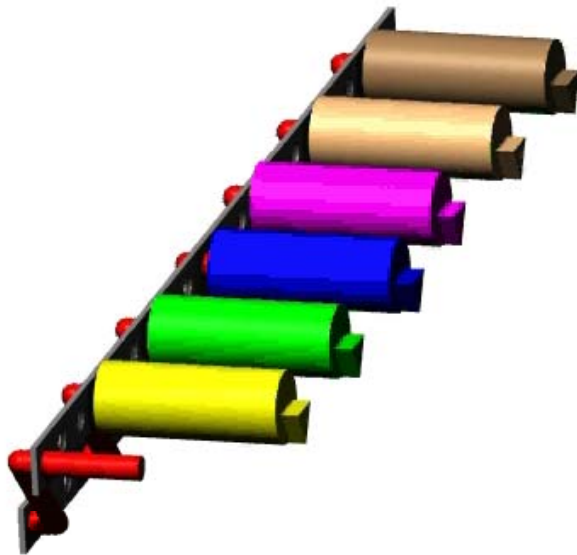


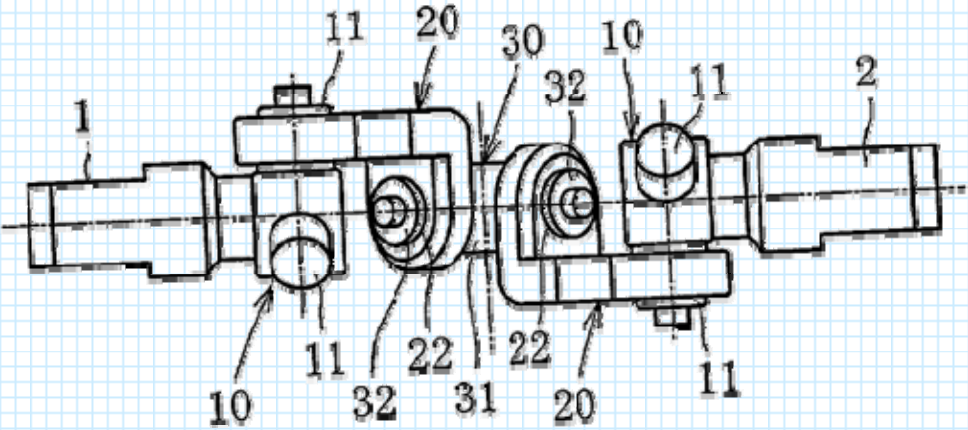
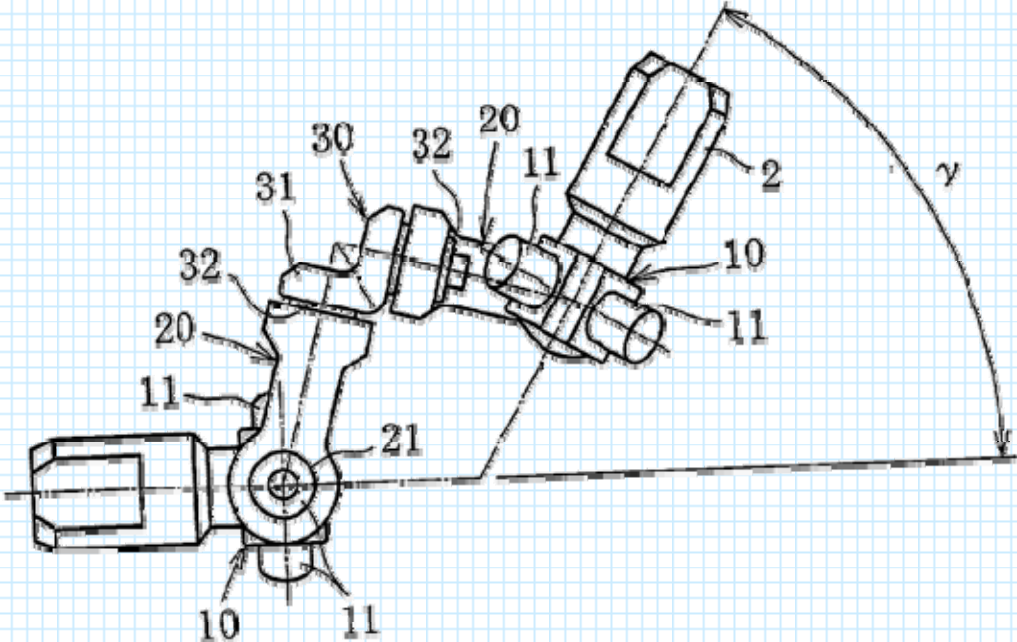
FIG. 3



