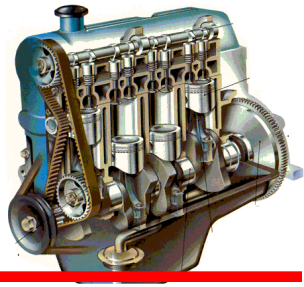

MDPG 126

Mechanics of Machines

Lecture 2:

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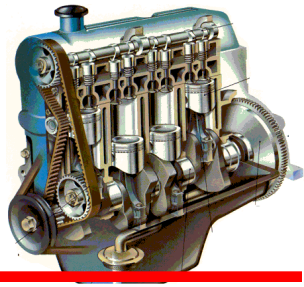
Kinematic Chains

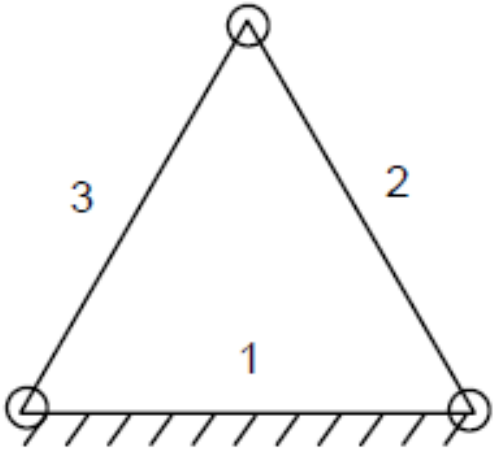


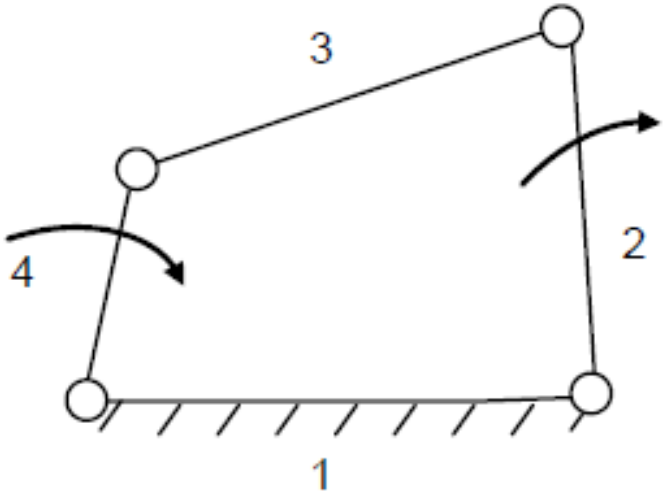
It may be observed that to form a simple closed chain we need at least three links with three kinematic pairs. If any one of these three links is fixed, there cannot be relative movement and, therefore, it does not form a mechanism but it becomes a structure which is completely rigid.

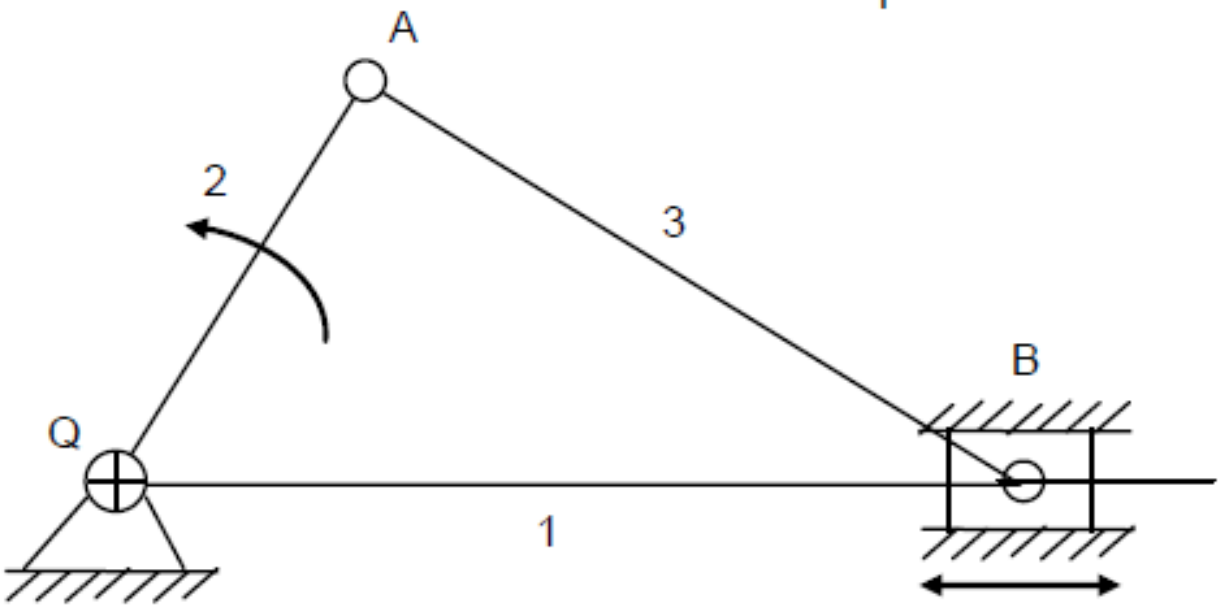
Thus, a simplest mechanism consists of four links, each connected by a kinematic lower pair (revolute etc.), and it is known as four bar mechanism.

In a kinematic chain, four links are required which are connected with each other with the help of lower pairs. These pairs can be revolute pairs or prismatic pairs. A prismatic pair can be thought of as the limiting case of a revolute pair.

