Unit I Fundamentals of Mechanism

Kinematic link, Types of links, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Degree of freedom, Mobility of -Bar Chain and its Inversions, Slider crank Chain and its Inversions, Double slider crank Chain and its Conversions, Mechanisms with Higher pairs, Equivalent Linkages and its Cases - Sliding Pairs in Place of Turning Pairs, Spring in Place of Turning Pairs, Cam Pair in Place of Turning Pairs

Machines are devices used to accomplish work. A mechanism is the heart of a machine. It is the mechanical portion of a machine that has the function of transferring motion and forces from a power source to an output.

Mechanisms are assemblage of rigid members (links) connected together by joints (also referred to as Mechanical linkage or linkage).

Kinematics It deals with the relative motions of different parts of a mechanism without taking into consideration the forces producing the motions. Thus, it is the study, from a geometric point of view, to know the displacement, velocity and acceleration of a part of a mechanism.

Example

The adjustable height platform (on the right) is driven by hydraulic cylinders. Although the entire device could be called a machine, the parts that take the power from the cylinders and drive the raising and lowering of the platform are mechanisms.

- A joint is a movable connection between links and allows relative motion between the links. Some common joints

KINEMATICS OF MACHINERY

- Deals with relative motion between the various parts of machine, and forces acting on them

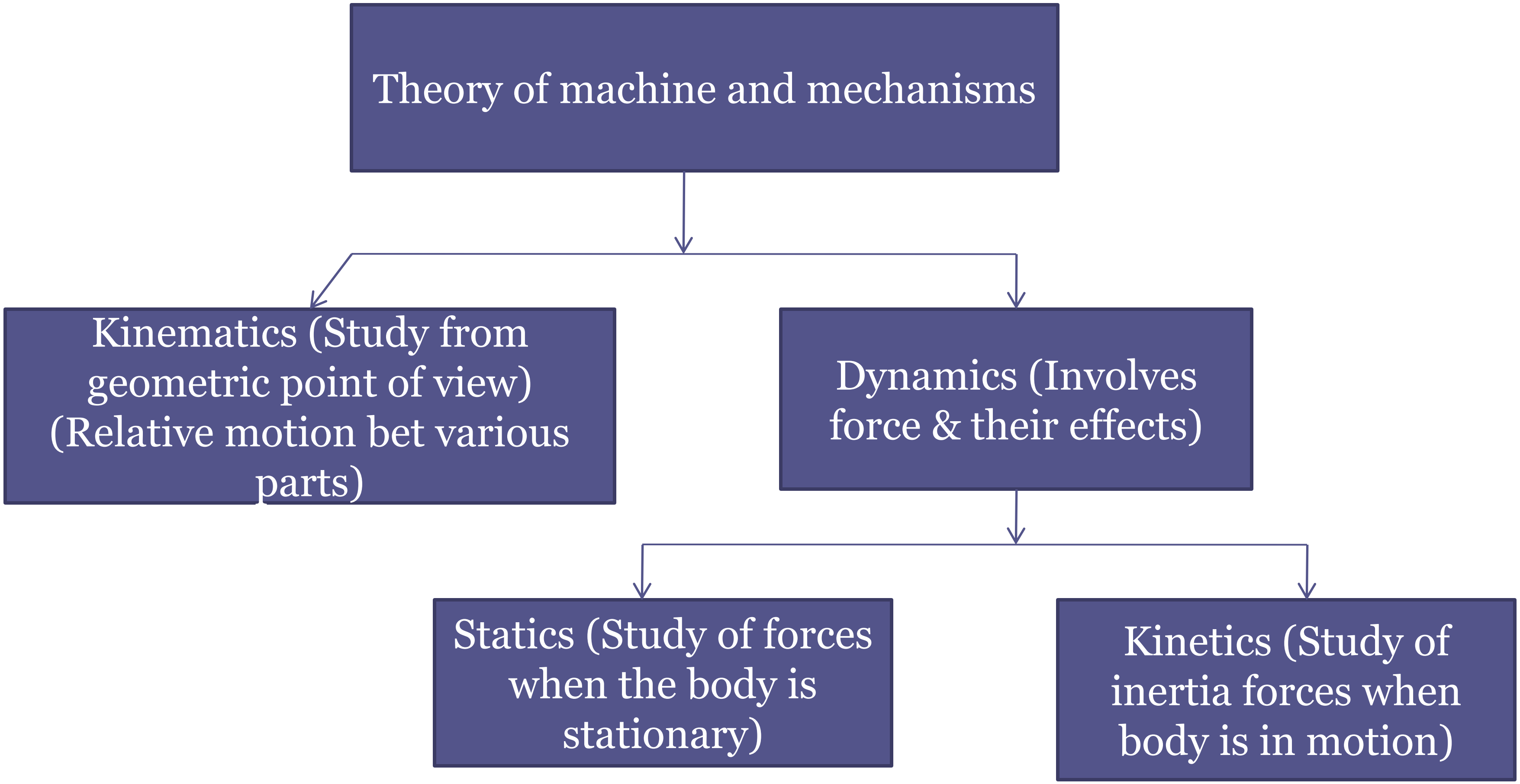
The design of a mechanical system needs a proper understanding of

- The geometrical aspects of motion
- The forces involved in motion

THEORY OF MACHINE AND MECHANISMS

- Analysis –
  - Study of motions & forces of different parts of mechanism
- Synthesis -
  - Design of various parts of machine regarding its shape, size, materials & arrangement of parts

CLASSIFICATION



Fundamentals of Kinematics & Mechanisms

- Machine –
  - consists the various elements arranged together so as to perform the prescribed task.

RIGID AND RESISTANT BODY

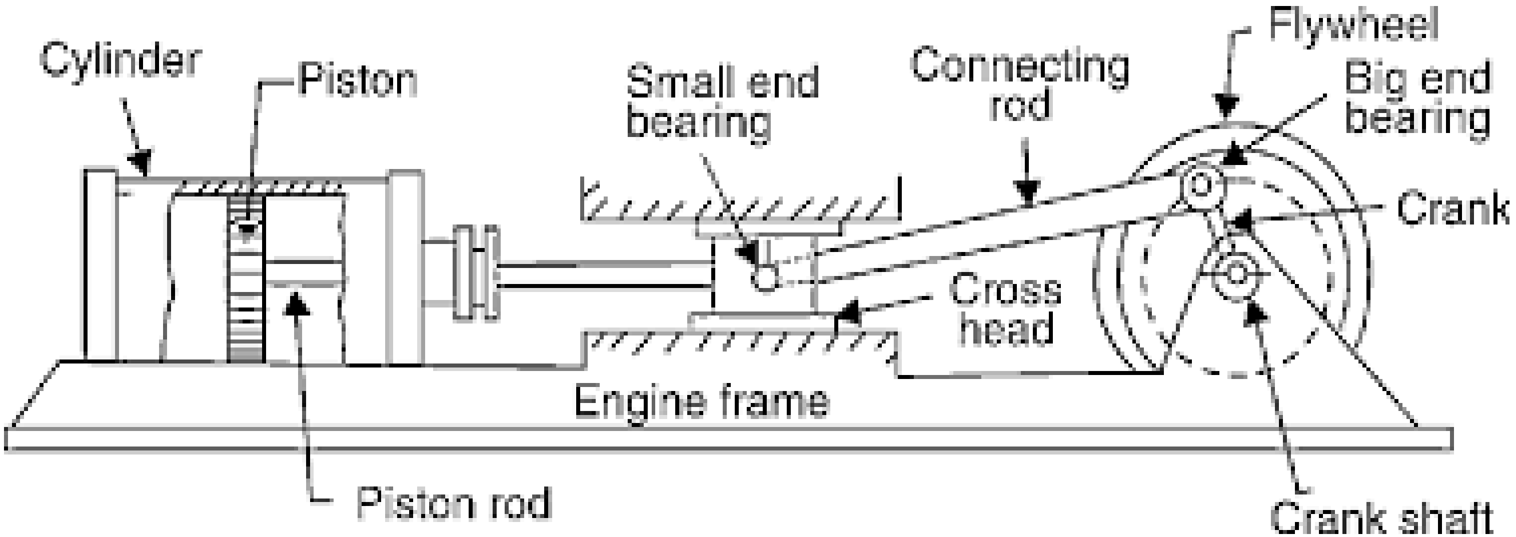
- A body is said to be rigid if under the action of forces, it does not suffer any distortion or the distance between any two points on it remains constant.

- Resistant body is one which transmits force with negligible deformation in the direction of force transmission

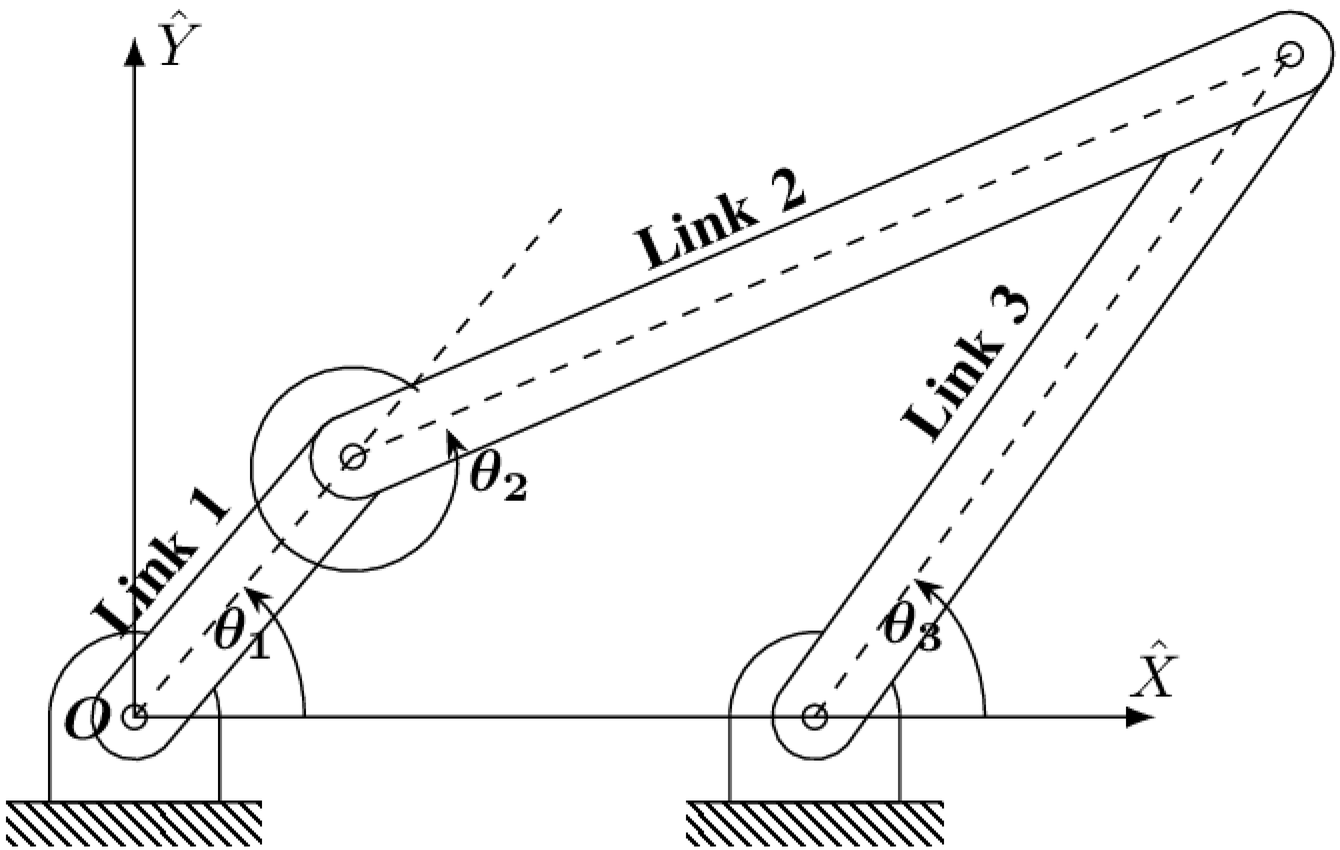
The smallest unit of a machine which must be able to transfer the relative motion

- For example, in a reciprocating steam engine,

piston, piston rod and crosshead constitute one link ; connecting rod with big and small end bearings constitute a second link ; crank, crank shaft and flywheel a third link and the cylinder

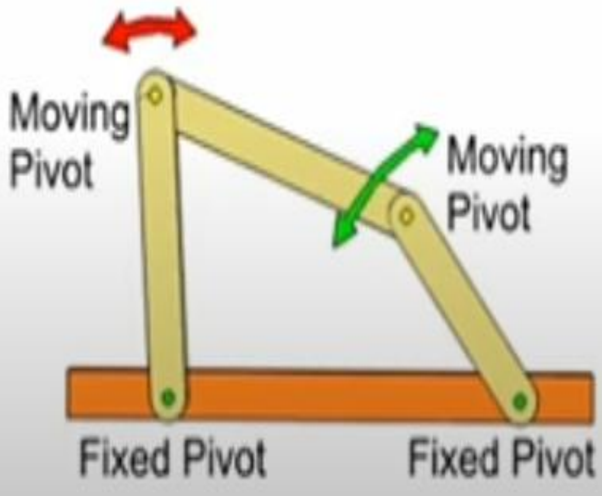


Kinematic chain



Mechanism

- If the link of a chain is fixed it'll be known as mechanism besides the transfer of relative motion should be there.



Machine

Fundamentals of Kinematics & Mechanisms

- Link-
  - A resistant body , which is the part of the machine and has a motion relative to other connected parts.

- Types –
  1. Rigid link
  2. Flexible link
  3. Fluid link

Fundamentals of Kinematics & Mechanisms

1. Rigid link
   - Do not undergo any deformation

eg; piston, connecting rod, crank

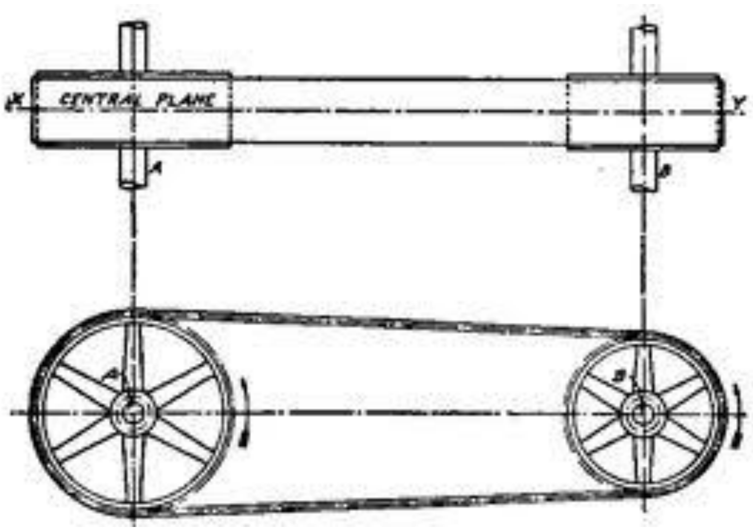
Connecting rod

Fundamentals of Kinematics & Mechanisms

2. Flexible link

- Partly deformed

eg; chains, belts, springs

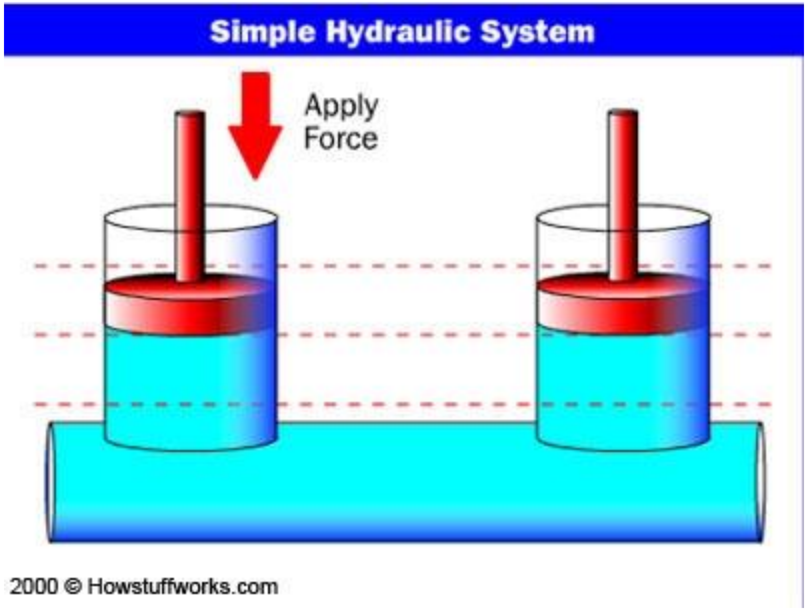


Fundamentals of Kinematics & Mechanisms

3. Fluid link

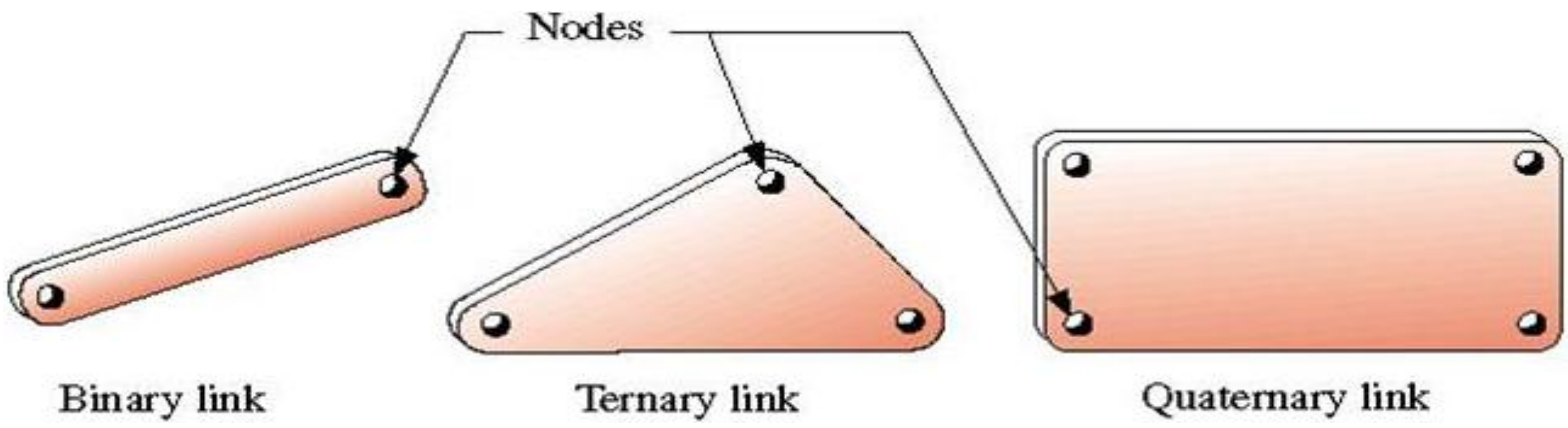
- Motion transmission by fluid pressure (fully deformed)