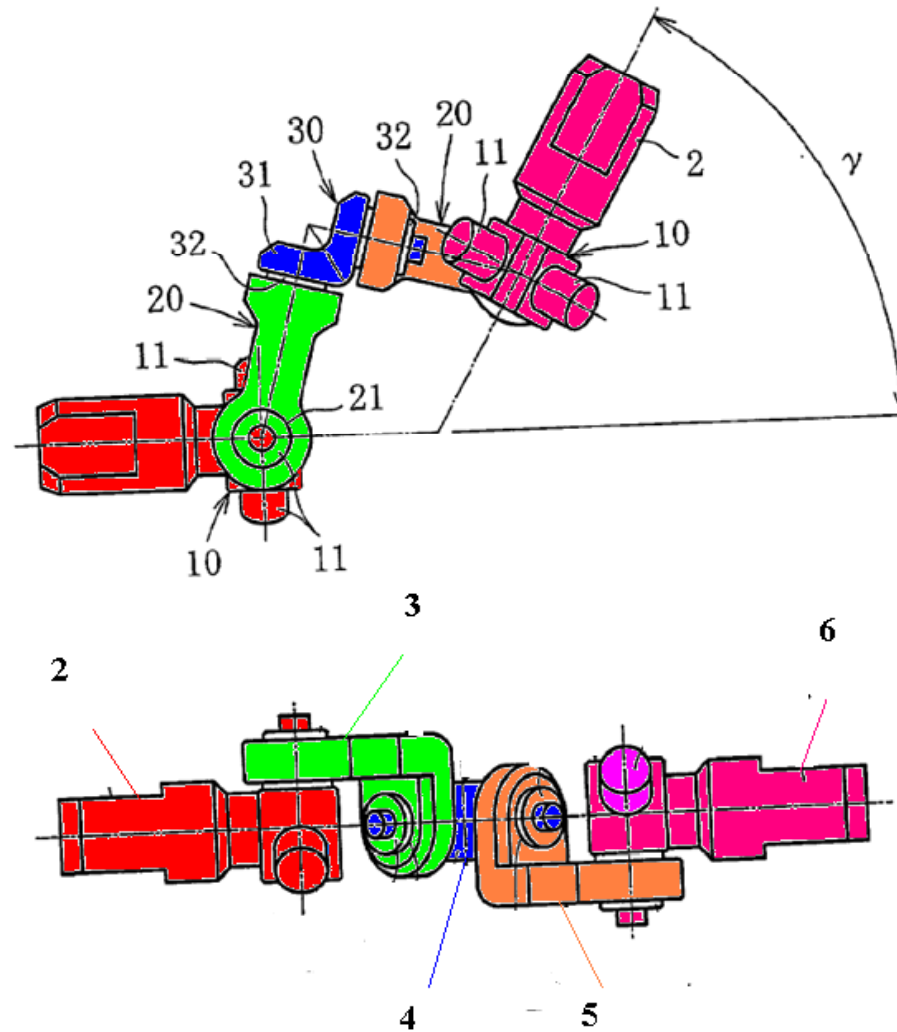
Paralelogram Linkages



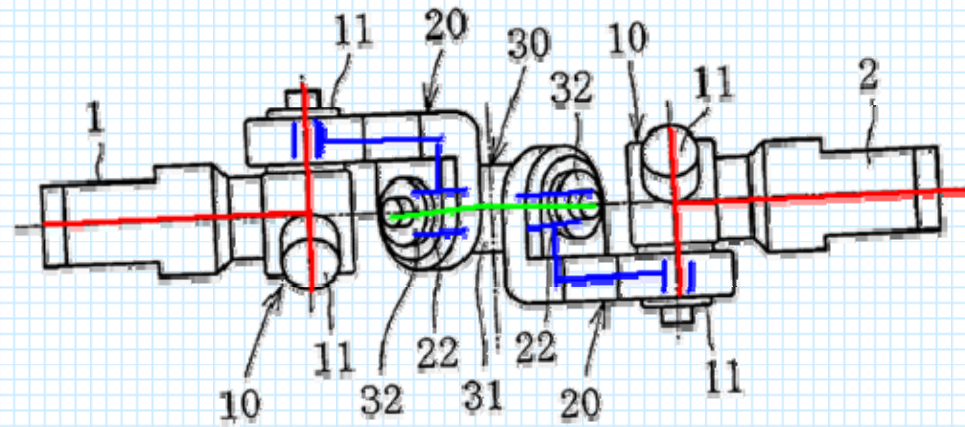
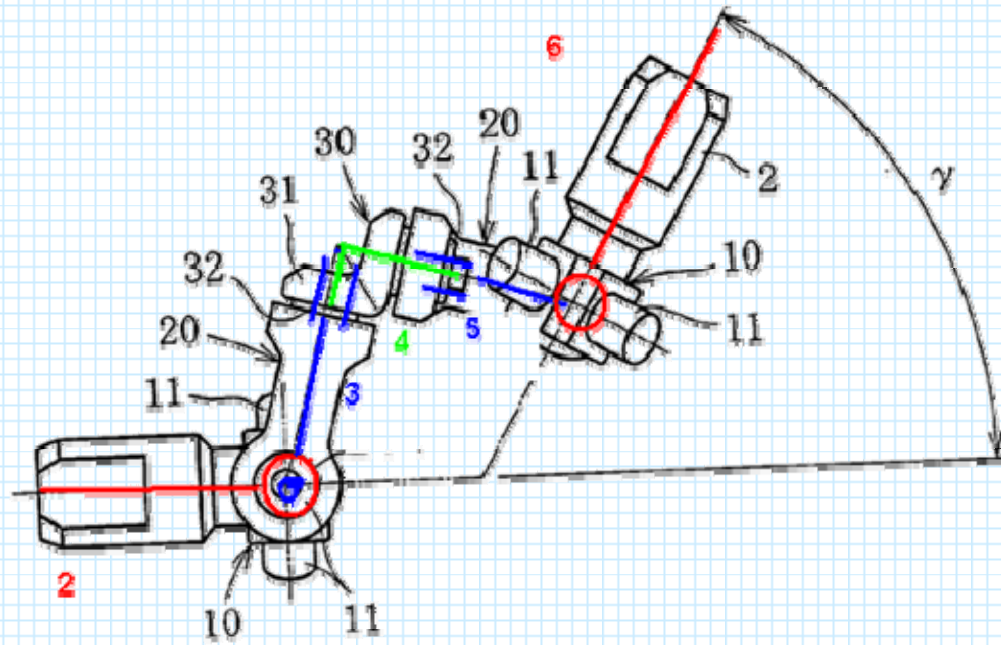
Example