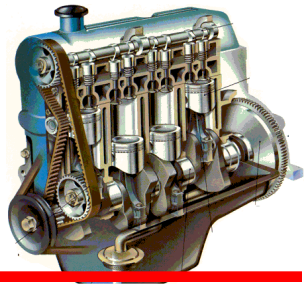
Kinematic Chains



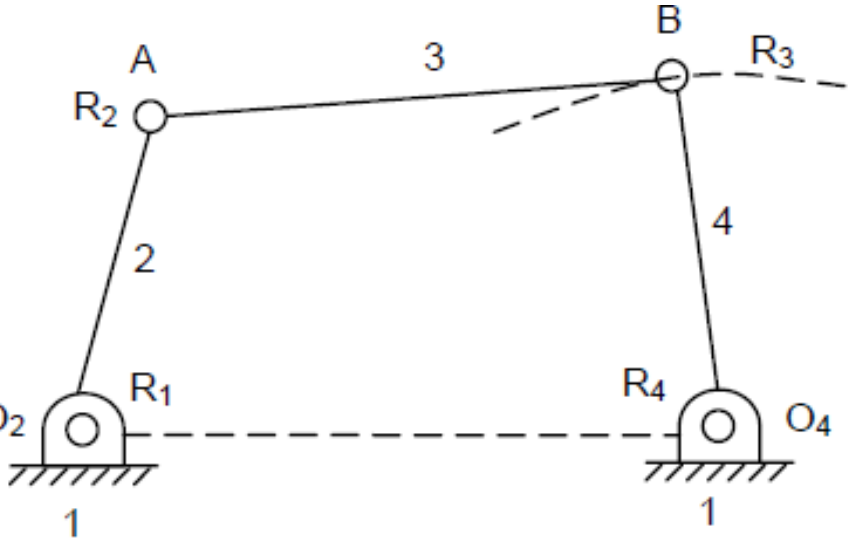


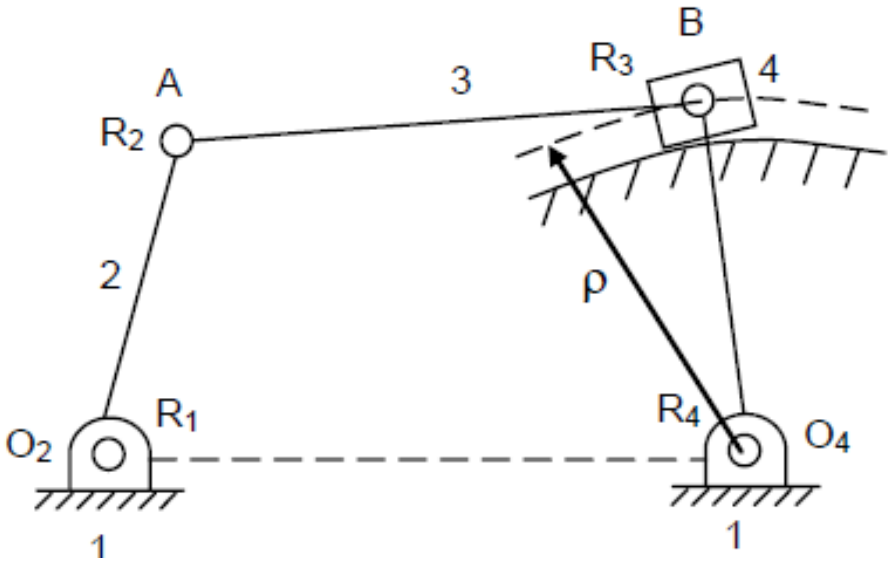


Kinematic Chains

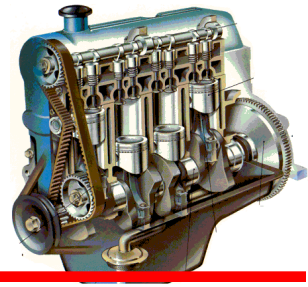


The curved slider in figure acts similar to the revolute pair. If radius of curvature 'ρ' of the curved slider becomes infinite, the angular motion of the slider changes into linear displacement and the revolute pair *R*4 transforms to a prismatic pair.