eg; liquid used in hydraulic press, jacks & brakes of an automobile



Fundamentals of Kinematics & Mechanisms

- Types of Rigid links-
  1. Binary link
  2. Ternary link
  3. Quarternary link



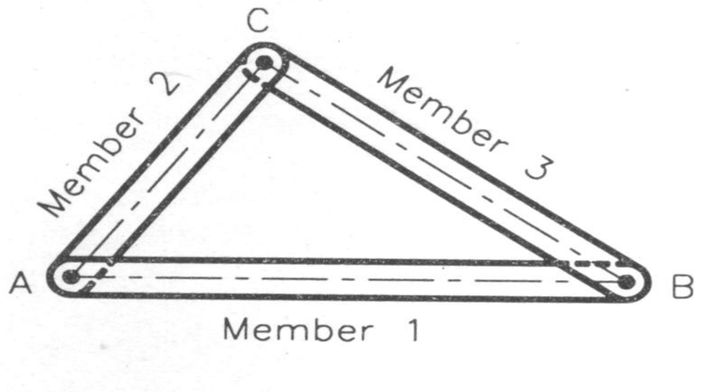
MACHINE

- A machine is a mechanism or a combination of mechanisms which, transmits force from the source of power to the resistance (load) to be overcome, and thus performs useful work.

STRUCTURE

- An assemblage of resistant bodies, having no relative motion between them and meant for carrying loads having straining action, is called a structure.

- Examples : Roof trusses, bridges, buildings

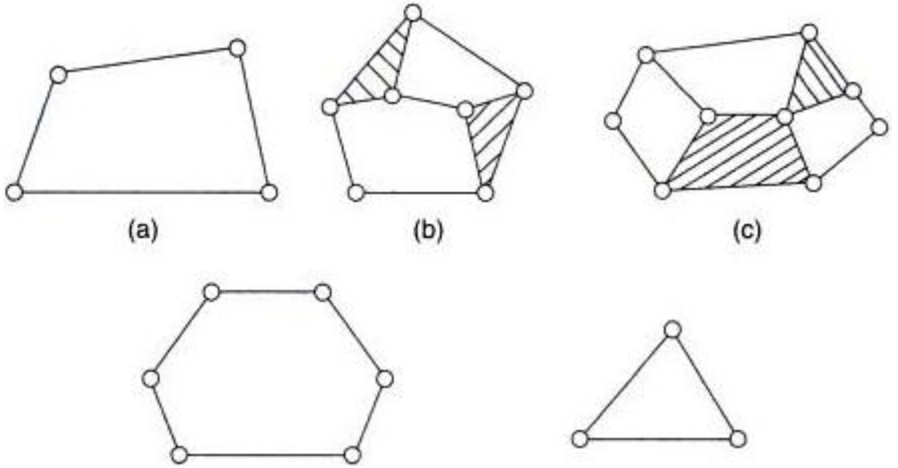


Differentiate between a machine & Structure

MACHINE	STRUCTURE
1) A machine is a mechanism or a combination of mechanisms which, transmits force from the source of power to the resistance (load) to be overcome, and thus performs useful work.	1) An assemblage of resistant bodies, having no relative motion between them and meant for carrying loads having straining action, is called a structure.
2) Relative motion exists between its parts.	2) No relative motion exists between its members
3)Machine serves to modify and transmit forces & motion.	3) Structure serves to modify and transmit forces only.
4) Examples : Shaper, lathe.	4) Examples : Roof trusses, bridges, buildings.

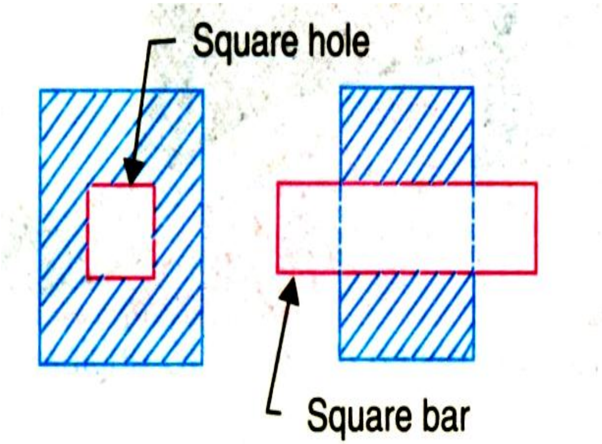
TYPES OF CONSTRAINED MOTIONS

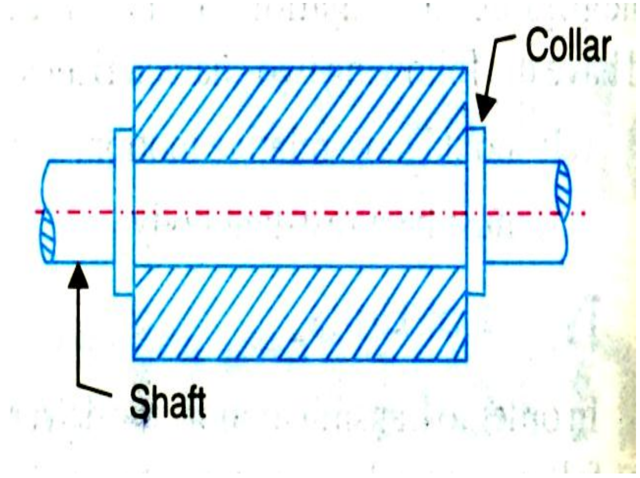
- Completely constrained motion
- Incompletely constrained motion
- Successfully constrained motion
- https://www.youtube.com/watch?v=RMBsBRWX7QE



Completely Constrained Motion

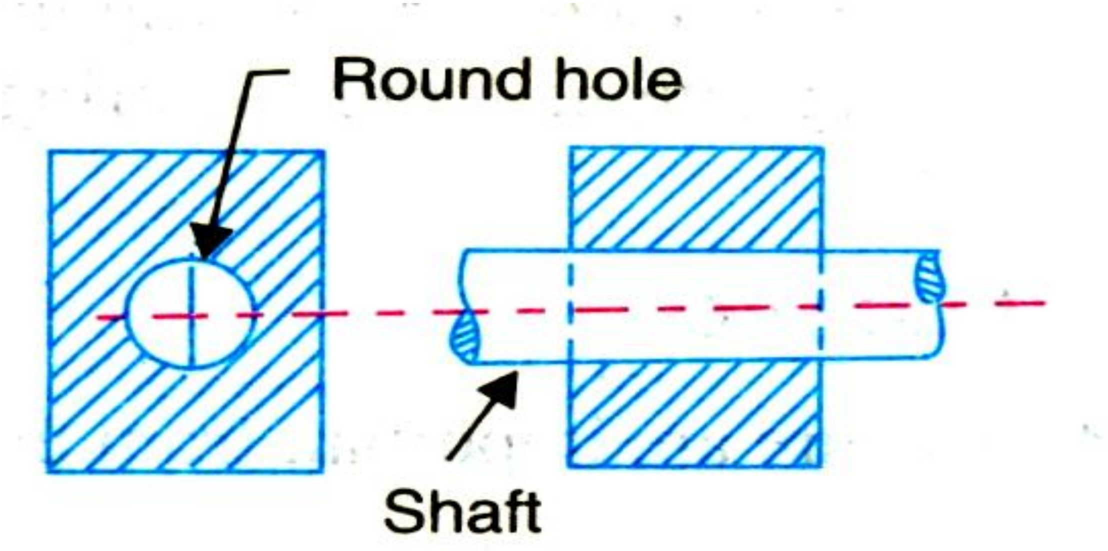
- When the motion between a pair is limited to a definite direction irrespective of the direction of force applied, then the motion is said to be a completely constrained motion.





INCOMPLETELY CONSTRAINED MOTION

- When the motion between a pair can take place in more than one direction, then the motion is called an incompletely constrained motion.



SUCCESSFULLY CONSTRAINED MOTION

- When the relative motion between the links is not completely constrained by itself but by some other means, then the motion is said to be successfully constrained motion. e.g. Piston reciprocates inside an engine cylinder.

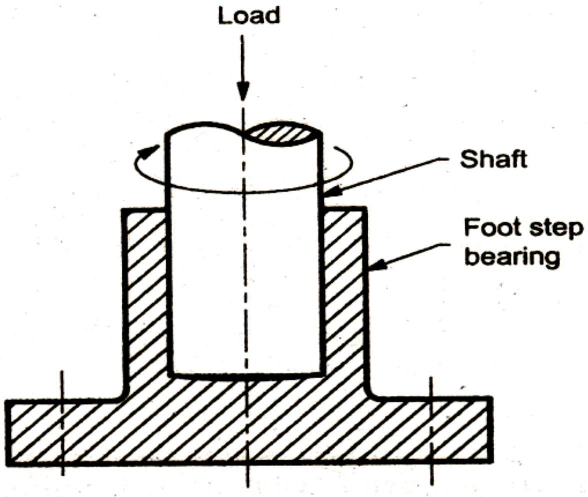
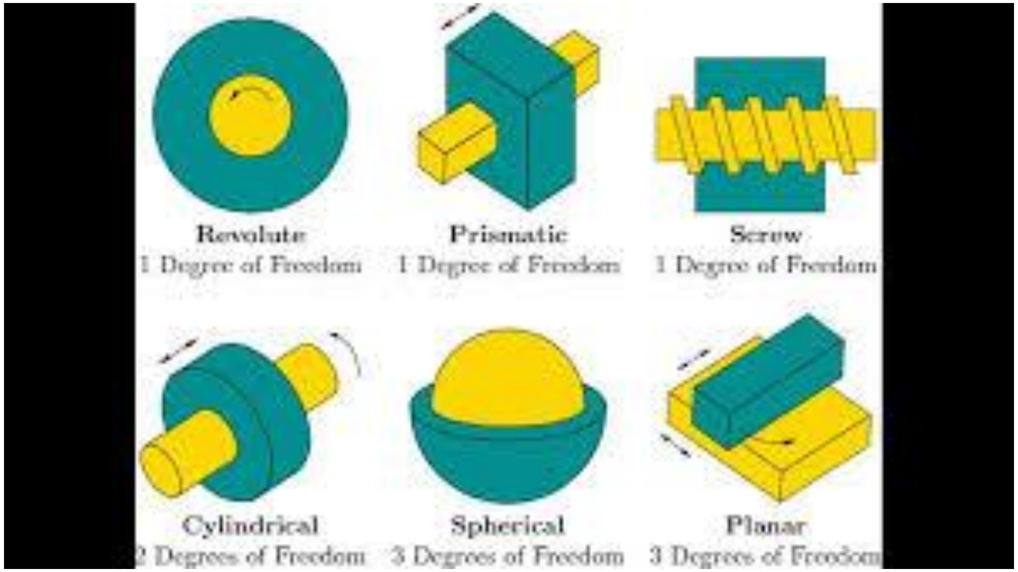


Fig. 1.7 : Successfully constrained motion

KINEMATIC PAIR

The two links or elements of a machine, when in contact with each other, are said to form a pair.

If the relative motion between them (pair) is completely or successfully constrained (i.e. in a definite direction), the pair is known as kinematic pair.



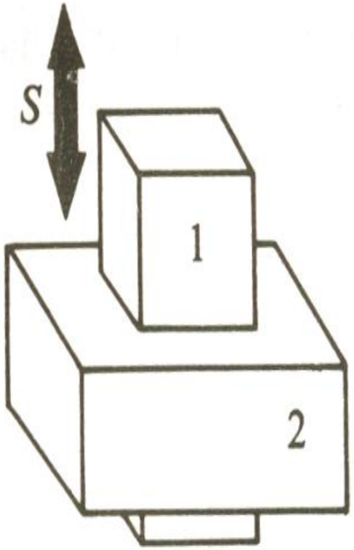
CLASSIFICATION OF KINEMATIC PAIRS

The kinematic pairs are classified based on the following considerations
https://www.youtube.com/watch?v=cU1PLmkjwIg

- (a) According to nature of relative motion between the contacting surfaces
  - (i) Sliding pair or prismatic pair
  - (ii) Turning or revolute pair
  - (iii) Rolling pair
  - (iv) Screw or helical pair
  - (v) Spherical or globular pair
- (b) According to nature of contact between the contacting surfaces
  - (i) Lower pair
  - (ii) Higher pair
- (c) According to nature of constraint between the contacting surfaces
  - (i) Closed pair
  - (ii) Unclosed pair

SLIDING PAIR

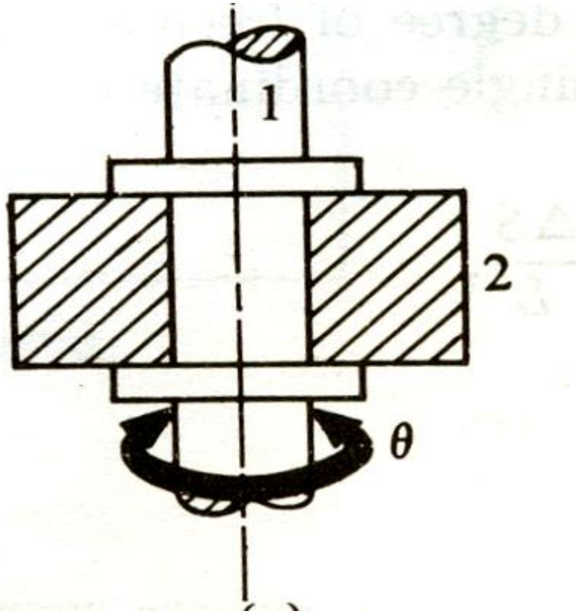
- If two links have a sliding motion relative to each other, they form a sliding pair.
- Eg:
  - A rectangular rod in a rectangular hole in a prism
  - The piston and cylinder,
  - ram and its guides in shaper,
  - tail stock on the lathe bed



- sliding pair has a completely constrained motion.