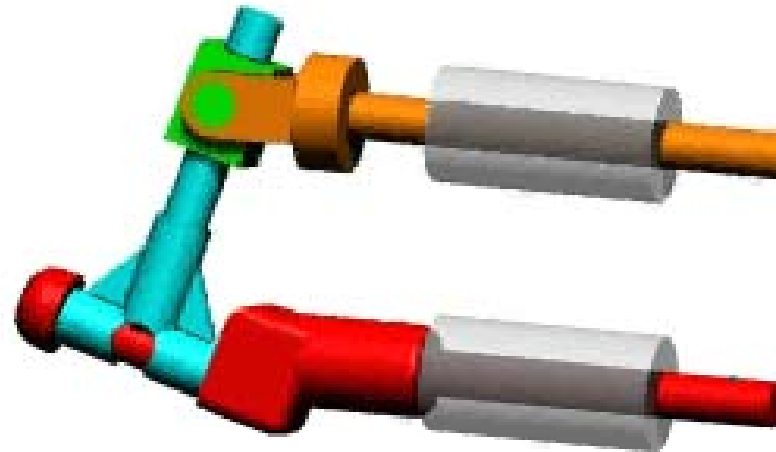
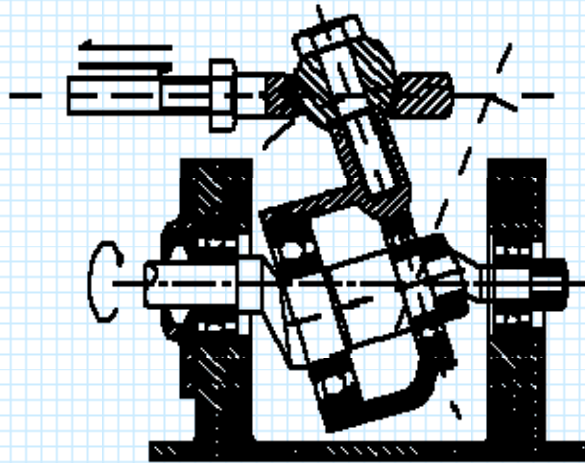
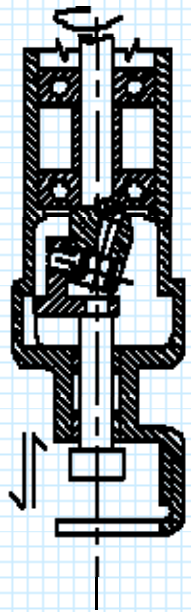
US patent US 2002/0183122
Constant velocity Universal Joint



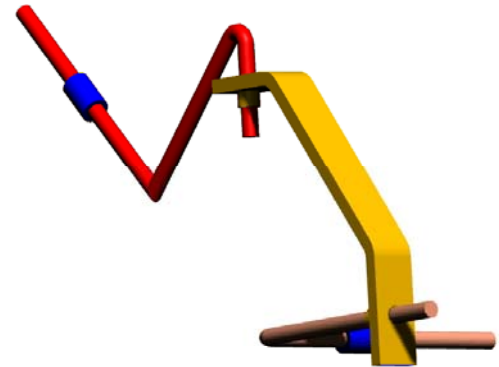
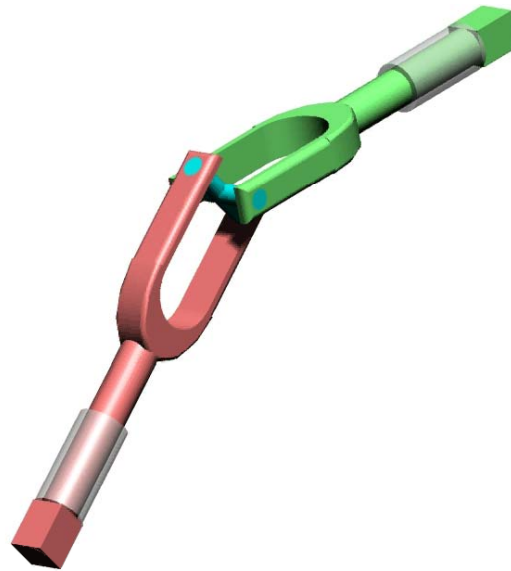
US patent US 2002/0183122
Constant velocity Universal Joint