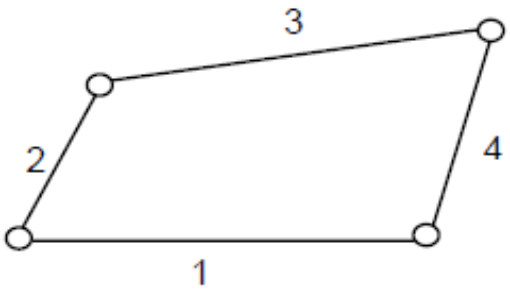


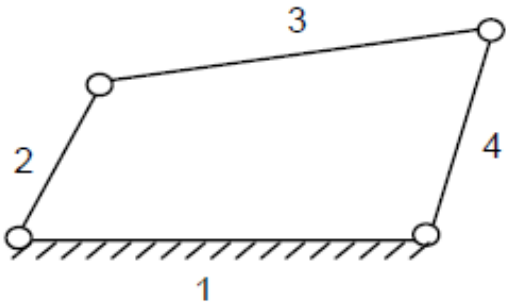


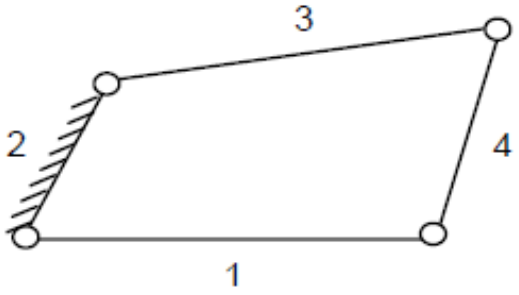
INVERSIONS OF KINEMATIC CHAIN

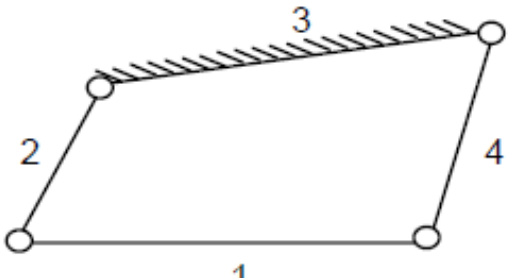


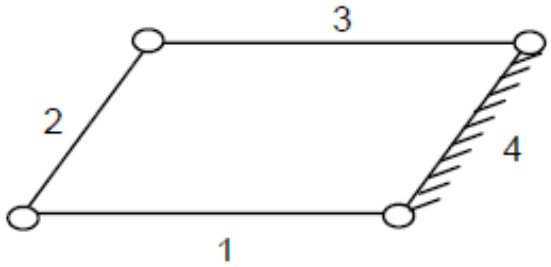
If in a four bar kinematic chain all links are free, motion will be unconstrained. When one link of a kinematic chain is fixed, it works as a mechanism. From a four link kinematic chain, four different mechanisms can be obtained by fixing each of the four links turn by turn. All these mechanisms are called inversions of the parent kinematic chain.



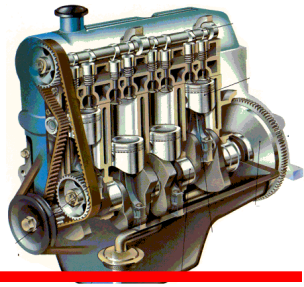








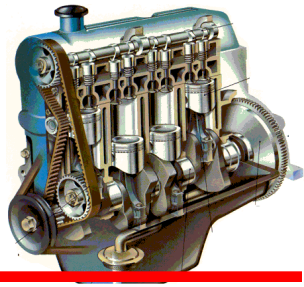
Four Bar Kinematic Chain



- Depending on different type of kinematic pairs, four bar kinematic chain can be classified into three categories :

1. 4R-kinematic chain which has all the four kinematic pairs as revolute pairs.
2. 3R-1P kinematic chain which has three revolute pairs and one prismatic pair. This is also called as single slider crank chain.
3. 2R-2P kinematic chain which has two revolute pairs and two prismatic pairs. This is also called as double slider crank chain.

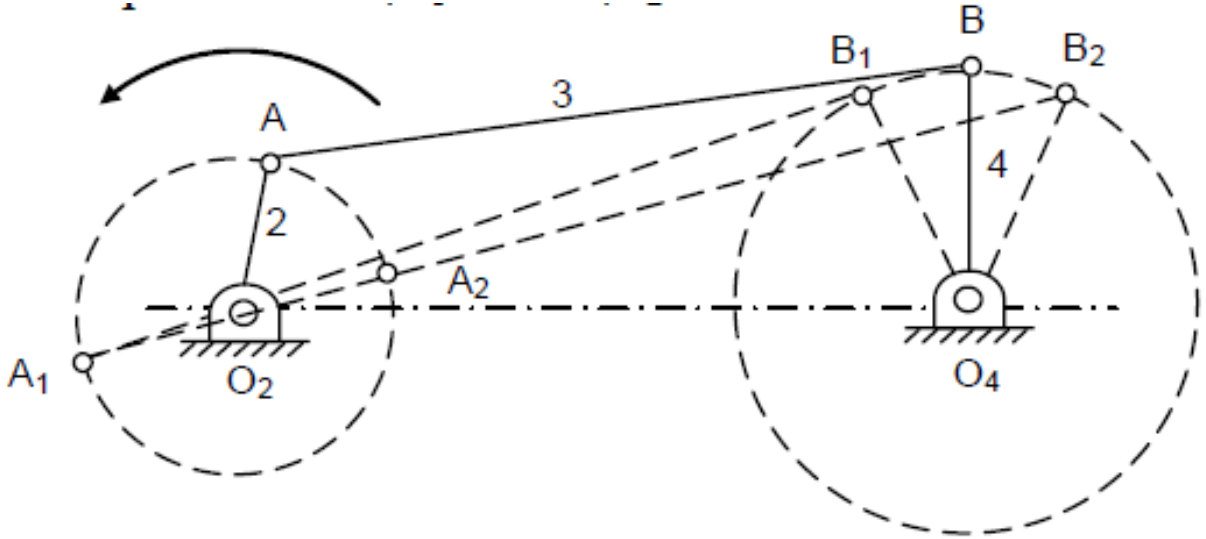
Inversions of 4R-Kinematic Chain



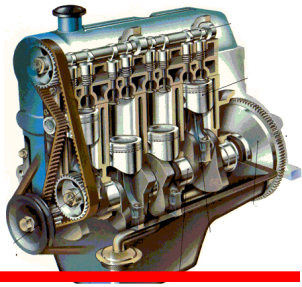
all four inversions of 4R-kinematic chain are identical. However, by suitably altering the proportions of lengths of links 1, 2, 3 and 4 respectively several mechanisms are obtained.