TURNING OR REVOLUTE PAIR

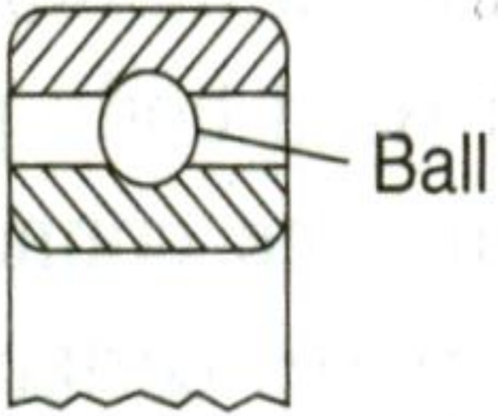
- When one link has a turning or revolving motion relative to the other, constitute a turning or revolving pair



ROLLING PAIR

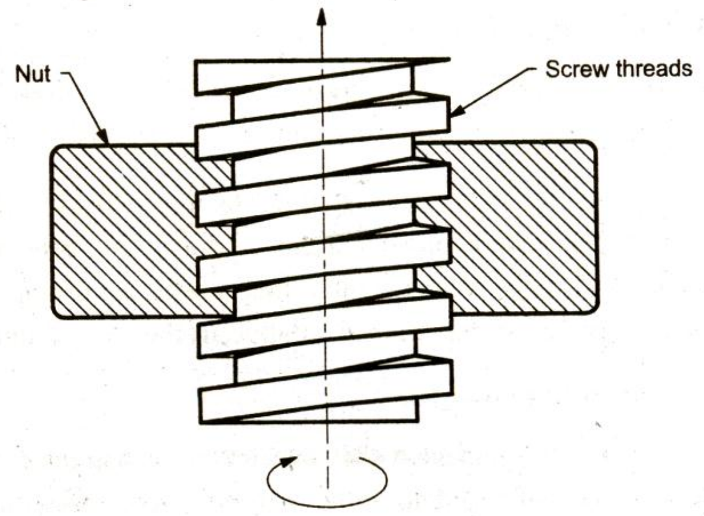
- When the links of a pair have a rolling motion relative to each other, they form a rolling pair,

- e.g. A rolling wheel on a flat surface,
  Belt drive,
  Wheels of rail,
  ball and roller bearings



SCREW OR HELICAL PAIR

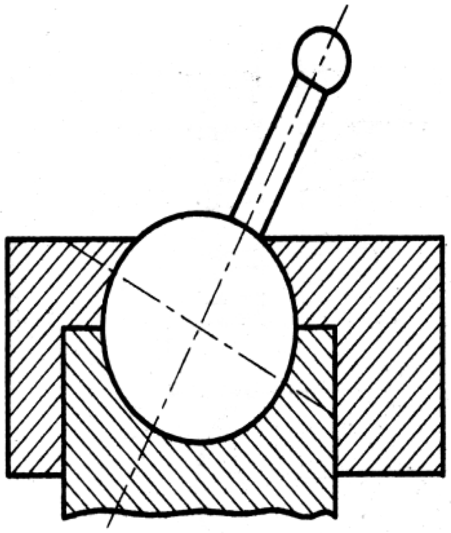
- When the two elements of a pair are connected in such a way that one element can turn about the other by screw threads, the pair is known as screw pair.



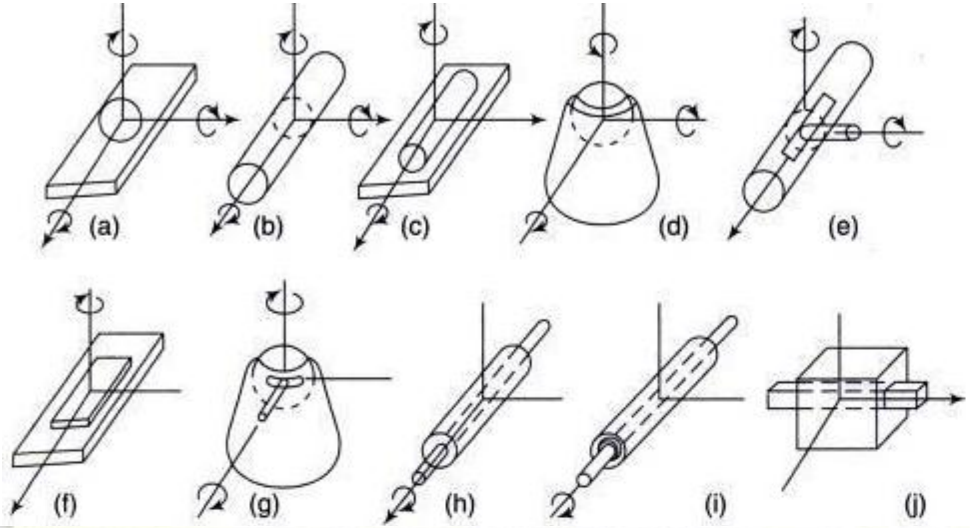
SPHERICAL PAIR

- When one link in the form of a sphere turns inside a fixed link, it is a spherical pair

- The ball and socket joint is a spherical pair



According the class of pair



Class	Number of Restraints	Form	Restraints on Translatory motion	Restraints on Rotary motion	Kinematic pair	Fig. 1.11
I	1	1st	1	0	Sphere-plane	a
II	2	1st	2	0	Sphere-cylinder	b
		2nd	1	1	Cylinder-plane	c
III	3	1st	3	0	Spheric	d
		2nd	2	1	Sphere-slotted cylinder	e
		3rd	1	2	Prism-plane	f
IV	4	1st	3	1	Slotted-spheric	g
		2nd	2	2	Cylinder	h
V	5	1st	3	2	Cylinder (collared)	i
		2nd	2	3	Prismatic	j

Classification of Kinematic Pairs

- (b) According to nature of contact between the contacting surfaces

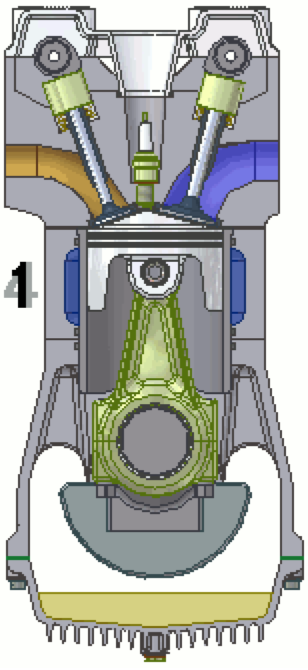
    (i) Lower pair

    (ii) Higher pair

LOWER PAIR

- When the two elements of a pair have a surface contact when relative motion takes place and the surface of one element slides over the surface of the other, the pair formed is a lower pair.
- It will be seen that sliding pairs, turning pairs and screw pairs form lower pairs.

LOWER PAIRS

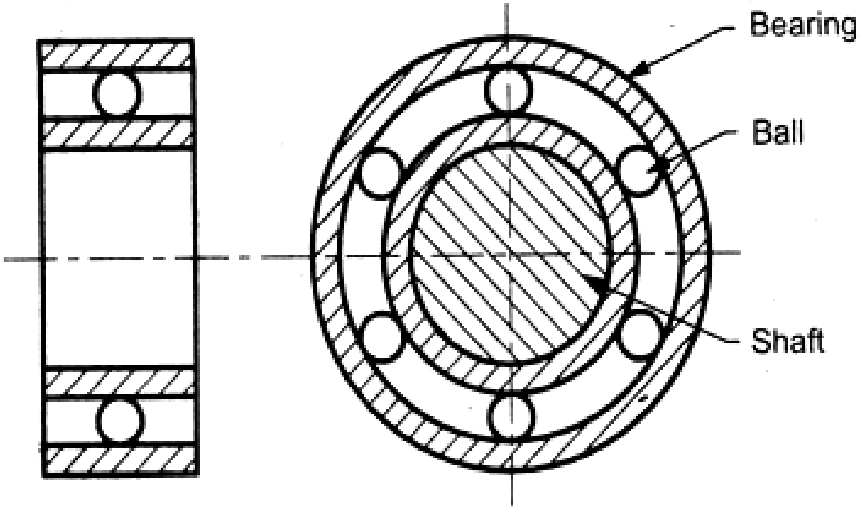


- NUT AND BOLT

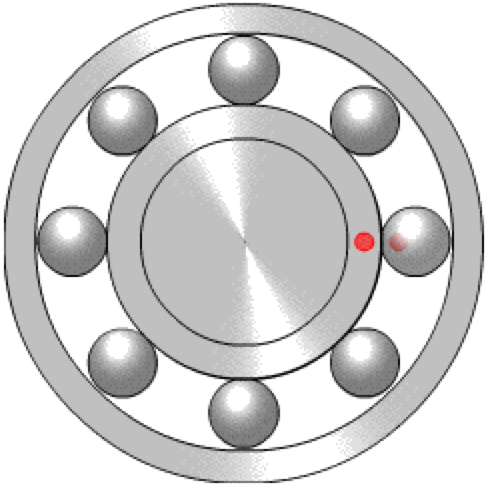
HIGHER PAIR

- When the two elements of a pair have a line or point contact when relative motion takes place, it is known as higher pair.

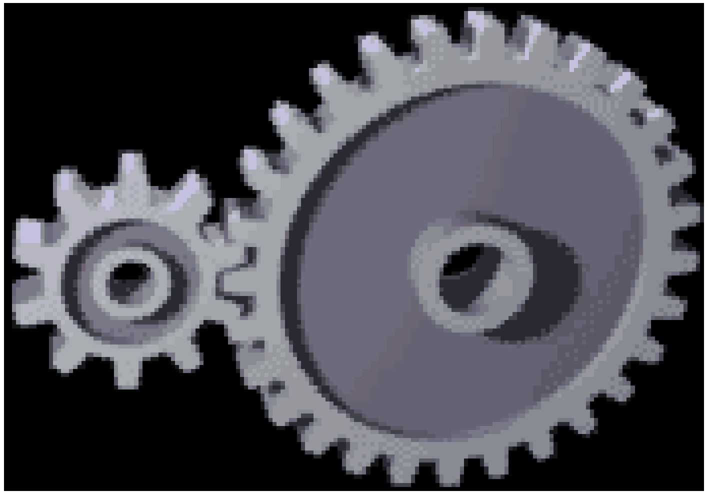
- Eg:
  - A pair of friction discs,
  - toothed gearing,
  - belt and rope drives,
  - ball and bearings and
  - cam and follower



- BALL BEARING



- GEAR



Classification of Kinematic Pairs

(c) According to nature of constraint between the contacting surfaces

(i) Self-Closed pair

(ii) Force-closed pair

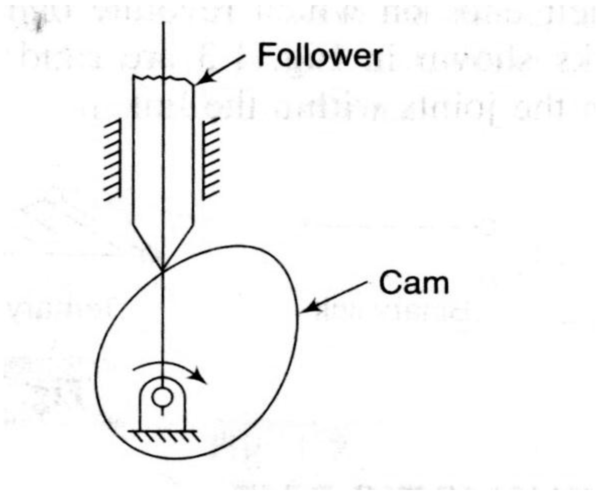
SELF-CLOSED PAIR

- When the elements of a pair are held together mechanically, it is known as a closed pair.

- All the lower pairs and some of the higher pairs are closed pairs.

FORCE-CLOSED PAIR

- When two links of a pair are in contact either due to force of gravity or some spring action, they constitute an unclosed pair.
- In this, the links are not held together mechanically, e.g. cam and follower pair



- CAM AND FOLLOWER

Kinematic Chain

- A kinematic chain is an assembly of links which are interconnected through pairs, permitting relative motion between the links
- https://www.youtube.com/watch?v=KBFFwgCCP0U

KINEMATIC CHAIN

- Conditions to form a kinematic chain

$$n = 2p - 4..............(1)$$

-

$$j = \frac{3}{2}n - 2................(2)$$

$$j + \frac{H}{2} = \frac{3}{2}n - 2................(3)$$

Where;

n- number of links p-no. of lower pairs

j-number of joints H-no. of higher pairs

KINEMATIC CHAIN

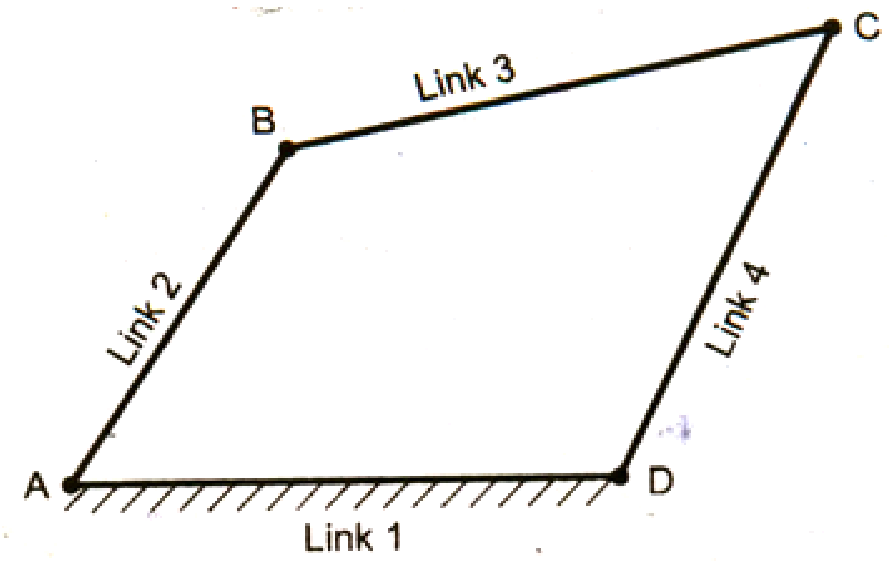
- A W Klien's criteria of constraint
-
- $L.H.S. \rangle R.H.S$ ....chain is locked/structure
- $L.H.S. = R.H.S.$ ......chain is constrained
-
- $L.H.S. \langle R.H.S.$ ....chain is unconstrained
-

Types of Joints in Kinematic Chain

- Binary Joint
- Ternary joint
- Quaternary joint

BINARY JOINT

- When two links are joined at the same connection, the joint is known binary joint.
- For example, a chain as shown in Fig. has four links and four binary joins at A,B,C,D

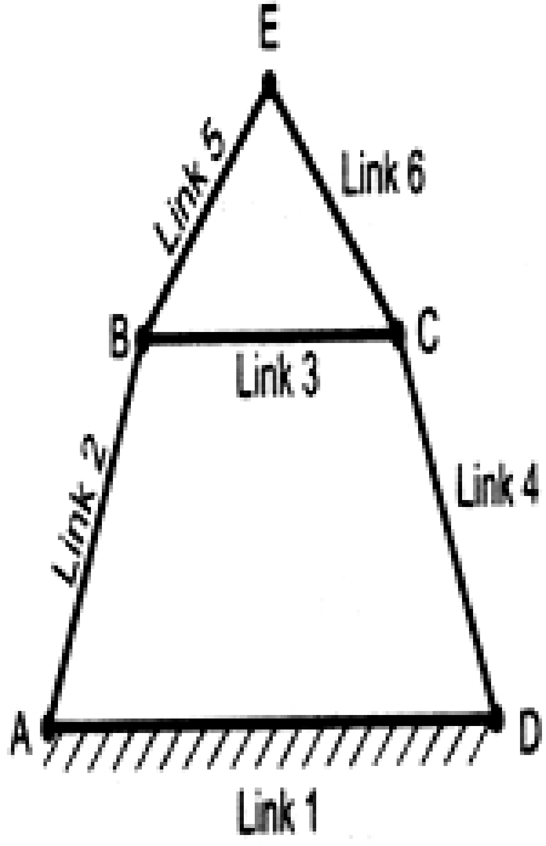


TERNARY JOINT

- When three links are joined at the same connection, the joint is known as ternary joint.

- It is equivalent to two binary joints as one of the three links joined carry the pin for the other two links.

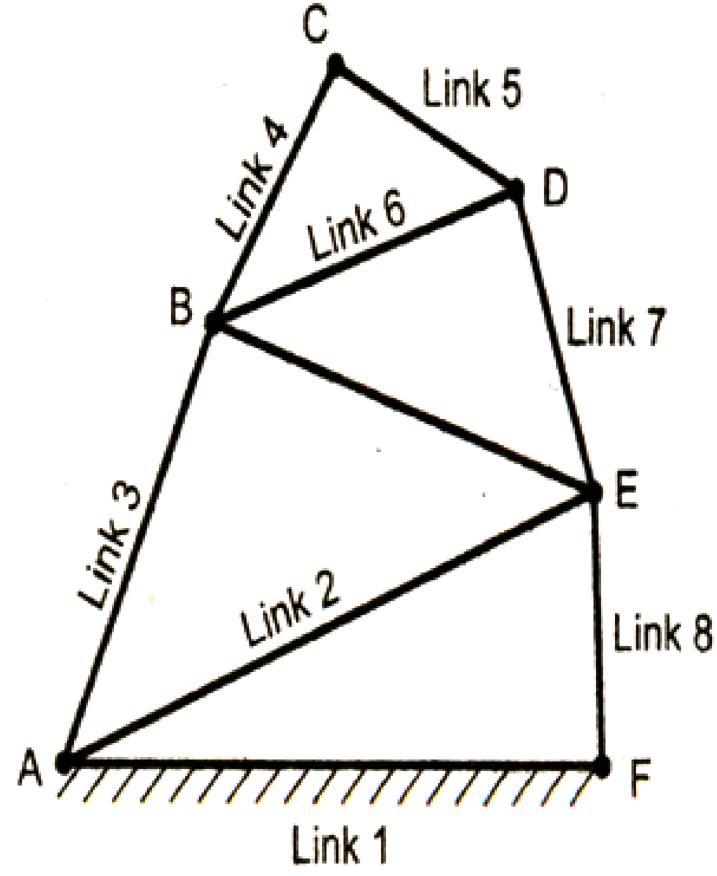
- For example, a chain, as shown in Fig, has six links. It has three binary joints at A, B and D and two ternary joints at C and E.



$$\text{No. of binary joints} = 2(\text{No. of ternary joints}) + \text{No. of binary joints}$$

QUATERNARY JOINT

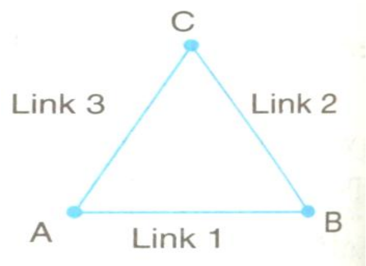
- When four links are joined at the same connection, the joint is called a quaternary joint.
- It is equivalent to three binary joints. In general, when l number of links are joined at the same connection, the joint is equivalent to (l — 1) binary joints.
- Fig. has two binary joint at F,C two ternary joints at A, D, and, and two quaternary joints at B and E.