Intersecting axes in space results in spherical space and $\lambda=3$

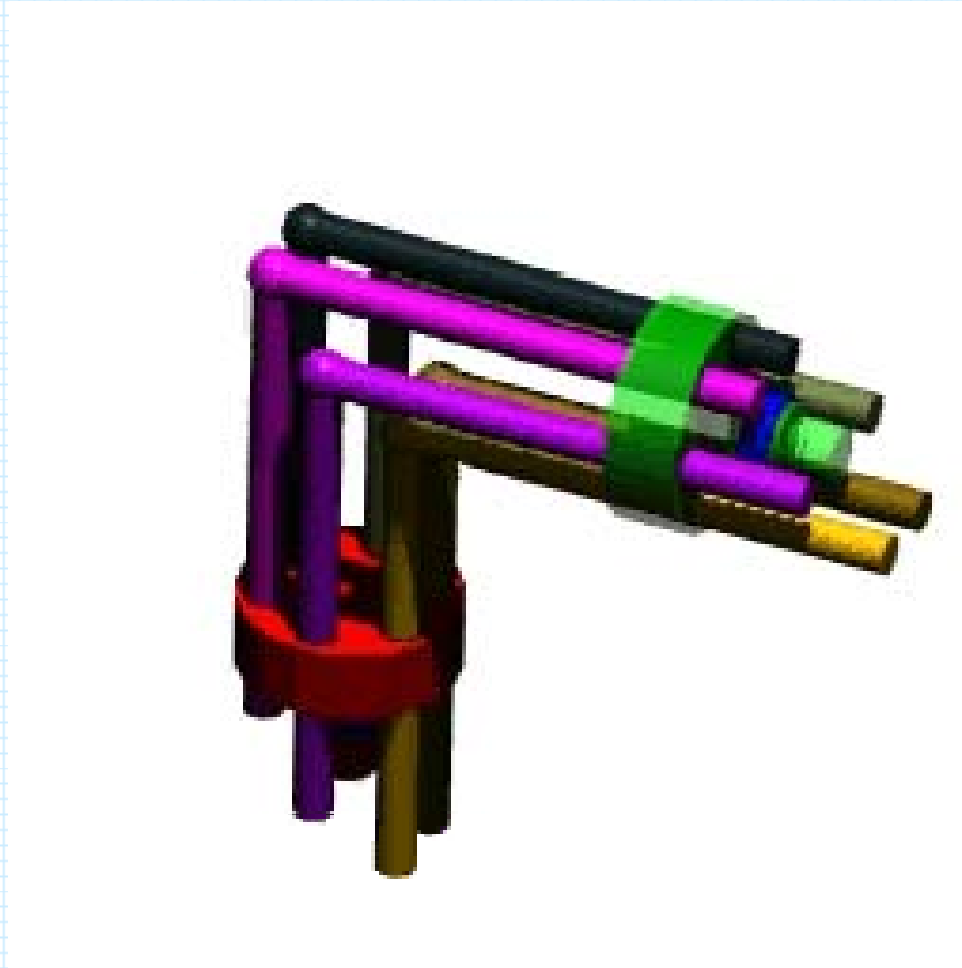


Spherical Four-Bar



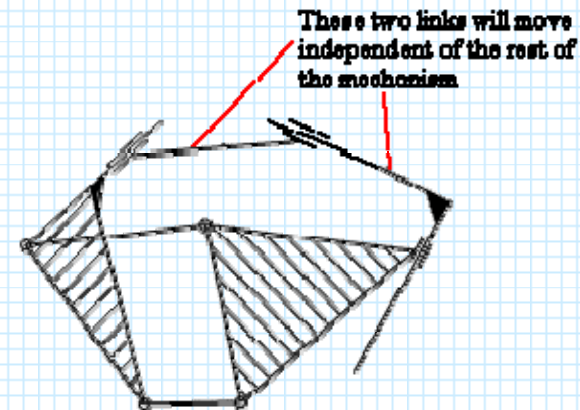
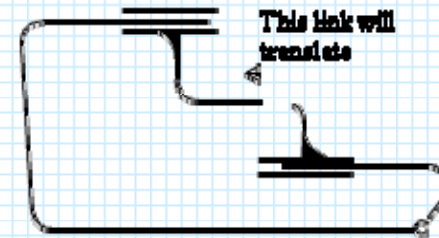
Parallel axes create additional freedom.

The constraints imposed by the joints are dependant to each other

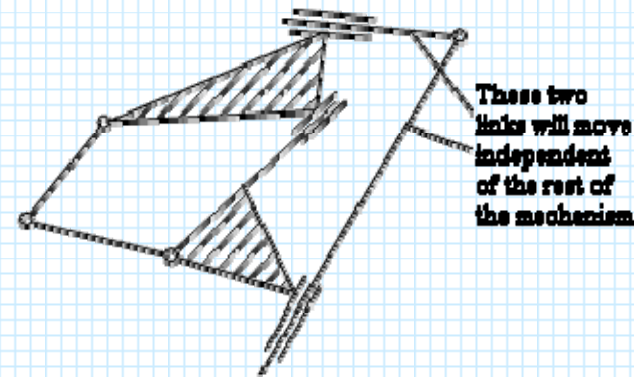


Some Rules for Planar Mechanisms with R and P joints

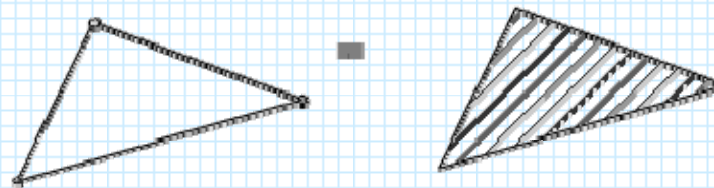
1. If the kinematic elements of a link form sliding pairs, the **axes of the sliding pairs cannot be parallel.**
2. Binary links of the kinematic chain which have only prismatic pair elements **cannot be directly connected to each other.**



3. No closed link loop may have less than two turning pairs. If there is only one revolute joint, due to the other joints, which will be prismatic, rotation will not be possible between the two links connected by the revolute joint.



4. A three-link loop with revolute and prismatic joints must be counted as one link. An exception to this case is a three link-loop with sliding pairs only

