**INTRODUCTION**

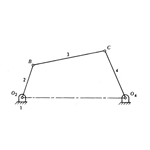
The goal was to create a four bar linkage and demonstrate its motion with a hand crank. We went above and beyond the rubric by adding 5 other legs. It didn't need to turn, it didn't need to be efficient, it just had to demonstrate we did the calculations and analysis of the path of the outer most point of the linkage.

**LITERATURE REVIEW**

Four-bar linkage or simply a 4-bar or four-bar is the simplest movable linkage. It consists of four rigid bodies (called bars or links), each attached to two others by single joints or pivots to form a closed loop.

Four-bars are simple mechanisms common in mechanical engineering machine design and fall under the study of kinematics. If each joint has one rotational degree of freedom (i.e., it is a pivot), then the mechanism is usually planar, and the 4-bar is determinate if the positions of any two bodies are known (although there may be two solutions). One body typically does not move (called the ground link, fixed link, or the frame), so the position of only one other body is needed to find all positions. The two links connected to the ground link are called grounded links. The remaining link, not directly connected to the ground link, is called the coupler link. In terms of mechanical action, one of the grounded links is selected to be the input link, i.e., the link to which an external force is applied to rotate it. The second grounded link is called the follower link, since its motion is completely determined by the motion of the input link.

Planar four-bar linkages perform a wide variety of motions with a few simple parts. They were also popular in the past due to the ease of calculations, prior to computers, compared to more complicated mechanisms.



**Fig.-1** Four Bar Linkage

Grashof's law is applied to pinned linkages and states; The sum of the shortest and longest link of a planar four-bar linkage cannot be greater than the sum of remaining two links if there is to be continuous relative motion between the links.

Kinematic Inversion

Every mechanism has moving members which move relative to each other about the joints connecting them. These relative motions result in the trajectories of the points on members of the mechanism. In any mechanism one link or member is fixed and acts as the frame. The trajectories and motion characteristics of mechanism depend on the choice of the reference frame link.

Inversions of a mechanism are the different configurations of the mechanism with change of the fixed reference link called frame. For different inversions of a mechanism although the motion characteristics are entirely different but the relative angular displacements of the members remain unchanged irrespective of the link chosen as frame.

The information obtained from one inversion of the linkage can be used to study other inversions of that linkage. Inversion technique is used extensively for analysis and synthesis of mechanisms.

Determining the Inversions of a Mechanism

Before going into details of obtaining inversions of a mechanism I would like to make it very clear that Inverse Kinematics is different from Kinematic Inversion. Read more about Inverse Kinematics.

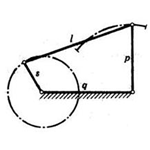
Every mechanism is formed of a kinematic chain. When one of the links in the kinematic chain is fixed it becomes a mechanism. To determine the inversions of a mechanism consider the kinematic chain forming the mechanism and obtain the desired inversions by fixing any one of the members as the frame link.

Inversions of a Four-Bar Mechanism

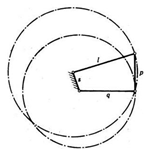
A typical four bar mechanism, as the name denotes, is formed of a kinematic chain of four members connected by revolute joints. This mechanism can have four possible configurations with a different link fixed as frame each time.

Configuration 1

Link 1 is taken as the base link or frame. In this configuration the shortest link is jointed to the base link and this joint can fully rotate and hence called as crank. The other link jointed to the base link oscillates and called as a rocker. This configuration of the four-bar kinematic chain is called as Crank-Rocker mechanism.

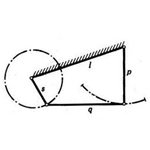


Configuration 2

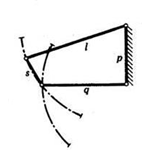
Link 2 is fixed as the base link. In this configuration shortest link is the base and both joints to the base can rotate completely. It is thus called as Double-Crank or a DragLink. 

Configuration 3

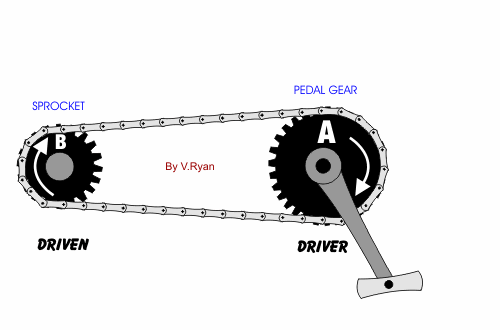
Link 3 is fixed as the base link. It can be observed that this configuration is same as the Crank-Rocker mechanism.