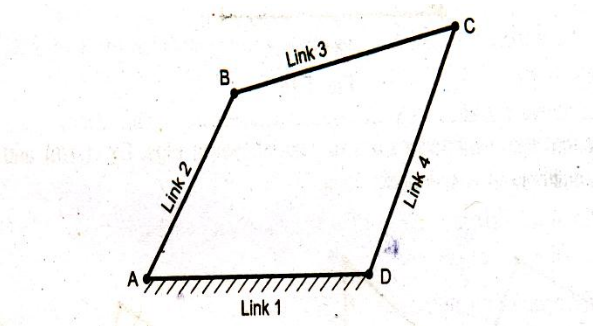
$$\text{No. of joints} = 3(\text{No. of quartenary joints}) + 2(\text{No. of ternary joints}) + \text{No. of binary joints}$$

- Check whether the following configurations are kinematic chain or not.

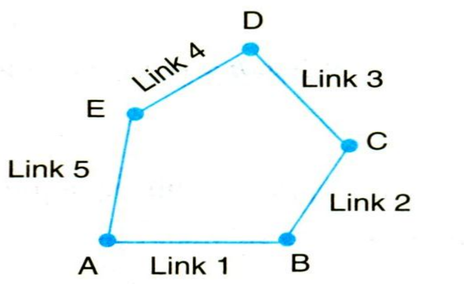
1)



2)



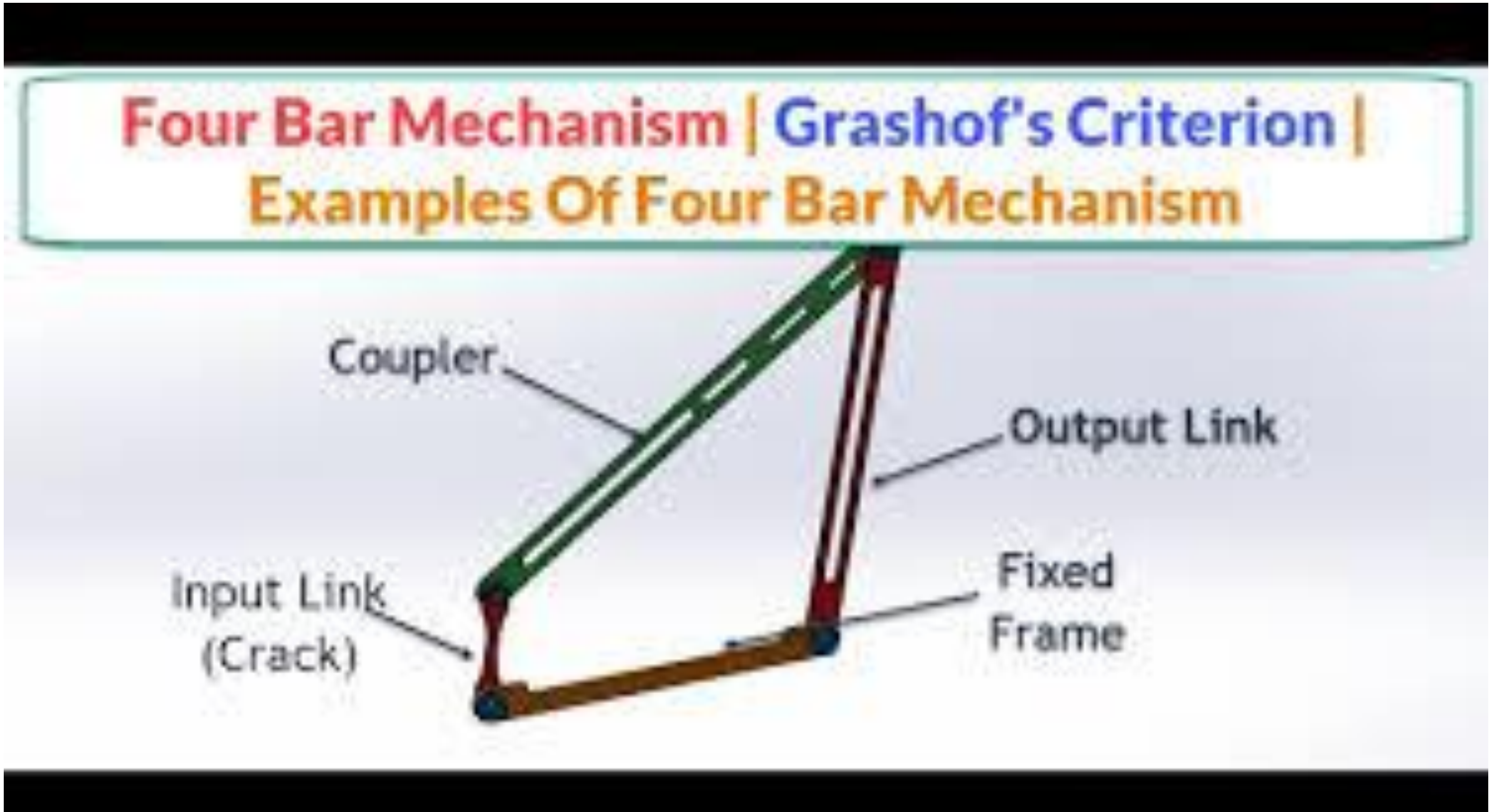
3)



KINEMATIC CHAIN

1. Four bar chain (4R)

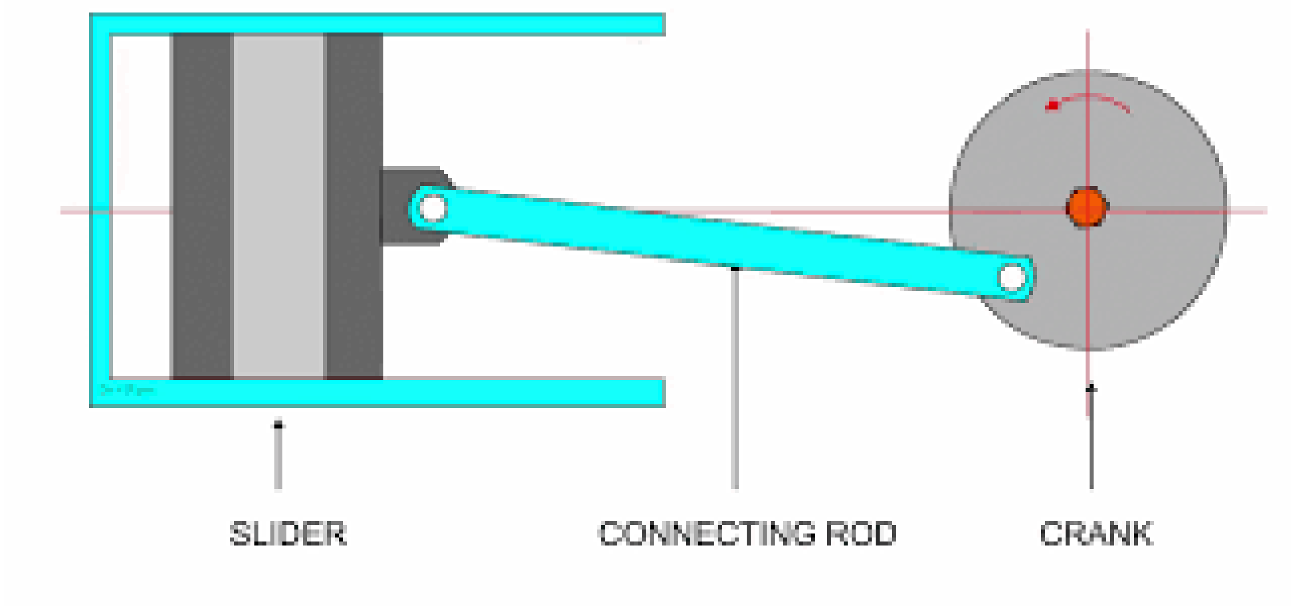
https://www.youtube.com/watch?v=KBFFwgCCPoU



KINEMATIC CHAIN

2. Single slider crank chain (3R-1P)

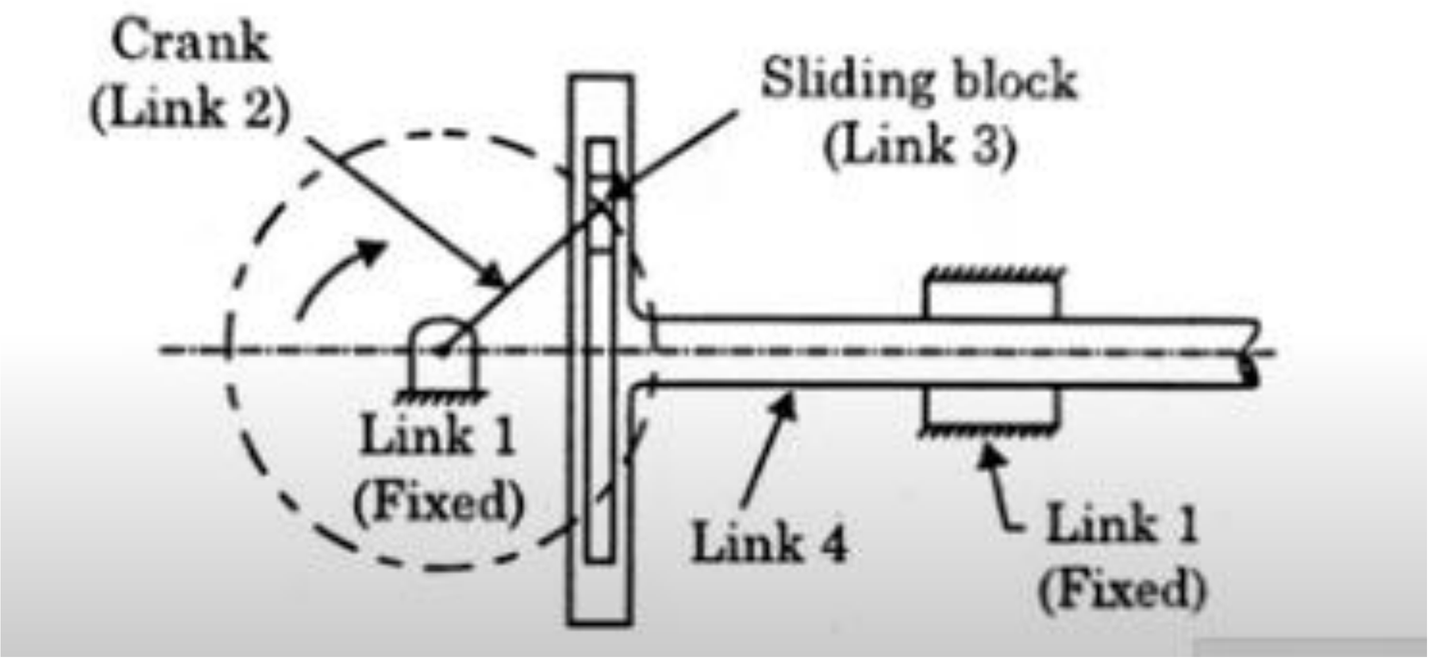
https://www.youtube.com/watch?v=lLHMoRemmMg



KINEMATIC CHAIN

Double slider crank chain (2R-2P)

https://www.youtube.com/watch?v=-waxgJT3Kh0



INVERSION

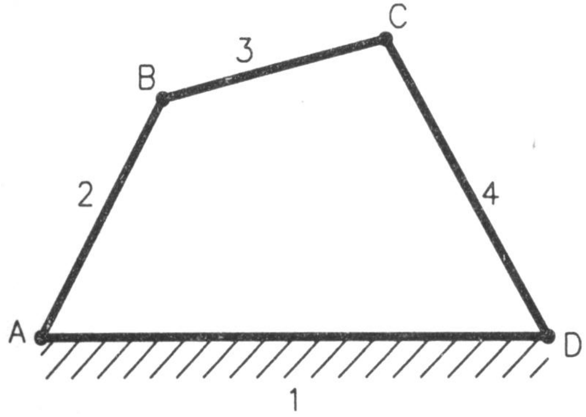
- When one of links is fixed in a kinematic chain, it is called a mechanism.

- So we can obtain as many mechanisms as the number of links in a kinematic chain by fixing, in turn, different links in a kinematic chain.

- This method of obtaining different mechanisms by fixing different links in a kinematic chain, is known as inversion of the mechanism.

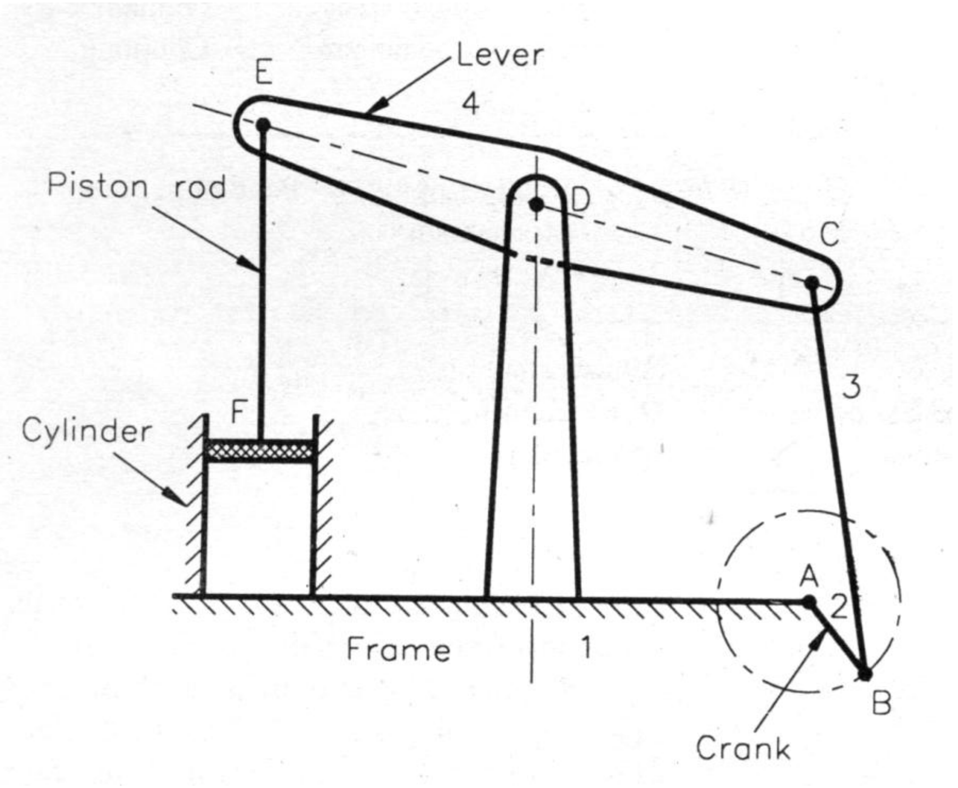
INVERSIONS OF FOUR BAR MECHANISM

- Crank and Lever Mechanism (First Inversion) (Beam engine mechanism)
- Coupling rod of a locomotive (Double crank mechanism)
- Watt's indicator mechanism (Double lever mechanism).



CRANK & LEVER MECHANISM
BEAM ENGINE (FIRST INVERSION)

- Beam Engine Mechanism is the most popular example of crank and lever mechanism. The purpose of this mechanism is to convert rotary motion into reciprocating motion.