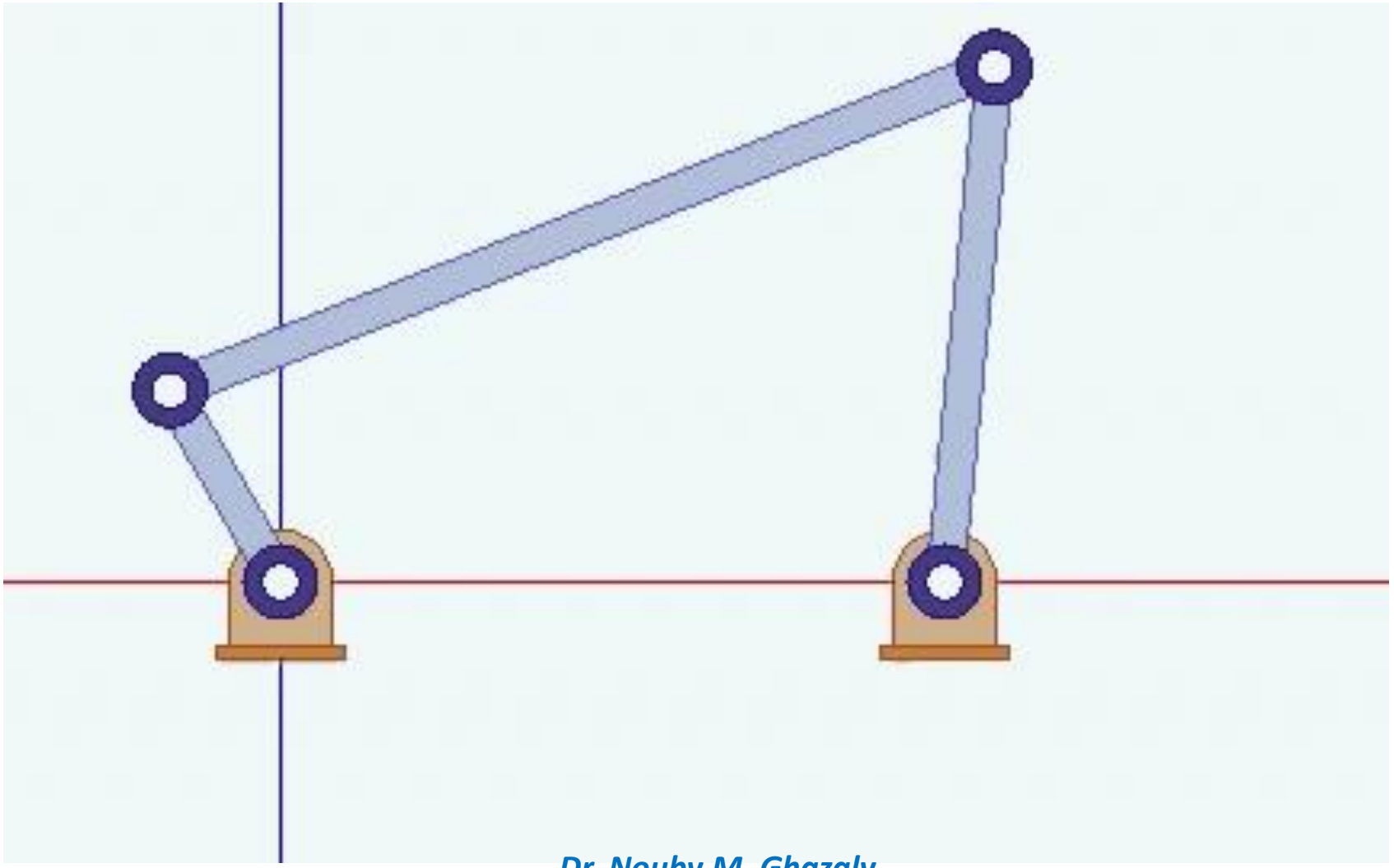
1-Crank-lever Mechanism or Crank-rocker Mechanism

In this case for every complete rotation of link 2 (called a crank), the link 4 (called a lever or rocker), makes oscillation between extreme positions *O*4*B*1 and *O*4*B*2.