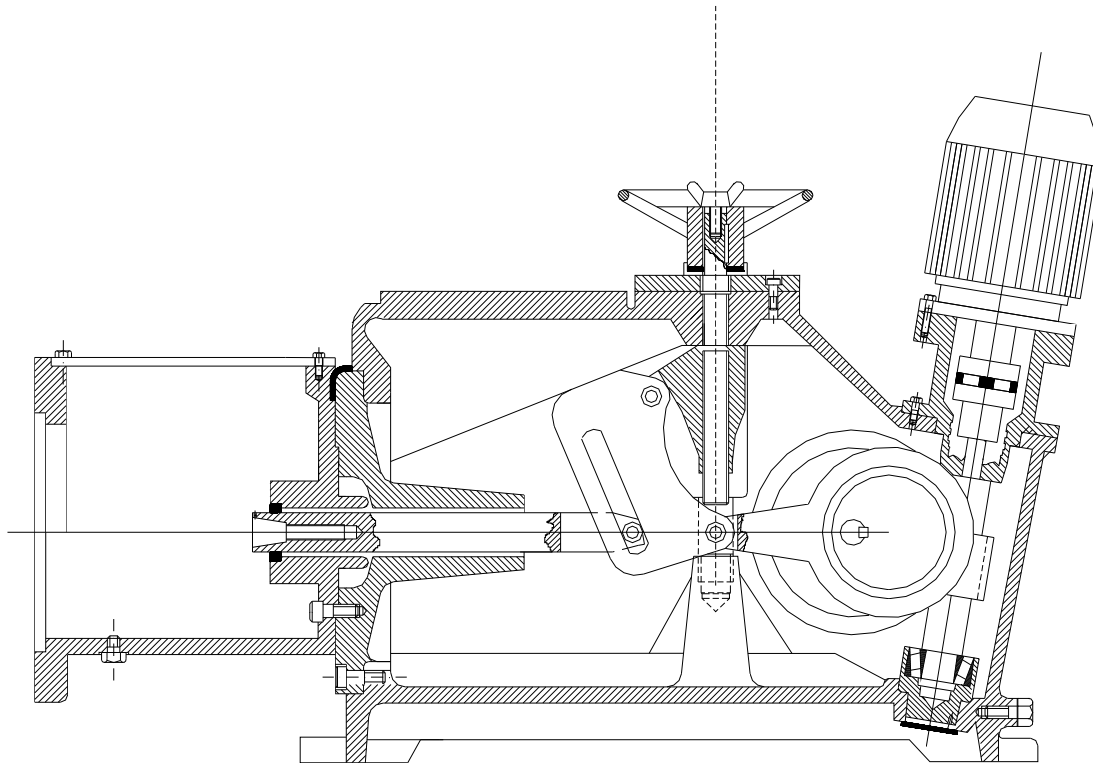


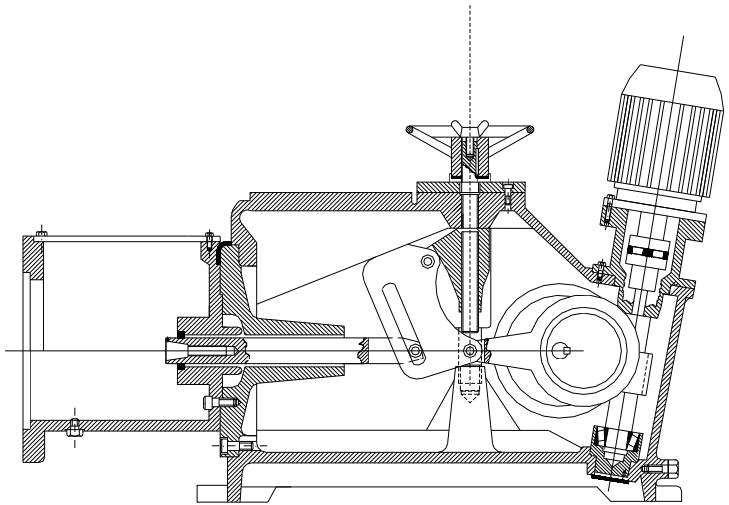
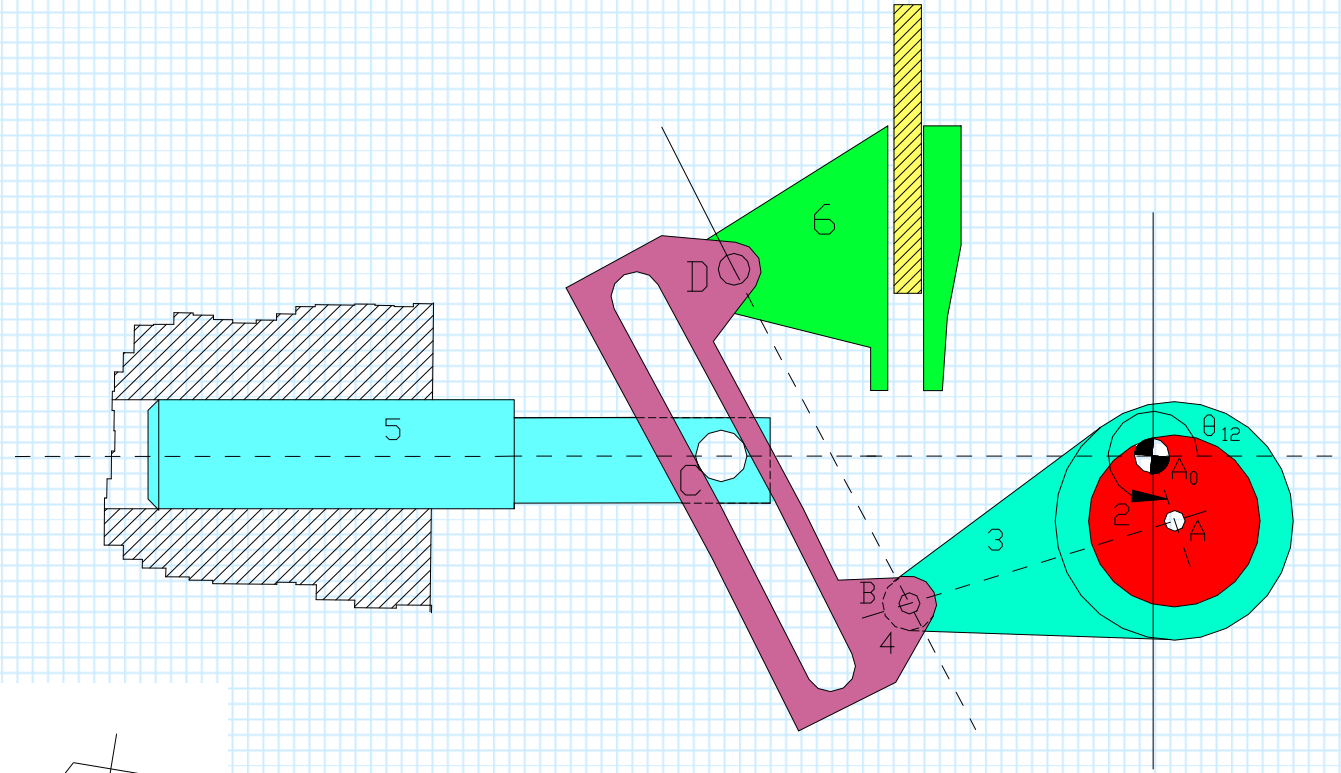
- Constrained Mechanisms