ENGINE ANIMATIONBEAM

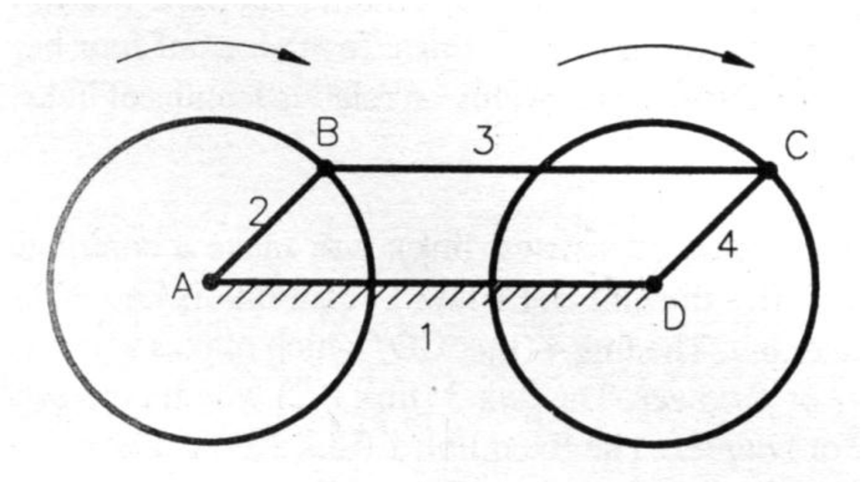
- https://www.youtube.com/watch?v=lcJN2qY1gRE

Double crank Mechanism

https://www.youtube.com/watch?v=oTcC_xXfdrA

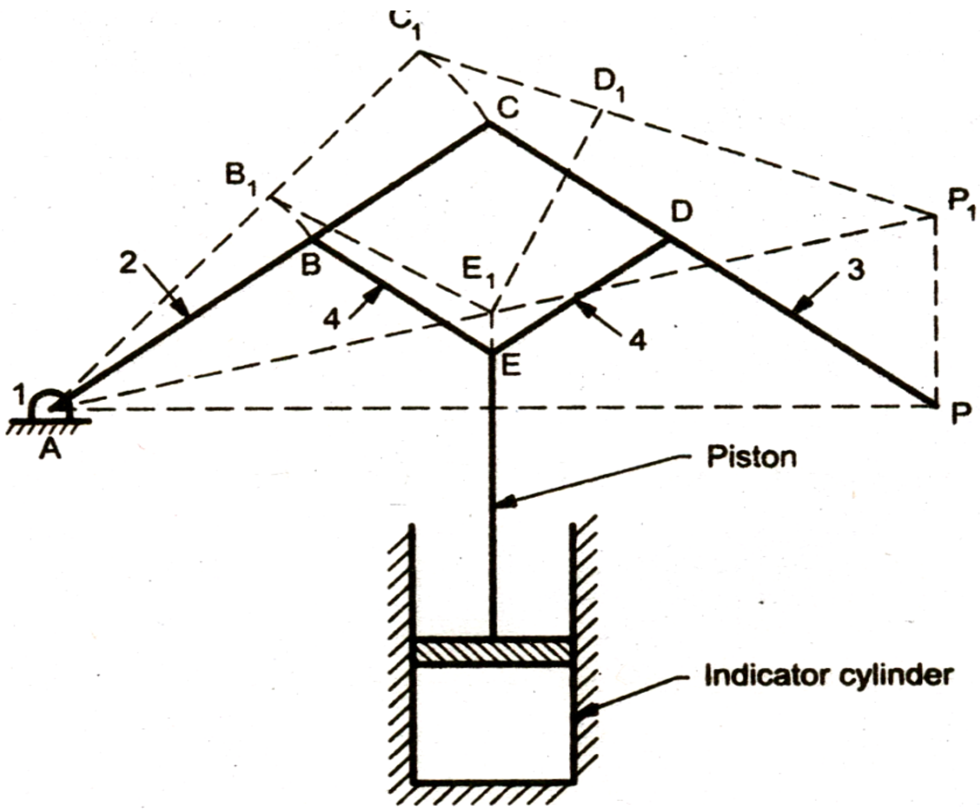
- This mechanism is meant for transmitting rotary motion from one wheel to the other wheel.

- Coupled wheels of locomotive is the example of double crank mechanism.



Watt’s indicator mechanism (Double lever mechanism).

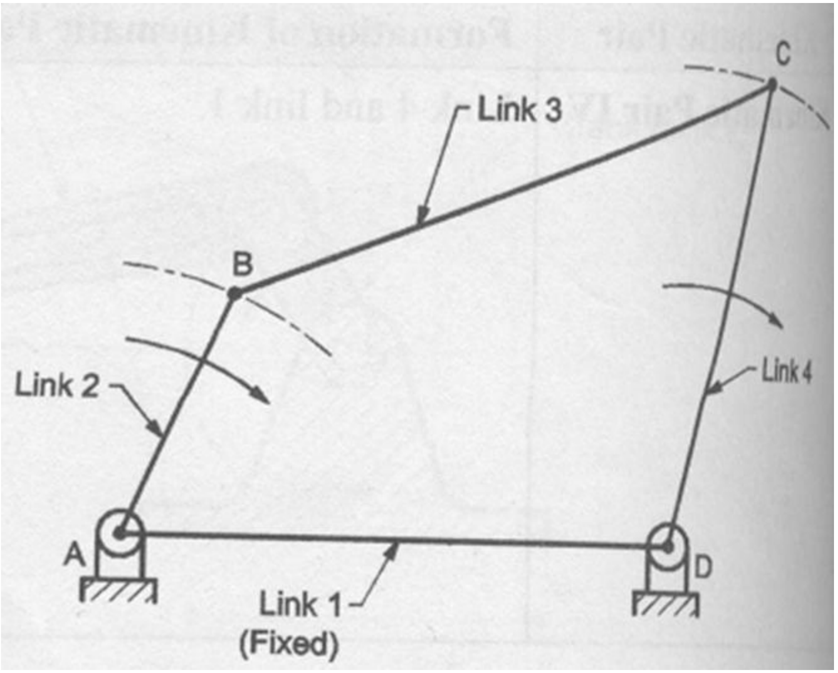
https://www.youtube.com/watch?v=xsh5H654llg



Grashof’s Law

- For a planar four-bar linkage, sum of the shortest and longest link-lengths must be less than or equal to the sum of the remaining two link-lengths, if there is to be a continuous relative rotation between two members.

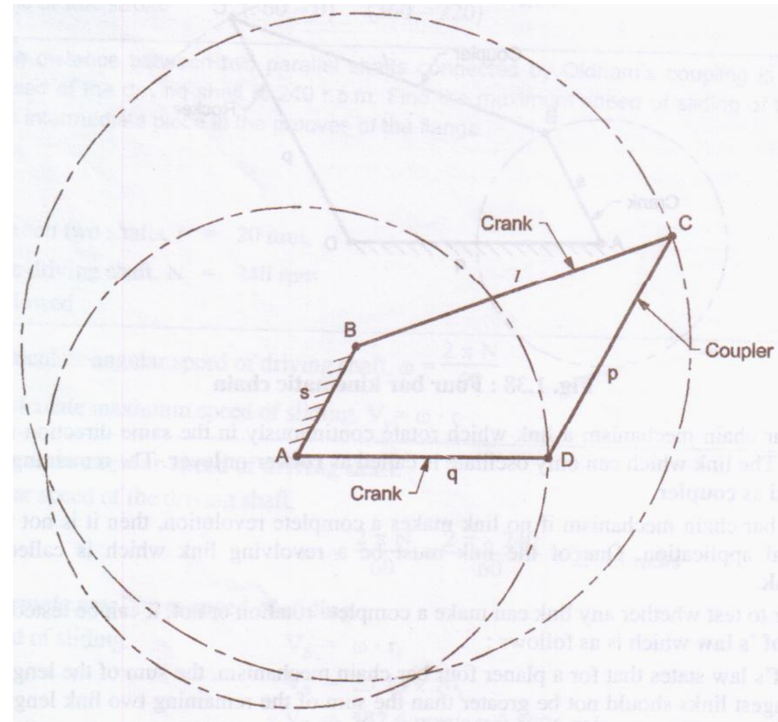
$$s + l \leq p + q$$



Types of Mechanisms for 3 different conditions of Grashof's Law

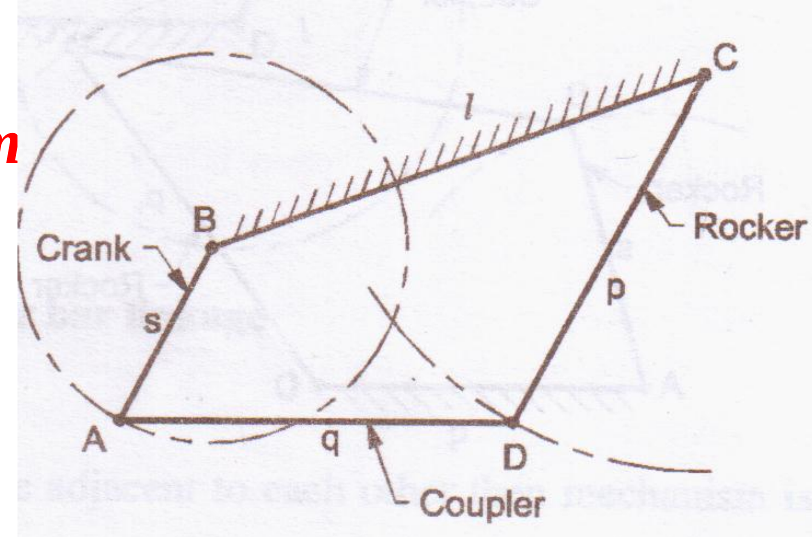
1] Class – I ($s + l < p + q$) :-

a) Grashoffian Four Bar Linkage / Double crank



- Link s - fixed
- Link *l* & q – crank
- Link p – coupler

a) Crank & rocker / Rotary oscillating converter mechanism

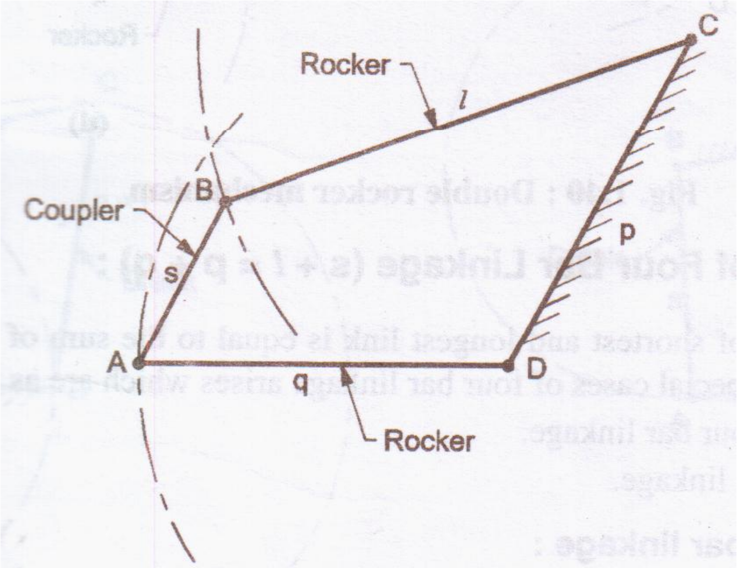


- Link *l* - fixed
- Link s – crank
- Link p – rocker
- Link q - coupler

Types of Mechanisms for 3 different conditions of Grashof's Law

c) Rocker rocker mechanism/ Double lever

- Link p - fixed
- Link *l* & q – rocker
- Link s – coupler

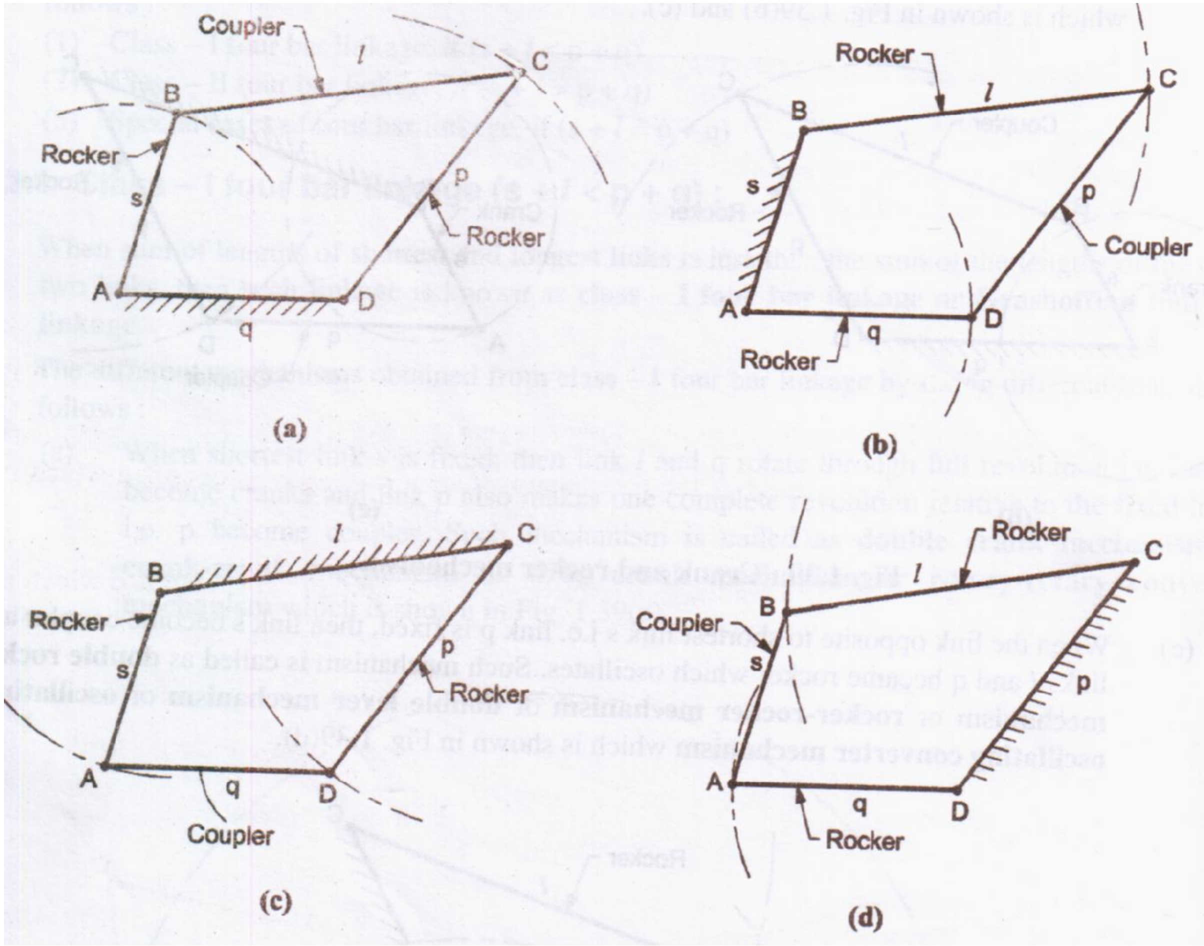


Types of Mechanisms for 3 different conditions of Grashof's Law

2] Class – II ($s + l > p + q$) :-

a) Non-Grashoffian Four Bar Linkage

Double rocker / Rocker-Rocker / Double Lever

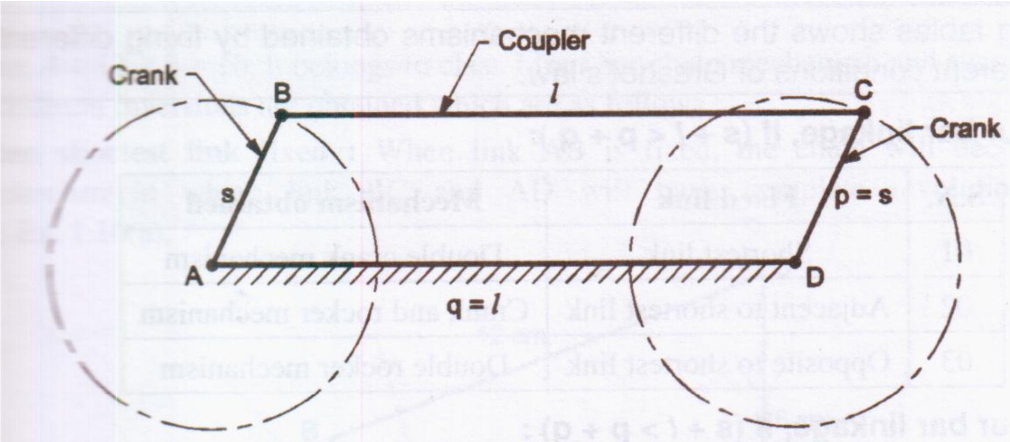


Types of Mechanisms for 3 different conditions of Grashof's Law

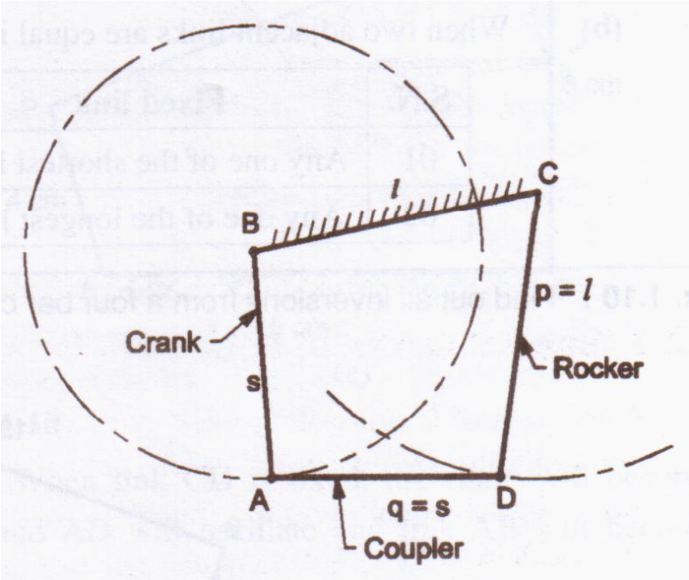
3] Special Cases of Four Bar Linkage (s + l = p + q) :-