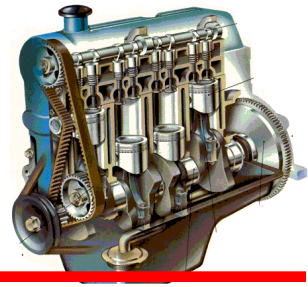


Crank-lever Mechanism
or
Crank-rocker Mechanism

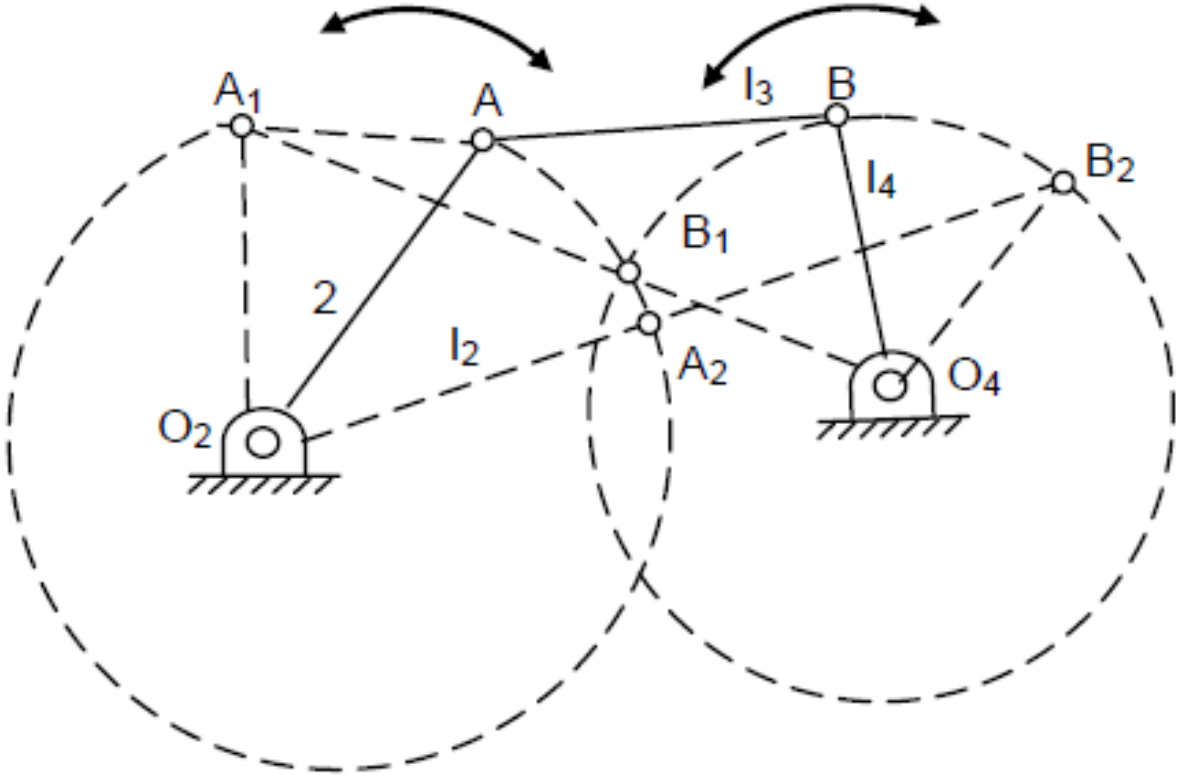




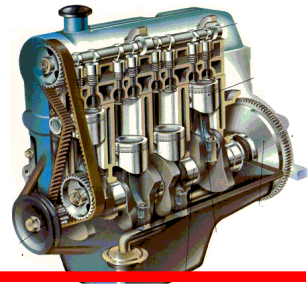
4R
Double-leaver Mechanism or Rocker-Rocker Mechanism



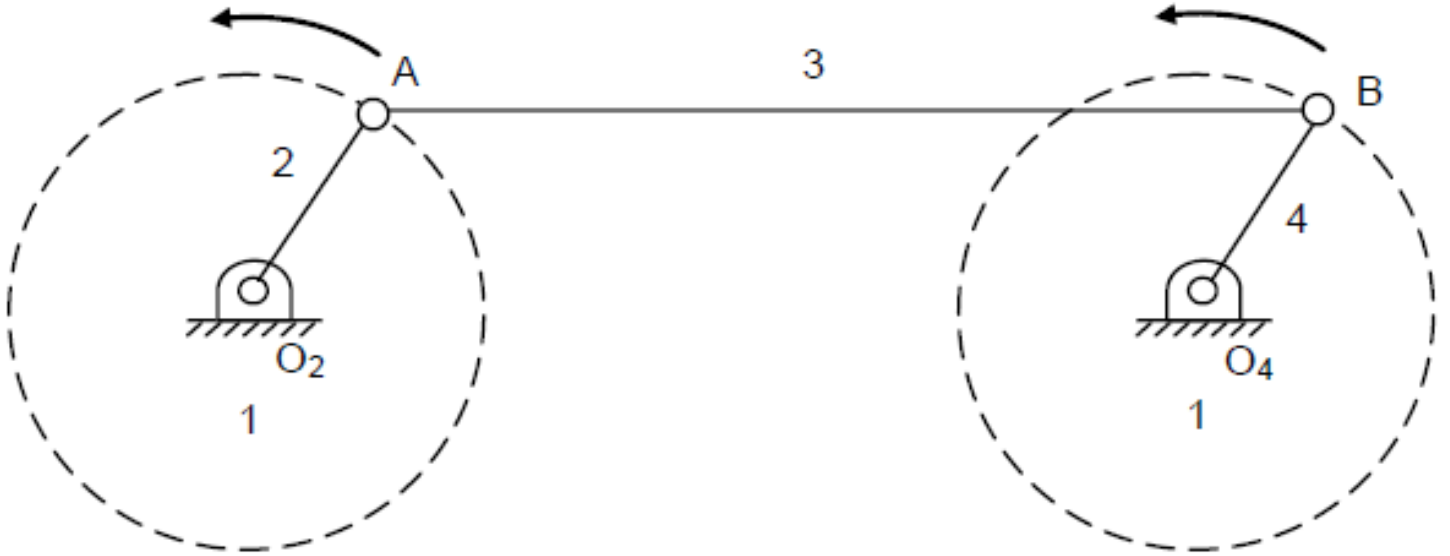
In this mechanism, both the links 2 and 4 can only oscillate. It may be observed that link *AB* has shorter length as compared to other links.