- Unconstrained Mechanisms

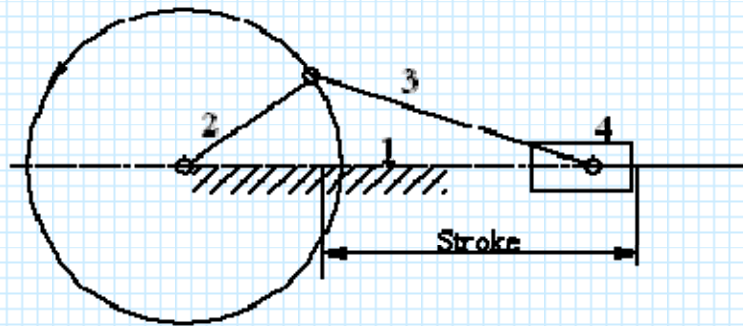
<http://br.youtube.com/watch?v=y7usX-f97Os&mode=related&search=>

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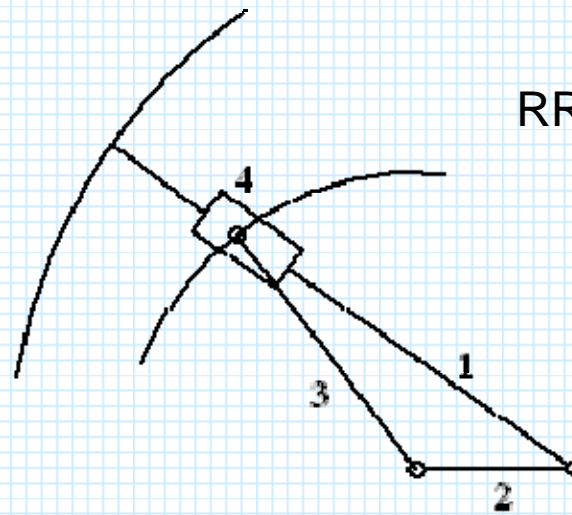




Kinematic Inversion

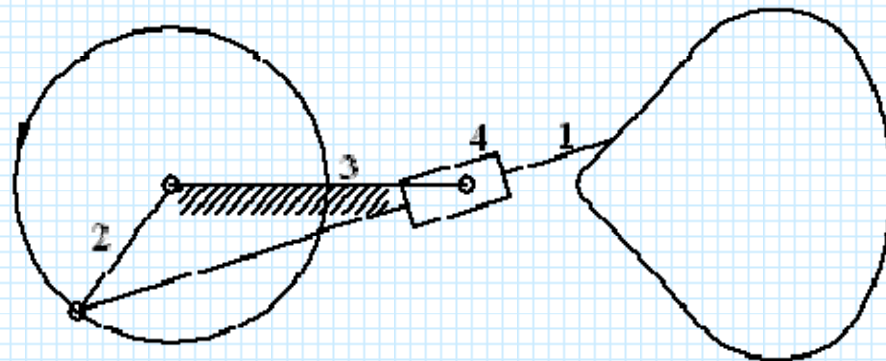


a) - Slider-Crank Mechanism

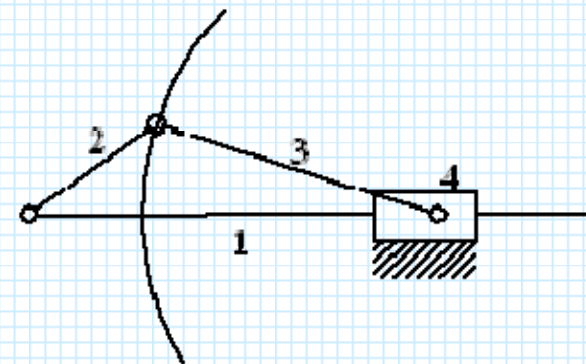


b) - Inverted Slider-Crank Mechanism

RRRP Chain

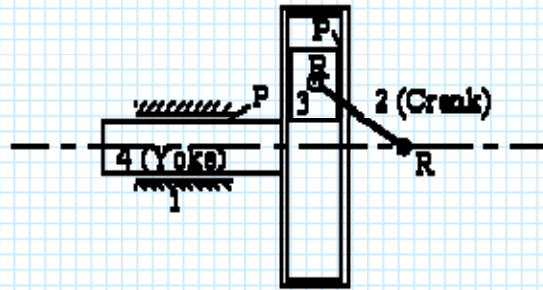


a) - Swinging Block Mechanism

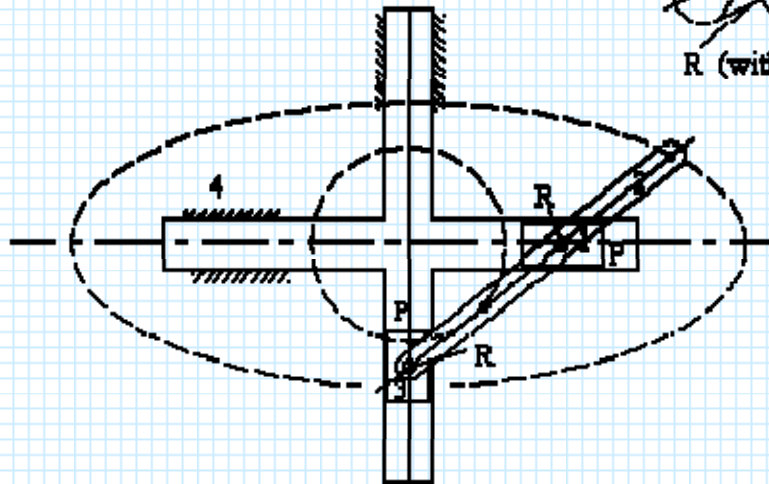
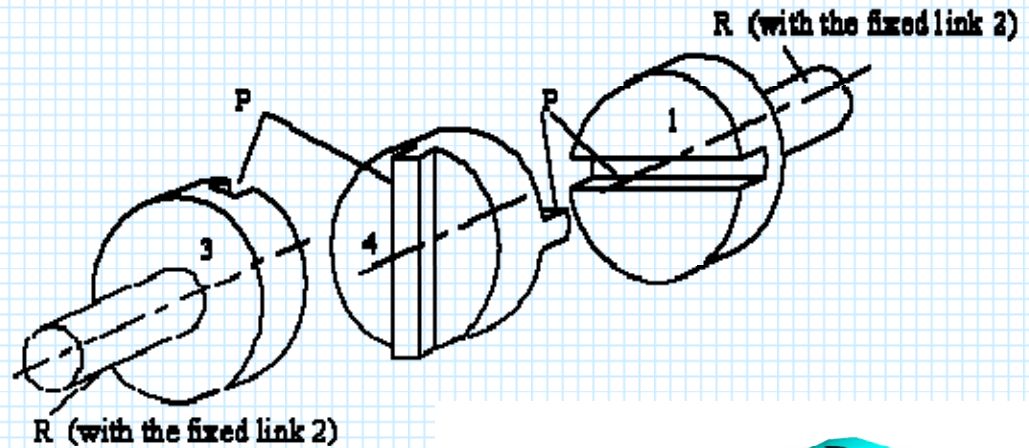