a) Parallel crank four Bar Linkage

Rotary-Rotary converter

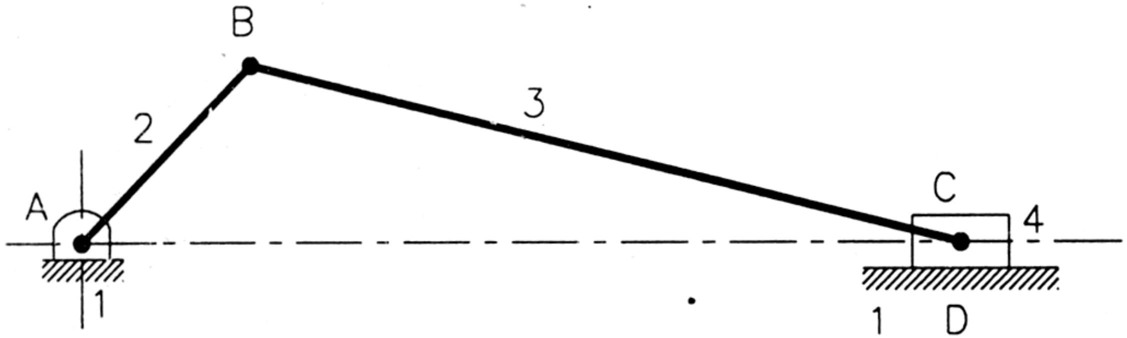


b) Deltoid four Bar Linkage



Inversions of Single Slider Mechanisms

- It consists of one sliding pair and three turning pair. It is usually found in reciprocating steam engine mechanism. This mechanism converts rotary motion into reciprocating motion



link 1 - frame, cylinder
link 2 - crank
link 3 - connecting rod
link 4 - piston or slider
pair A - turning pair, (link 1 and 2)
pair B - turning pair, (link 2 and 3)
pair C - turning pair, (link 3 and 4)
pair D - sliding pair, (link 1 and 4)

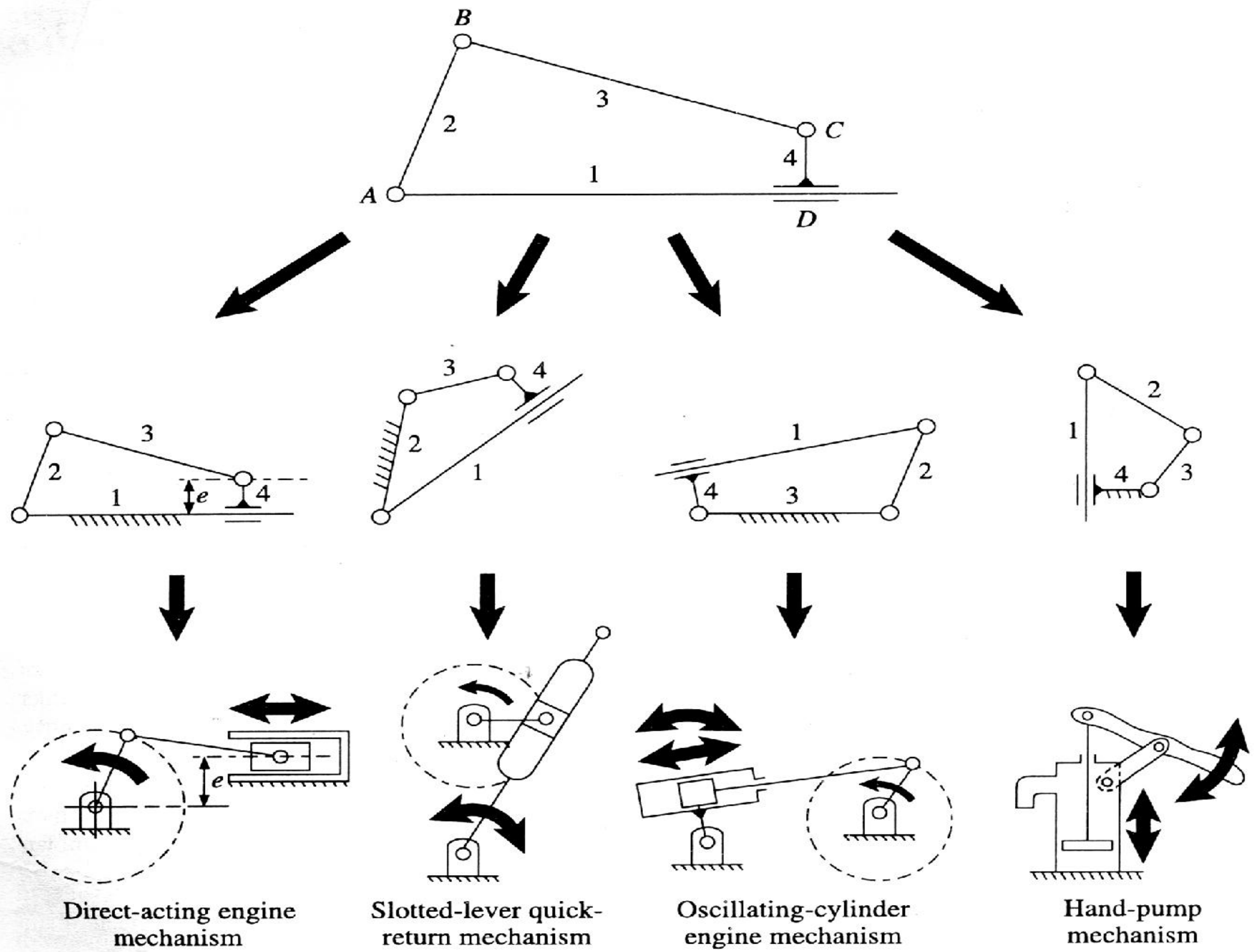
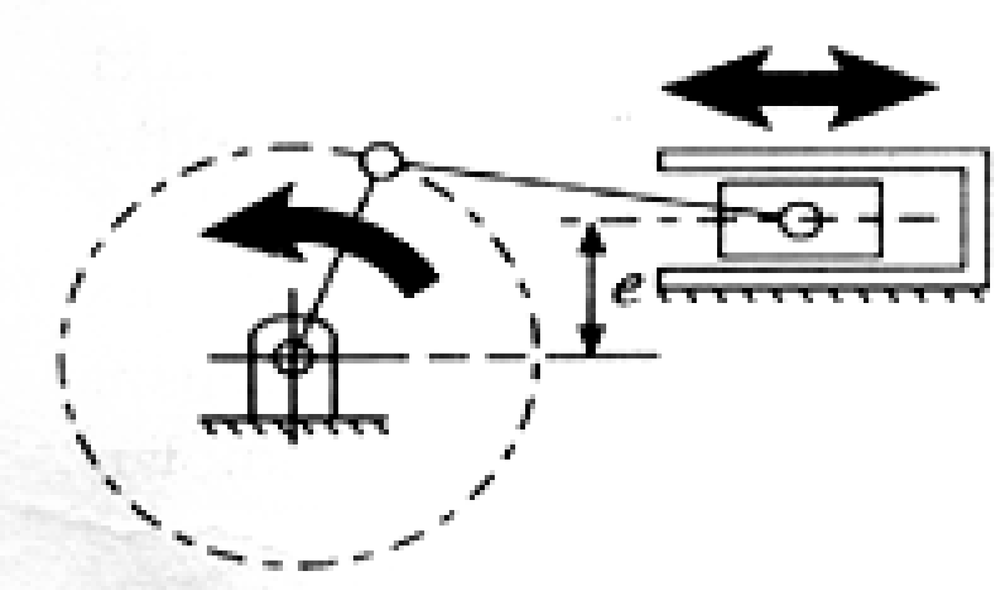

B
C
A
D
1
2
3
4
e
Direct-acting engine mechanism
Slotted-lever quick-return mechanism
Oscillating-cylinder engine mechanism
Hand-pump mechanism

FIGURE 1.34

Reciprocating Engine Mechanism/Bull Engine (First Inversion)

- It converts rotary motion into reciprocating and vice-versa.

- This mechanism has four links and forming three turning pairs and one sliding pair.

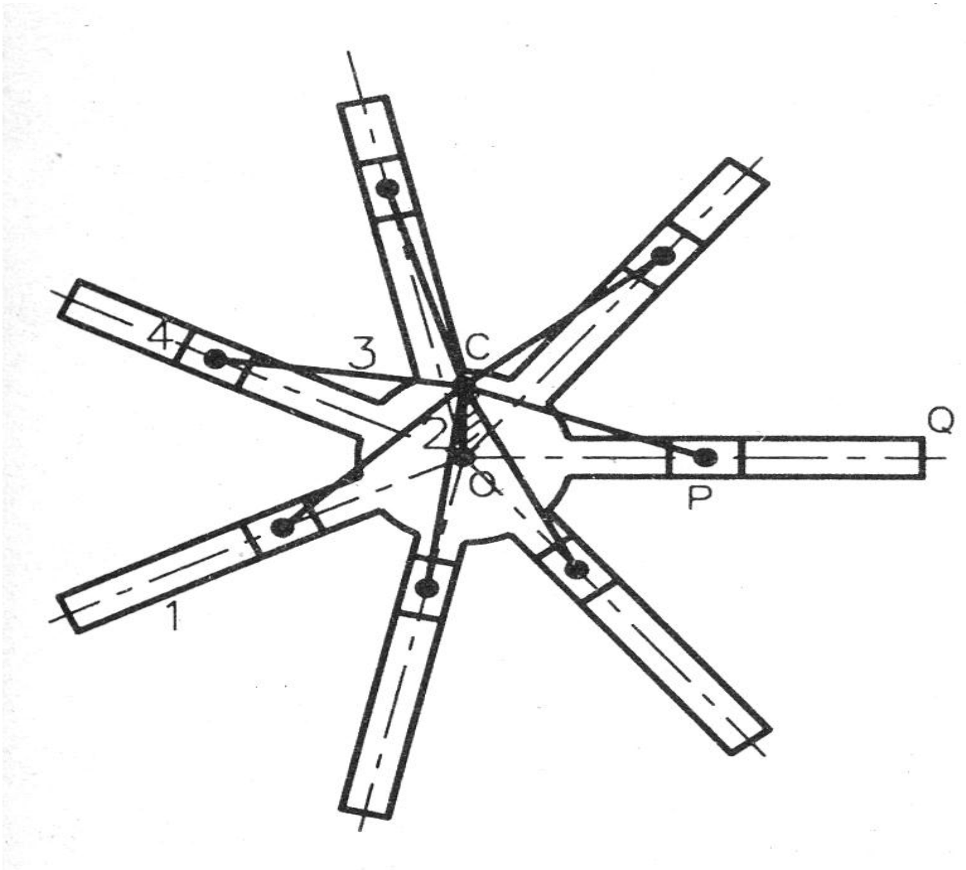


Link 1 - Cylinder and Frame (Fixed)
Link 2 – Crank
Link 3 - Connecting rod
Link 4 - Piston or Slider

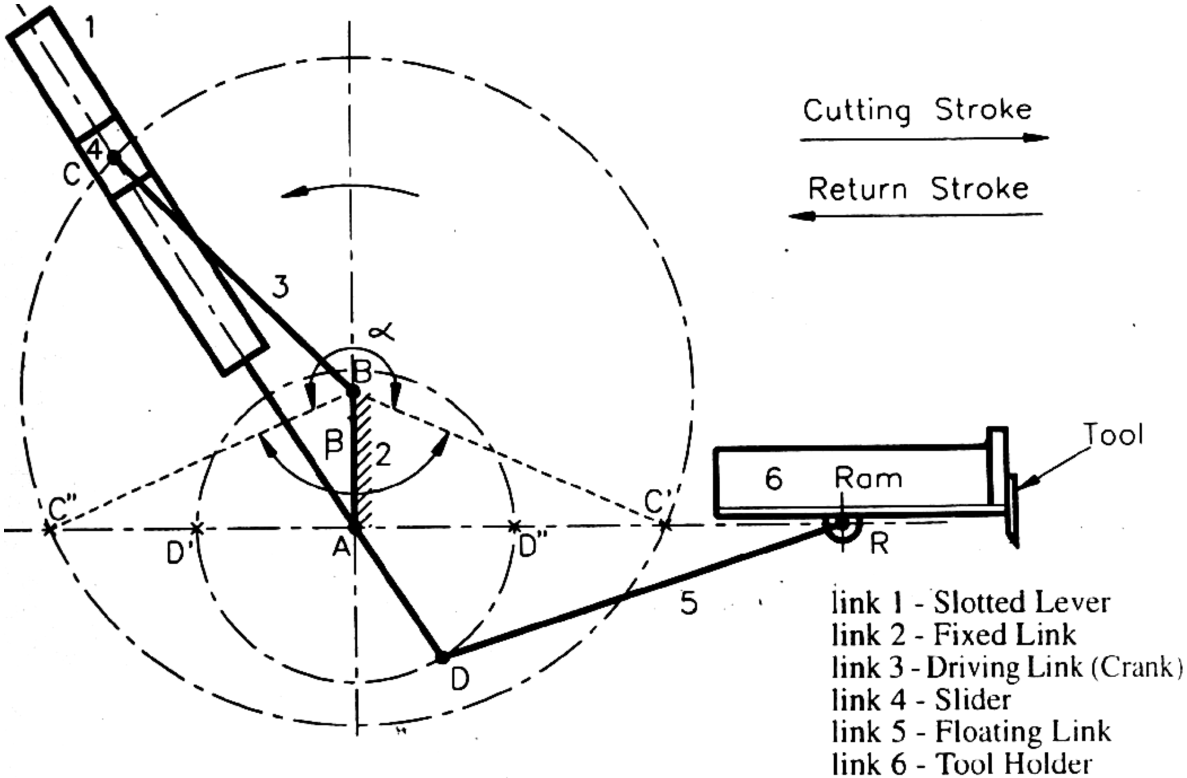
Package

A) Rotary engine (Second inversion)

link 1- Cylinder link
link2- Fixed Link
link 3 - Connecting Rod
link 4 - Piston ,



B)Withworth quick return mechanism (Second inversion)



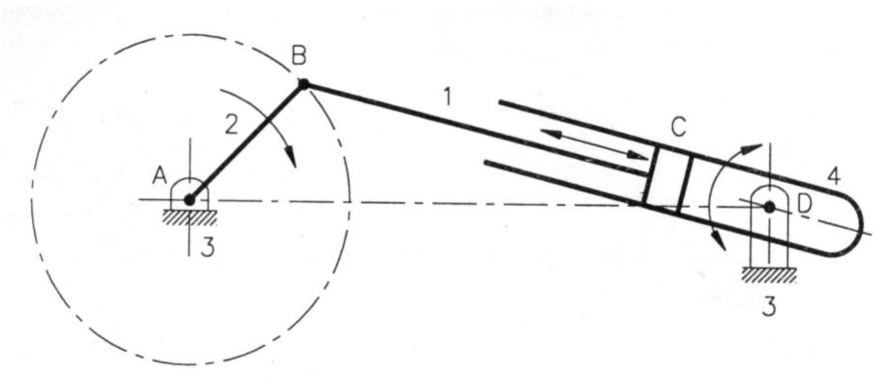
:8 : Whitworth Quick Return Motion Mechanism.


Package

A)Oscillating Cylinder Engine Mechanism (Third Inversion)

- Link 1 - Piston & Piston Rod
- Link 2 - Crank
- Link 3 - Fixed Link
- Link 4 – Cylinder

- In this mechanism, the link 3 forming the turning pair is fixed. The link 3 corresponds to the connecting rod of a reciprocating engine mechanism.
- When the crank (link 2) rotates, the piston attached to the piston rod (link 1) reciprocates and cylinder (link 4) oscillates about a pin pivoted to the fixed link (link 3) at A.