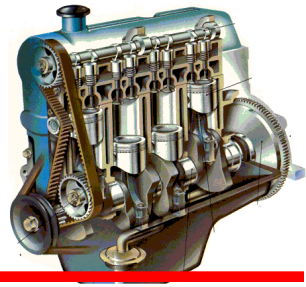
4R
Double Crank Mechanism



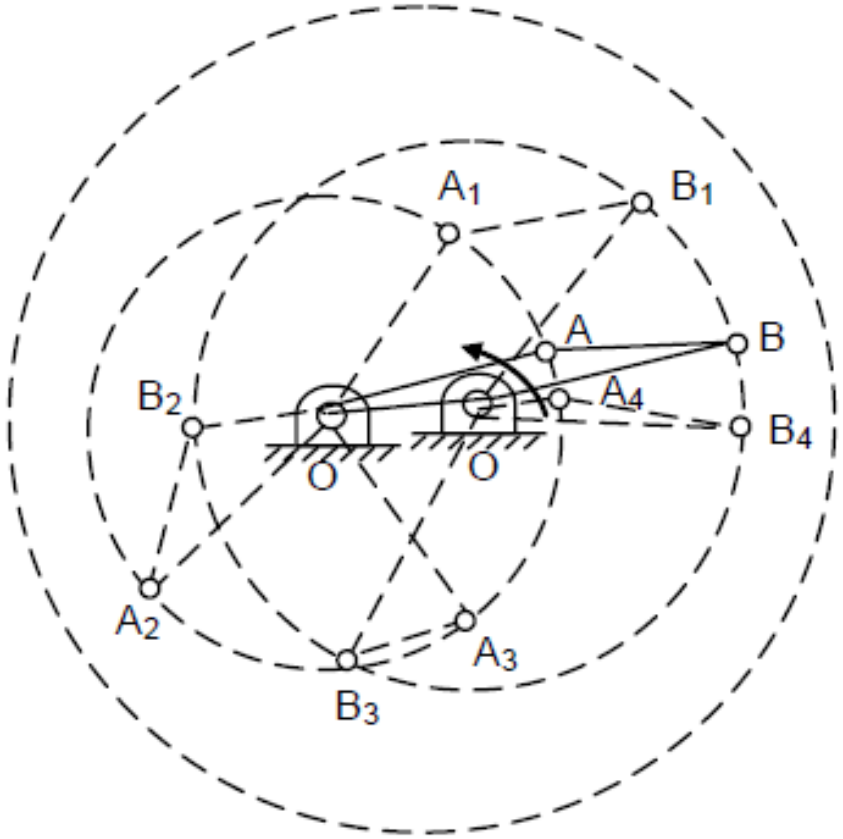
- **The links 2 and 4 of the double crank mechanism make complete revolutions. There are two forms of this mechanism.**
- ***Parallel Crank Mechanism***
- **In this mechanism, lengths of links 2 and 4 are equal. Lengths of links 1 and 3 are also equal.**



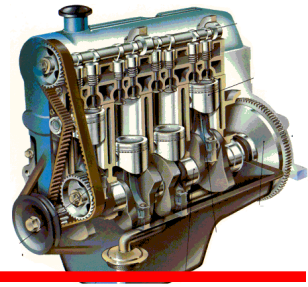
4R
Double Crank Mechanism



- *Drag Link Mechanism*
- **In this mechanism also links 2 and 4 make full rotation. As the link 2 and 4 rotate sometimes link 4 rotate faster and sometimes it becomes slow in rotation.**

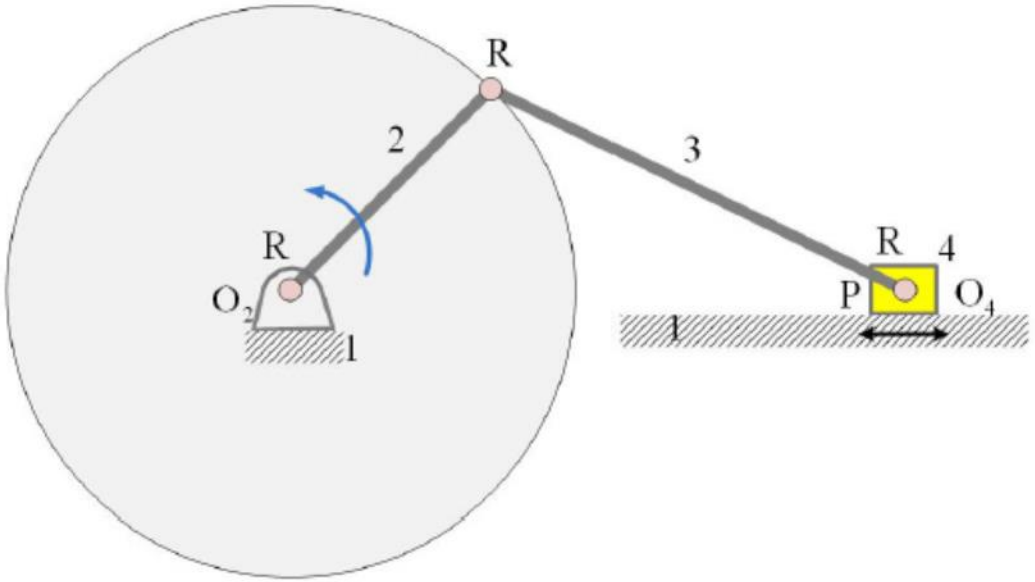


Inversions of 3R-1P Kinematic Chain

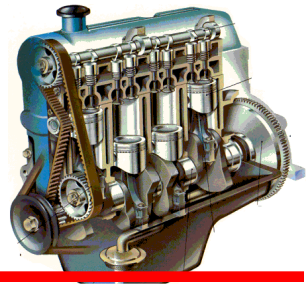


In this four bar kinematic chain, four links shown by blocks are connected through three revolute pairs and one prismatic pair.

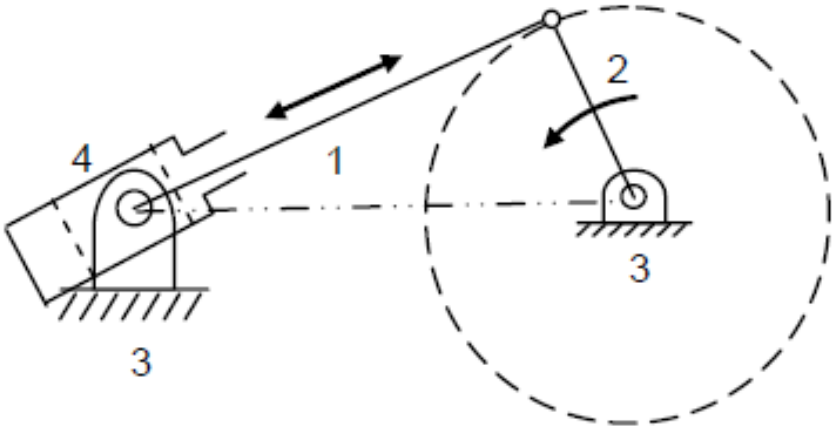
- **First Inversion**
- **In this mechanism, link 1 is fixed, link 2 works as crank, link 4 works as a slider and link 3 connects link 2 with 4. It is called connecting rod. Between links 1 and 4 sliding pair has been provided.**