c) - Slider-Crank Mechanism

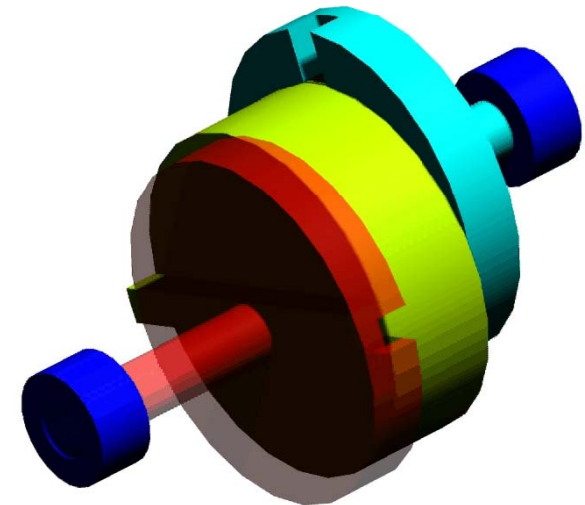
Kinematic Inversion



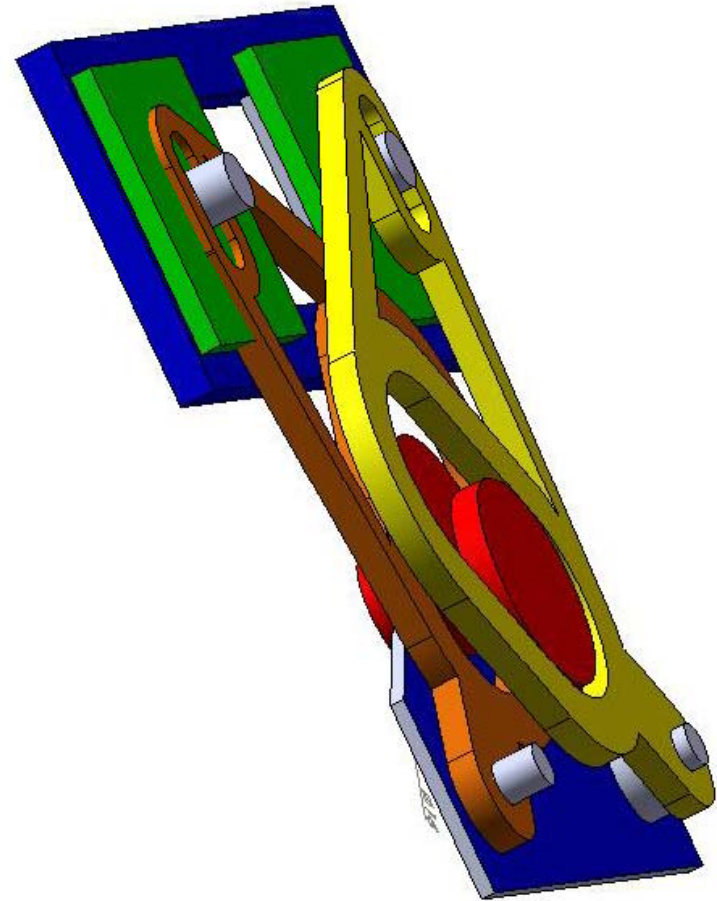
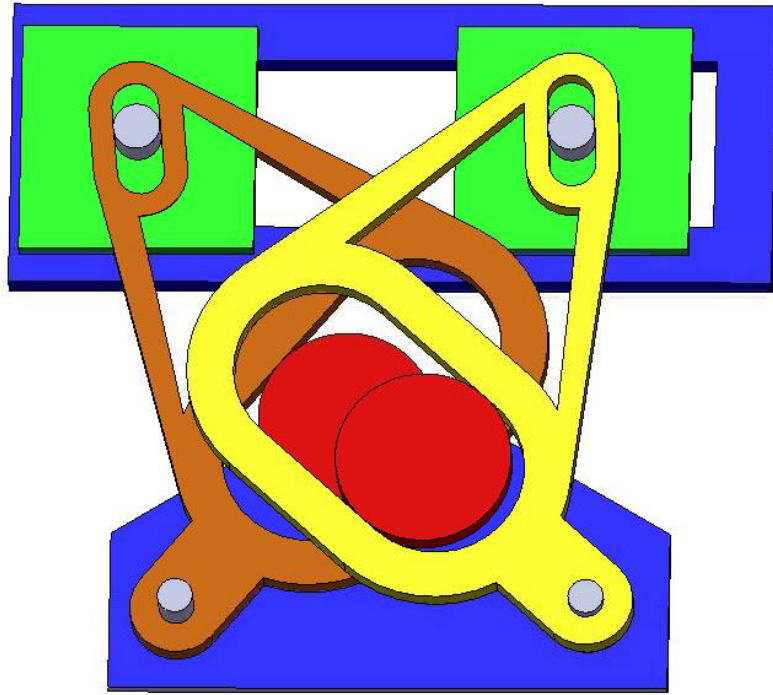
a) Scotch-Yoke Mechanism



c) Double slide (Elliptic tremmel)







Grübler's Equation

- General Degree of Freedom Equation

$$F = \lambda(\ell - j - 1) + \sum_j f_i$$

- If $\lambda=3$ (planar space) and $f_i=1$ (revolute or prismatic joints only)
And we search for single degree of freedom mechanisms $F=1$
($\sum f_i = j$)

Or

$$1 = 3(\ell - j - 1) + j$$
$$3\ell - 2j + 4 = 0 \qquad \text{Grübler's Equation}$$

Conclusions

1. Number of links must be even
since $3l=2j+4$
2. The Number of Binary links in the mechanism must be greater than 4
3. The Number of kinematic elements on any one link cannot be greater than half of the number of links in the mechanism.