Configuration 4

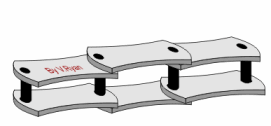
Link 4 is fixed as the base link. In this configuration shortest link is the coupler and both the links connected to the base link cannot rotate fully, both oscillate. In this configuration the four-bar kinematic chain is called as Double-Rocker 

Everyone has seen a bicycle or used one and noticed that it is driven by a large driver gear wheel with pedals attached. Smaller gears at the back are driven round, in turn driving round the back wheel. As the back wheel turns the bicycle moves forwards. Gears driven by chains are used in machinery, motorcycles, in car engines and have many more applications.



**Fig 2**: Gear wheels with chain

A chain is made up of a series of links with the links held together with steel pins. This arrange makes a chain a strong, long lasting way of transmitting rotary motion from one gear wheel to another.



**Fig3:** Chain linkage

Chain drive has one main advantage over a traditional gear train. Only two gear wheels and a chain are needed to transmit rotary motion over a distance. With a traditional gear train, many gears must be arranged meshing with each other in order to transmit motion.

The study of Kinematics of mechanisms and the machines, which are composed of one or more mechanisms, involves analysis of geometry of motion. Different components of any mechanism move relative to the each other following certain constraints to produce the desired motion. Kinematic analysis is of prime importance in design of mechanisms and machines.

For kinematic design of a mechanism analysis is done for positions of points on a solid body and the time derivatives of the position. The first derivative of position with respect to time is velocity, the second derivative is acceleration and further derivatives can be analyzed according to the design requirements. Similarly for angular position there is angular velocity and angular acceleration.

Mechanisms

The simplest example for a mechanism will be a liver hinged at a wedge. It transfers input motion at one end to the output motion on the other end. A scissors is a combination of two livers; the mechanical work from one end can be transformed to cutting motion on the output end. The two livers in scissors are connected together by a joint (revolute joint). A slightly more complex mechanism is a slider crank mechanism.

Thus mechanisms can be defined as assembly of rigid members connected to each other through joints. A mechanism transfers the input motion or work at the input point or point of actuation to one or more output points. Like in case of slider crank mechanism, the input rotational motion of the crank is transferred to the slider as a reciprocating motion.

simple Mechanisms

Kinematic Joints

The members in a mechanism are connected by kinematic joints. A kinematic joint is formed by direct contact between the surfaces of the members forming that joint. The contact between the surfaces of the members can be point contact, line contact or area contact. The joints are classified according to the type of contact and relative motion of the members. The contact stresses developed will also depend on the contact type.

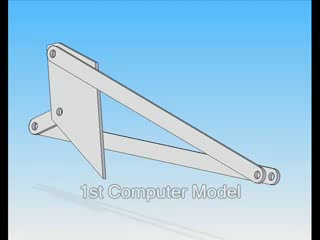
There are two types of joints according to the type of contact:

1. Lower pair joint

2. Higher pair joint

Lower pair joint has area contact between the two mating surfaces of the members forming joint, as in the case for slider, revolute and hinge.

Higher pair joint has the contact between the mating surfaces as point or line contact as in the case for cam pair and cam-follower.



**Fig3:** 1st computer model

**Design & specification**



**Fig 5:** Working model

**Dimensions of construction**

Length of leg : 20 cm

Total length : 68cm

Total width : 30cm

Total height : 30cm

**Dimensions of four bar chain system**

Length of crank (link4) : 6.5cm

Length of rocker arm (link2) : 21.5cm

Length of connecting rod (link3) : 11cm

Fixed Length (link1) : 24cm

**Total linear displacement of system:** 39 cm per rotation of crank link

**Application & drawbacks**

1: It can be used in agricultural field for sowing .

2: It can be used in automobiles.

3: It is less efficient.

4: It is heavy in constructions.

5: It is difficult to handle.

Conclusion

Our aim to use the four bar linkage and to demonstrate the calculation and analysis of path of outermost linkage which has been done successfully. We get a linear displacement of outermost linkage is about 39 cm by one complete rotation of crank.

Cost Estimation

1. Chain = Rs. 157
2. Gear wheels (3) = Rs. 150
3. Mild steel plates, rod = Rs.240
4. Other expenses = Rs. 60

Total cost = Rs.607

**References**

1. Theory of Machines by S.K. Gupta & R.S Khurmi
2. [www.chainsprocketgear.com](http://www.chainsprocketgear.com)
3. [www.wikipedia.com](http://www.wikipedia.com)

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