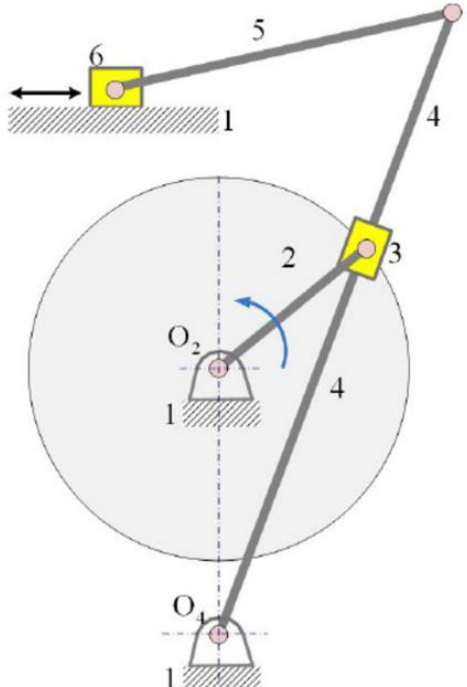


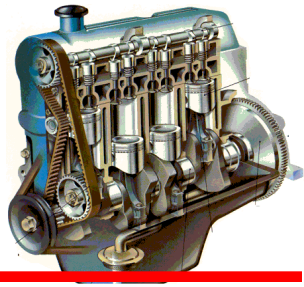
3R-1P



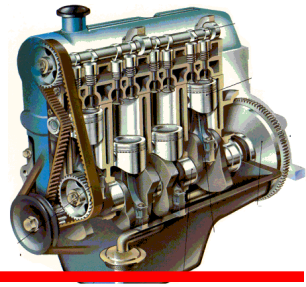
- **Third Inversion**
- **This inversion is obtained by fixing link 3. Some applications of this inversion are oscillating cylinder engine and crank and slotted lever quick return motion mechanism of a shaper machine. Link 1 works as a slider which slides in slotted or cylindrical link 4. Link 2 works as a crank.**



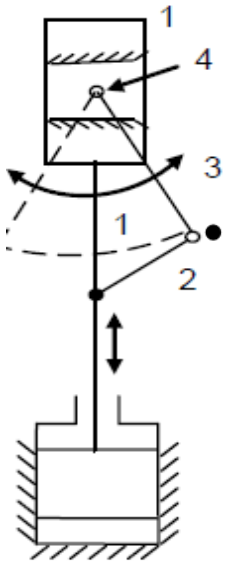




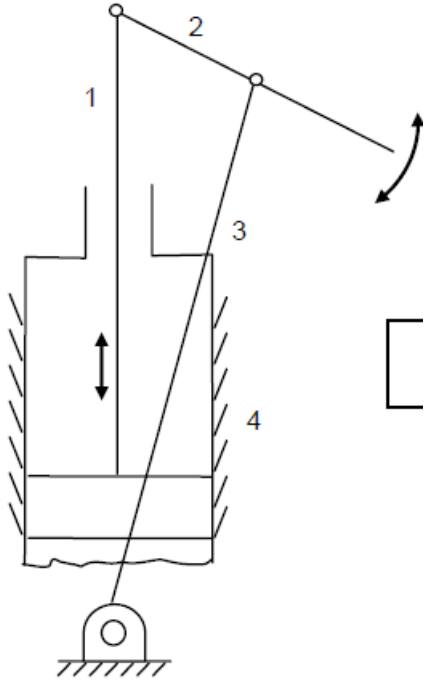
How Whitworth Quick Return motion mechanism works



- **Fourth Inversion – Pendulum Pump**
- **It is obtained by fixing link 4 which is slider. Application of this inversion is limited. The pendulum pump and hand pump are examples of this inversion. In pendulum pump, link 3 oscillates like a pendulum and link 1 has translatory motion which can be used for a pump.**

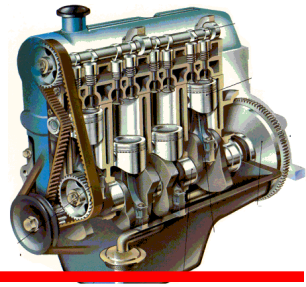


- pendulum pump

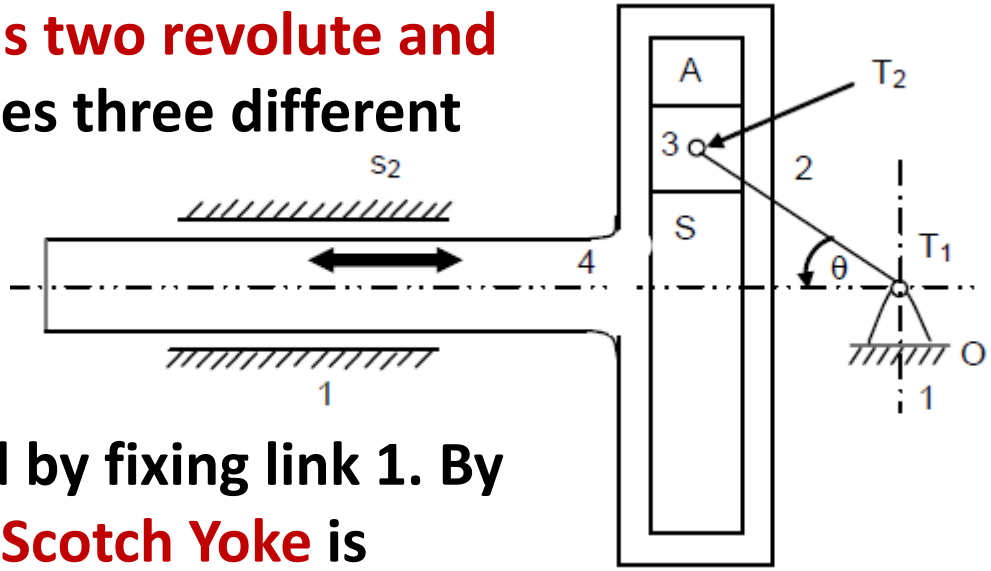


- hand pump

Inversions of 2R-2P Kinematic Chain (Double Slider Crank Chain)