Enumeration of Mechanisms

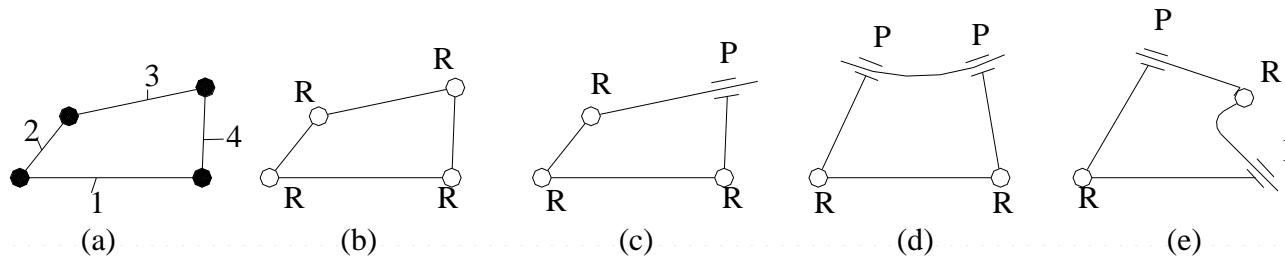
Enumeration: To list, to count

Enumeration of mechanisms: To determine all possible mechanisms that satisfy some given criteria

Example: Determine all possible mechanisms with 4 links and that satisfy Grübler's Equation

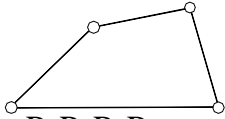
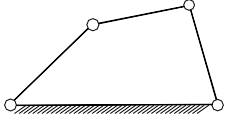
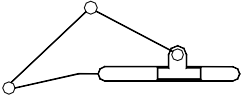
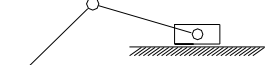
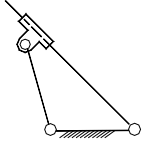
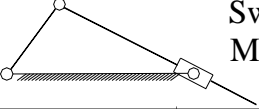
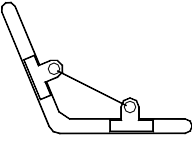
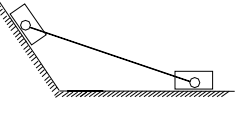
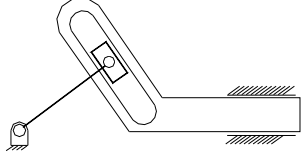
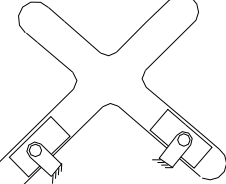
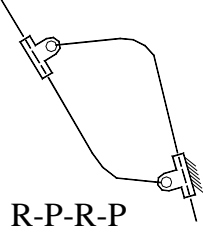
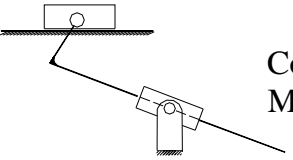
$\lambda=3$ (planar space) and $f_i=1$ (revolute or prismatic joints only)
and $F=1$, $3l-2j=4$. Since $l=4$, $j=4$. 4 links connected to each other by 4 joints. All the links must be binary.

All the possible Kinematic Chains:



All the possible Mechanisms

(planar 1 Dof mechanisms with R and P joints and with 4 links only)

 <p>R-R-R-R</p>	 <p>Four-Bar Mechanism</p>		
 <p>R-R-R-P</p>	 <p>Slider-Crank Mechanism</p>	 <p>Inverted Slider or Quick-Return Mechanism</p>  <p>Swinging Block Mechanism</p>	
 <p>R-R-P-P</p>	 <p>Double Slider</p>	 <p>Scotch-Yoke Mechanism</p>	 <p>Oldham Coupling</p>
 <p>R-P-R-P</p>	 <p>Conchoidal Motion Mechanism</p>		

Enumeration

Example

Planar, one degree of freedom mechanisms with R and P joints and with 6 links

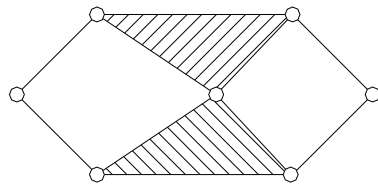
$l=6$ $F=1$, $\lambda=3$, $f_i=1$ for all joints therefore $\sum f_i=j$: Hence $j=7$

$$2j = 2l_2 + 3l_3 = 14$$

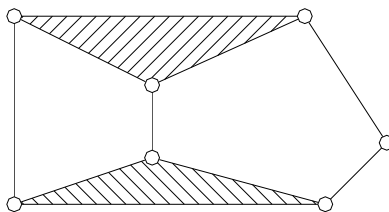
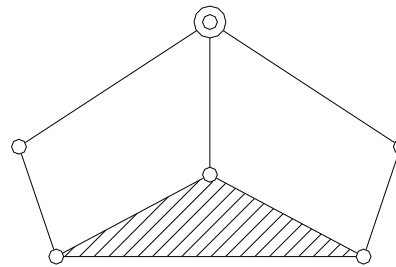
$$l = l_2 + l_3 = 6$$

$$l_2 = 4, \quad l_3 = 2$$

Possible Kinematic Chains:



Watt's Chain



Steffenson's Chain