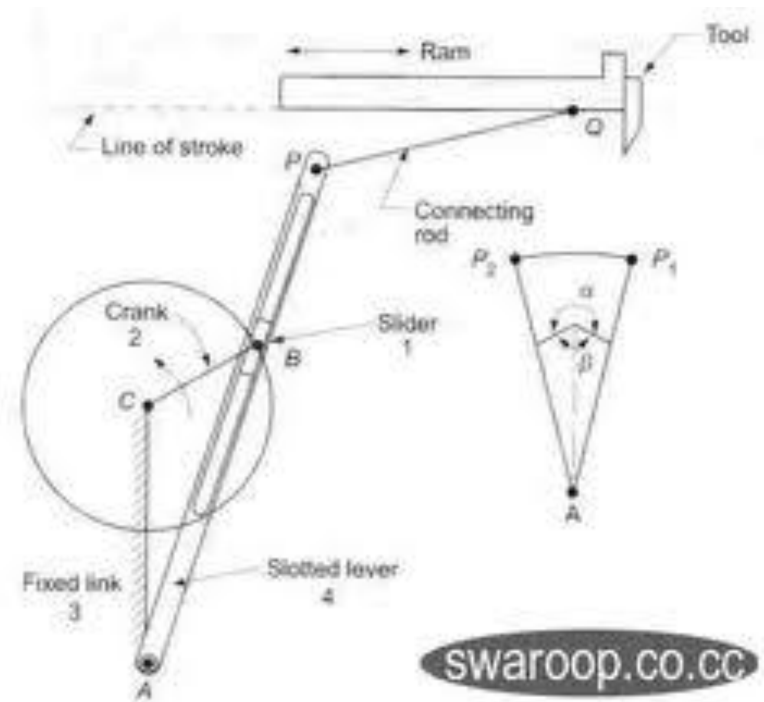
Package

B)Crank and Slotted Lever Mechanism (Third Inversion)

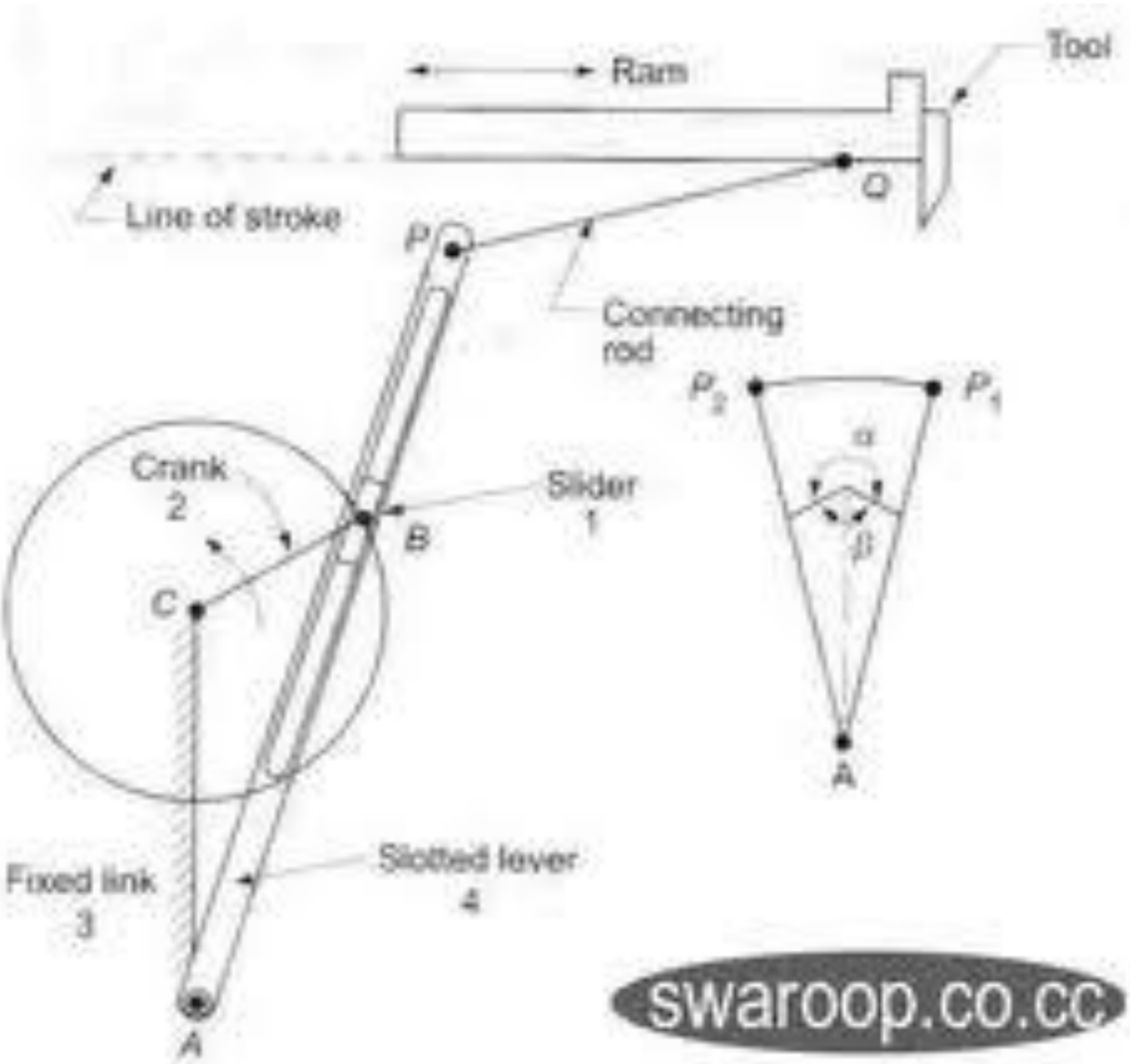
- This mechanism is mostly used in shaping machines and slotting machines. This is a Quick return motion mechanism.

- The slider (1) reciprocates in oscillating slotted lever (4) and crank (2) rotates while link 3 is a stationary link. Another link 5, connects the end of link 4 to the ram (6).

- Stroke = (length of slotted bar × length of crank) / length of fixed link

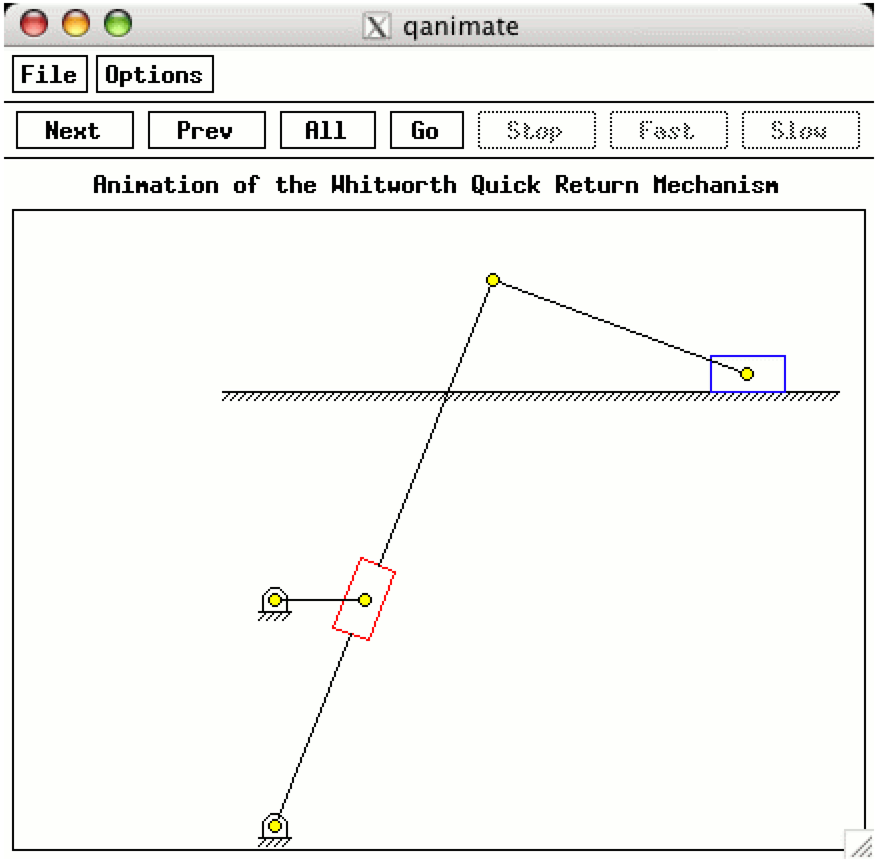


$$\frac{\text{time of cutting}}{\text{time of return}} = \frac{\alpha}{\beta} = \frac{\alpha}{360^\circ - \alpha}$$

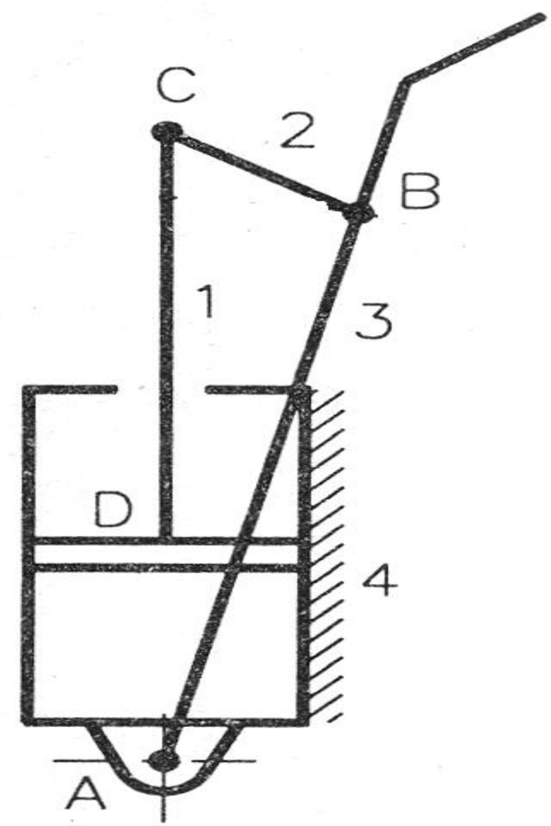


Ram
Tool
Line of stroke
Q
P
Connecting rod
P_2
P_1
α
β
A
Crank 2
Slider 1
B
C
Fixed link 3
Slotted lever 4
A
swaroop.co.cc

ANIMATION OF QUICK RETURN MOTION MECHANISM



Hand pump (fourth inversion

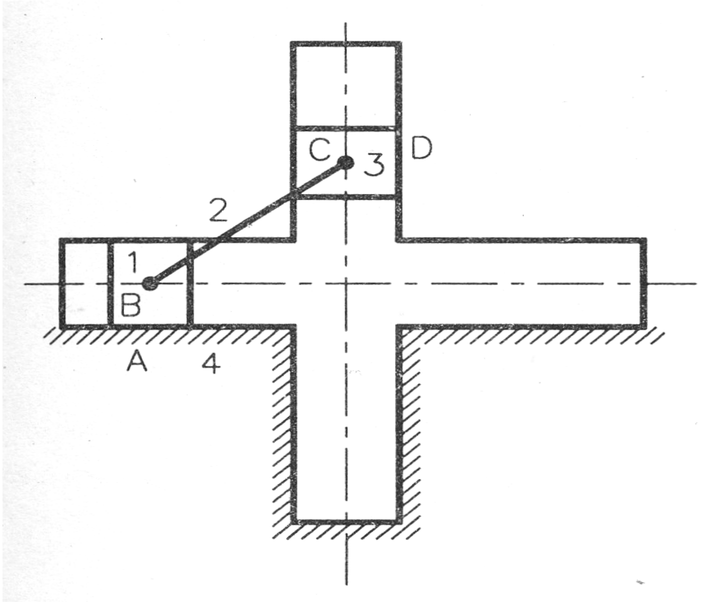


. 1.31 : Hand Pump

Double slider crank chain

- A kinematic chain which consists of two turning pairs and two sliding pairs is known as double slider crank chain,

- INVERSIONS:-
- 1)Elliptical Trammel
- 2)scotch-yoke mechanism
- 3)Oldham coupling



Package

ELLIPTICAL TRAMMEL

- Here, the slotted frame is fixed. Any point, such as S on the link BC will trace out an ellipse as the blocks B and C slide along their respective slots.
- It is an instrument for drawing ellipses. Clearly, the CS and BS are respectively the semi-major and semi-minor axis.
- link 1 - Slider
- link 2 - Connecting Link
- link 3 – Slider
- link 4 - Slotted frame (fixed link)