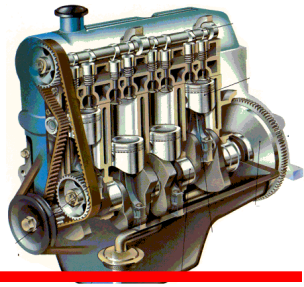


This four bar kinematic chain has two revolute and two prismatic. This chain provides three different mechanisms

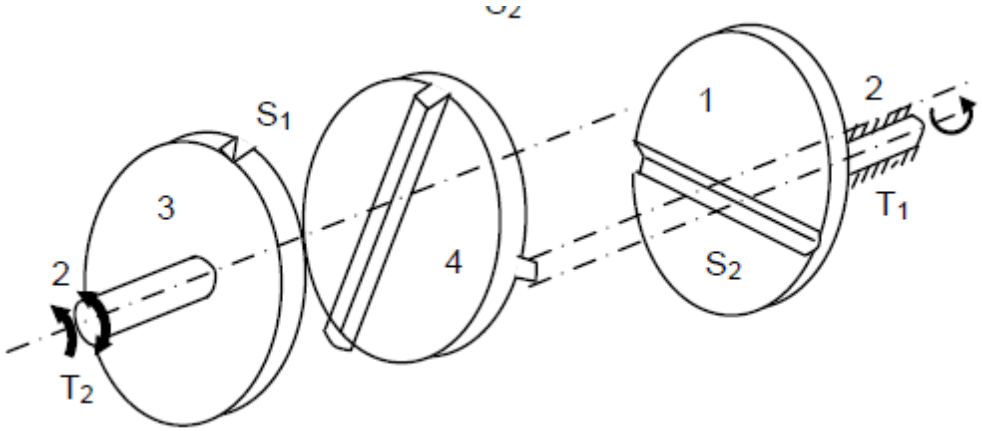


- First Inversion
- The first inversion is obtained by fixing link 1. By doing so a mechanism called Scotch Yoke is obtained. The link 1 is a slider similar to link 3. Link 2 works as a crank. Link 4 is a slotted link. When link 2 rotates, link 4 has simple harmonic motion for angle 'Ɵ' of link 2

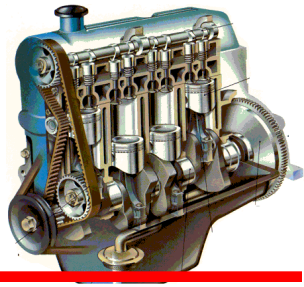
2R-2P



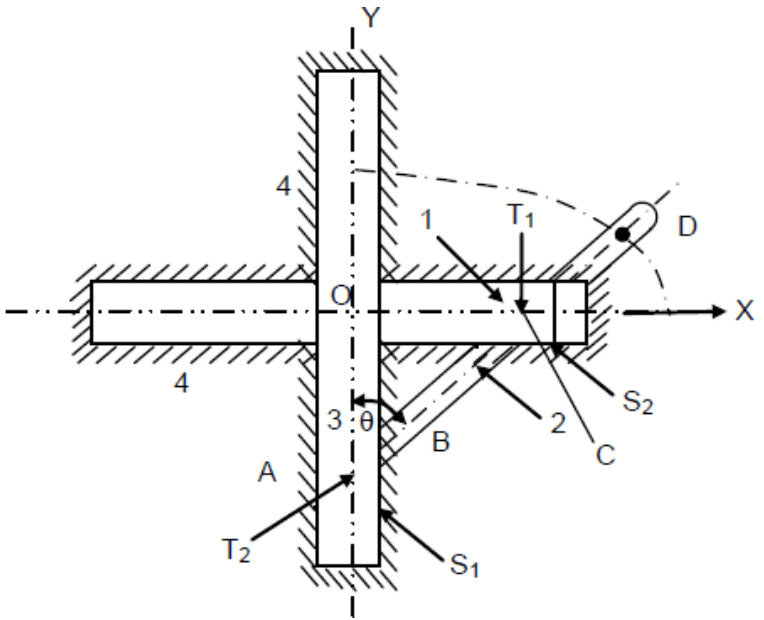
- **Second Inversion**
- **In this case, link 2 is fixed and a mechanism called Oldham's coupling is obtained. This coupling is used to connect two shafts which have eccentricity 'ε'. The axes of the two shafts are parallel but displaced by distance ε. The link 4 slides in the two slots provided in links 3 and 1. The centre of this link will move on a circle with diameter equal to eccentricity.**



2R-2P



- **Third Inversion**
- **This inversion is obtained by fixing link 4. The mechanism so obtained is called elliptical trammel which is shown in Fig. This mechanism is used to draw ellipse. The link 1, which is slider, moves in a horizontal slot of fixed link 4. The link 3 is also a slider moves in vertical slot. The point *D* on the extended portion of link 2 traces ellipse with the system of axes**



Questions?