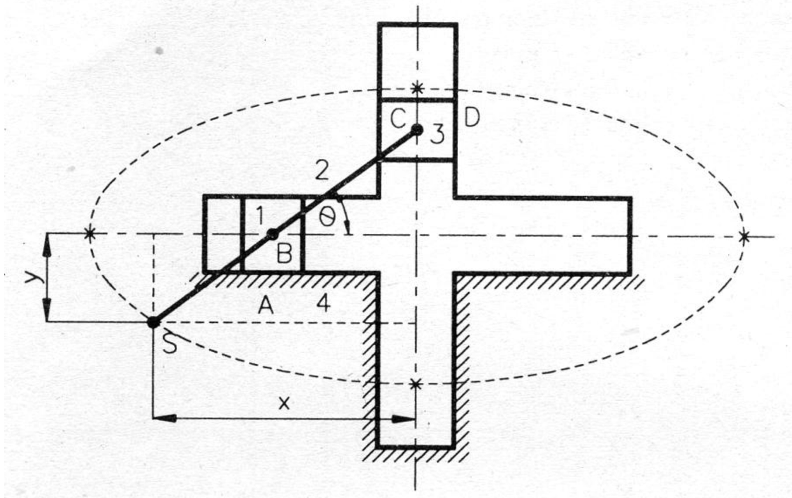


Fig. 1.33 : Elliptical Trammel

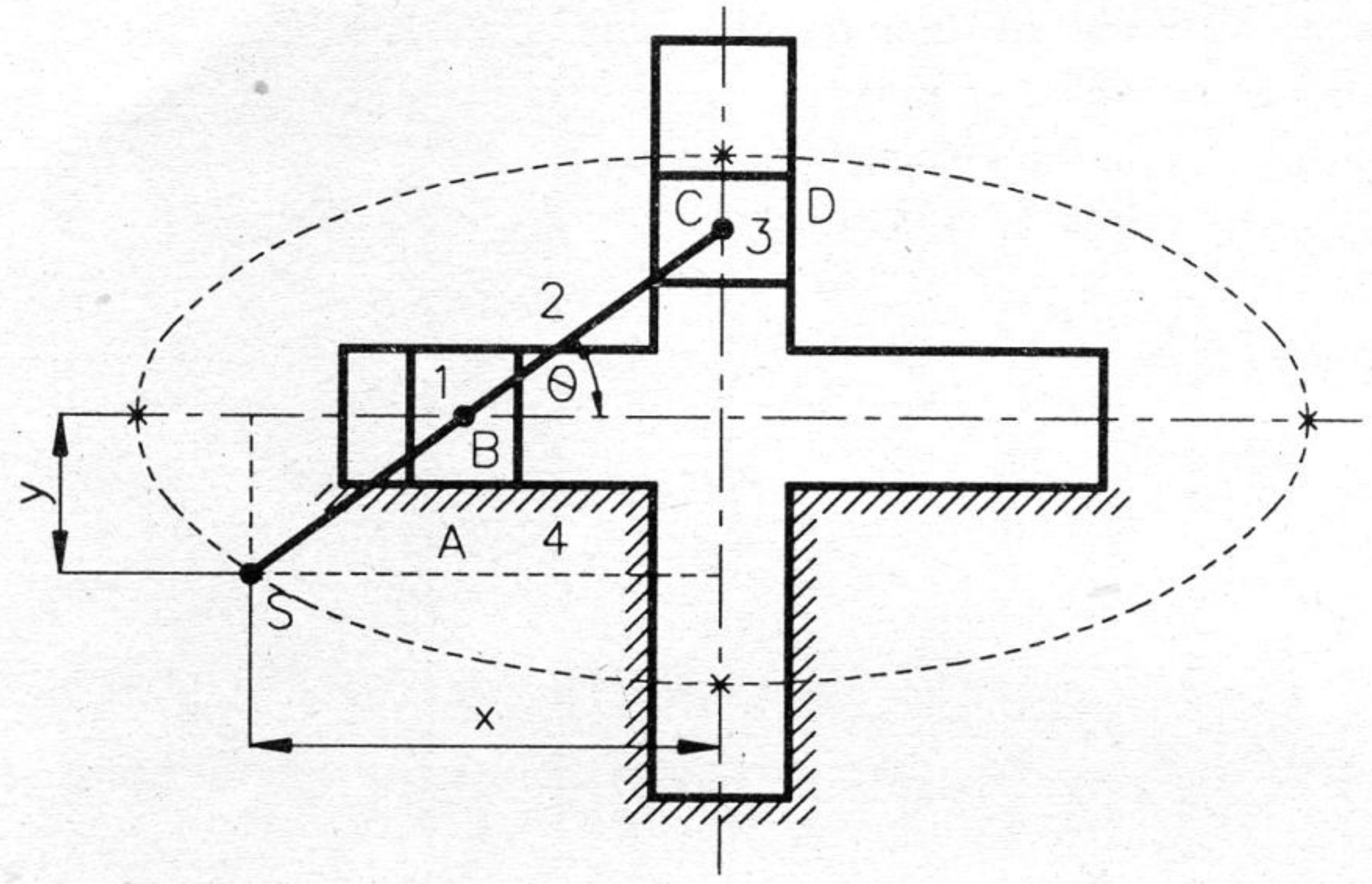


Fig. 1.33 : Elliptical Trammel

ANIMATION OF ELLIPTICAL TRAMMEL

elliptical trammel.wmv

SCOTCH YOKE MECHANISM

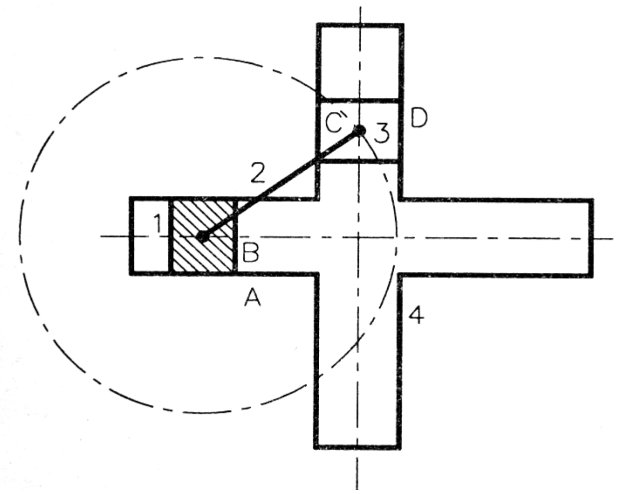
link 1 – Slider (fixed link) ,

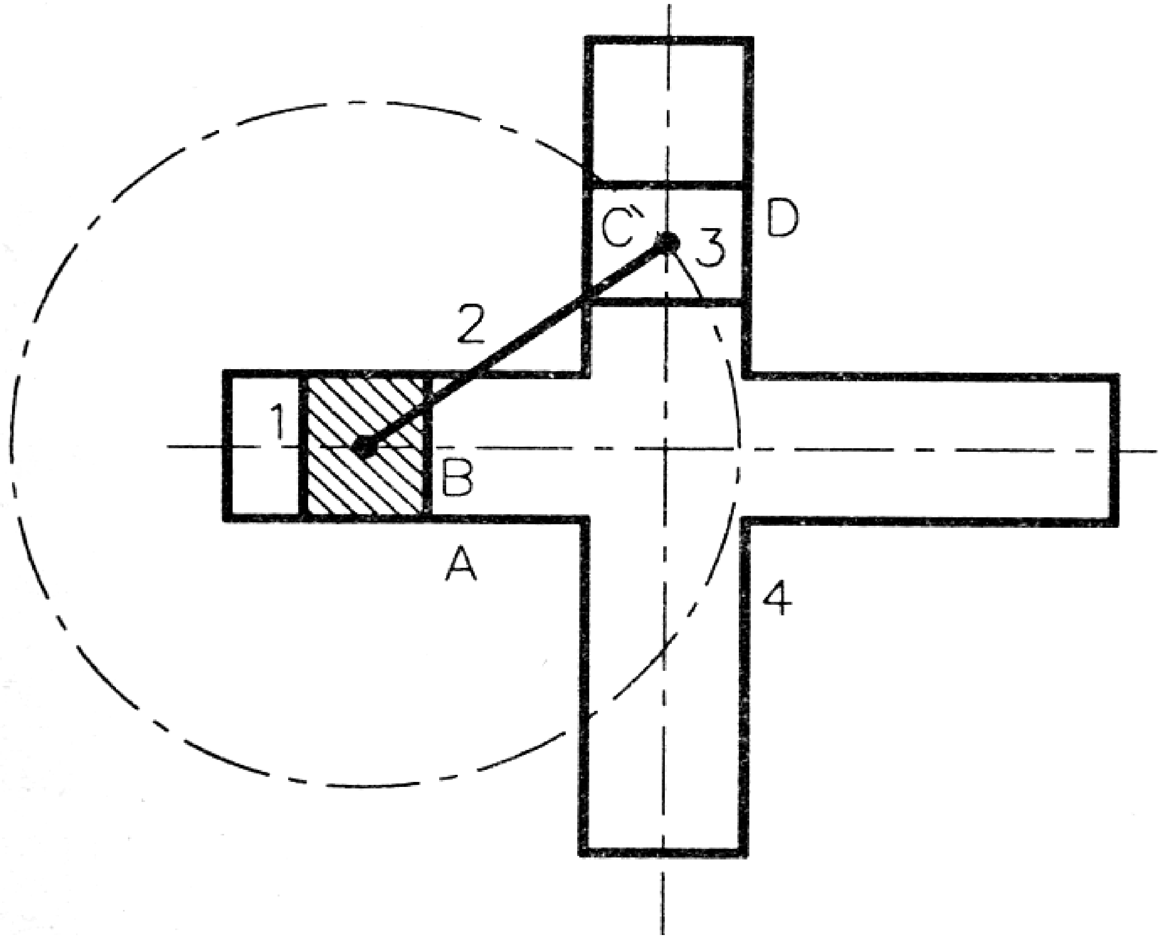
link 2 - Connecting link ,

link 3 - Slider link ,

link4 – Slotted Frame

- Here, one of the two slide blocks i.e. either link 1 or link 3, is kept fixed. In such an arrangement, the whole frame i.e. link 4 will reciprocate as seen in Scotch-Yoke mechanism.
- Here, rotary motion of link 2 is converted to reciprocating motion to link 4.

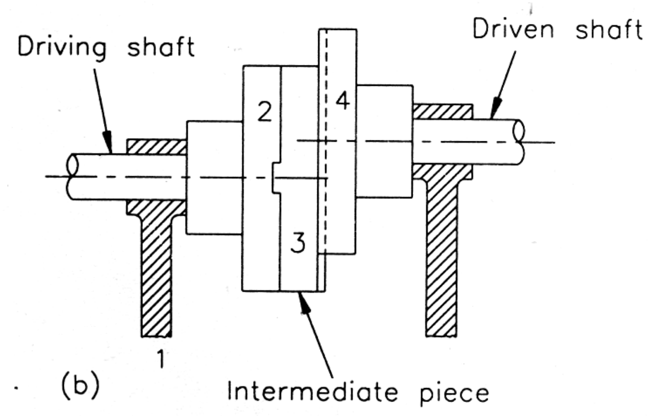



C`
D
3
2
1
B
A
4

Package

OLDHAM COUPLING (THIRD INVERSION)

- Here the Connecting link in the basic configuration is fixed.

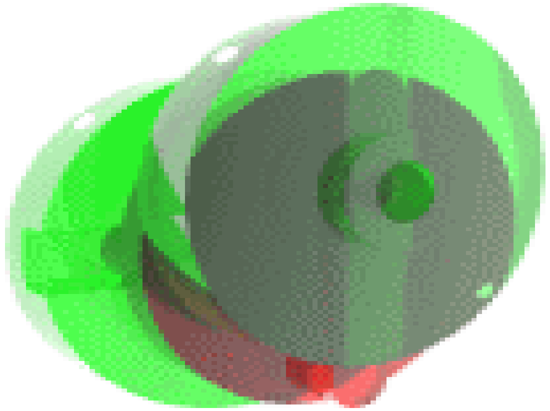


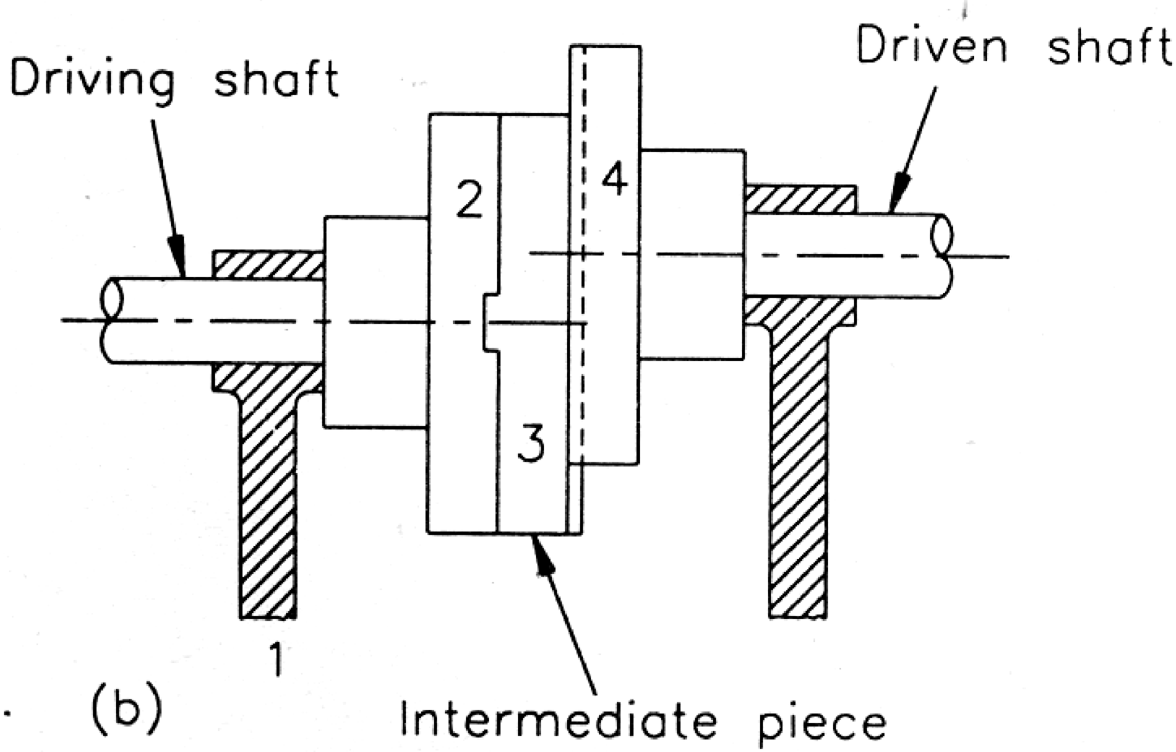
- Maximum sliding speed of each tongue is

  Vs = w. r

  W = angular velocity of each shaft

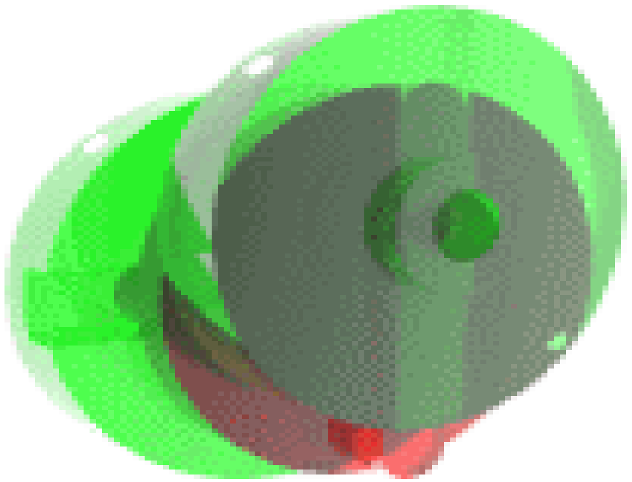
  r = distance between the axes of shafts





(b)

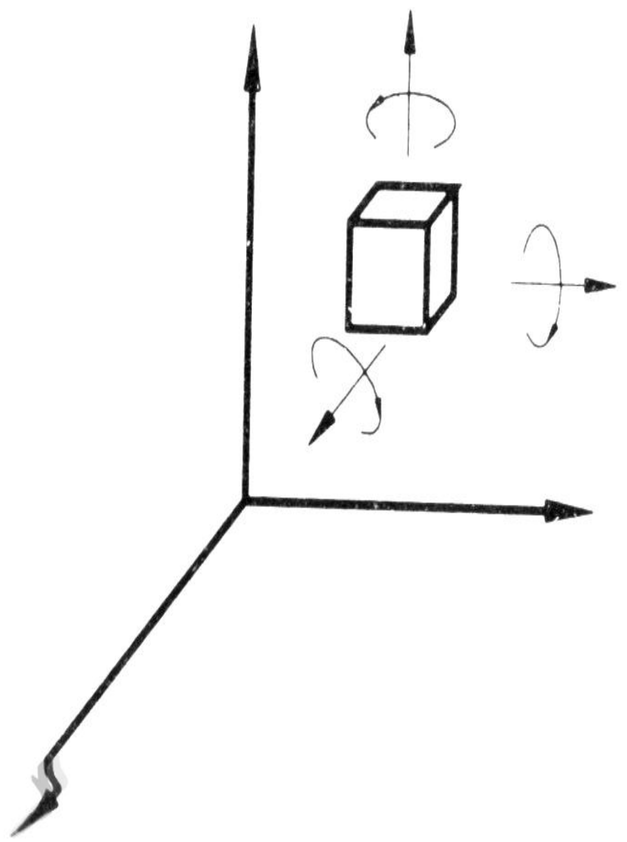
Animation of Oldham coupling



DEGREE OF FREEDOM

- Degrees of freedom of a pair is defined as the number of independent co-ordinates required to define the position & orientation of a body.

- Point in space have 3 DOF

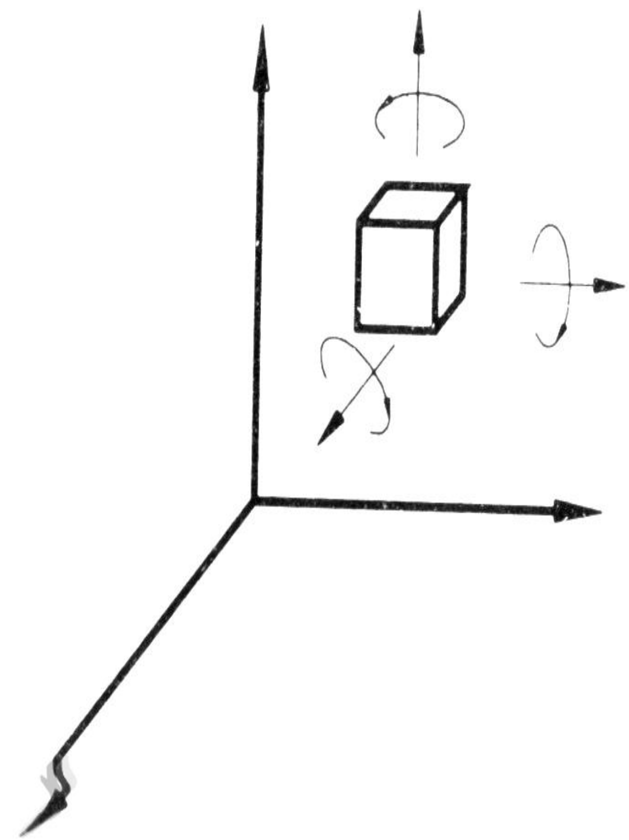


DEGREE OF FREEDOM

- Degrees of freedom of a pair is defined as the number of independent relative motions, both translational and rotational, a pair can have.

- For spatial mechanisms
  Degrees of Freedom = 6 - (Number of Constraints)

- For planar mechanisms :-
  Degrees of Freedom = 3 - (Number of Constraints)



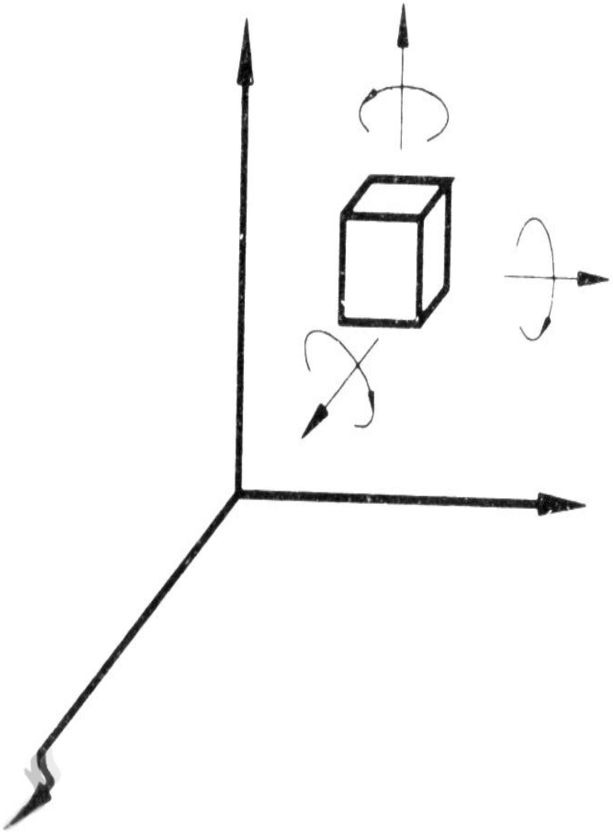
DEGREE OF FREEDOM

- For spatial mechanisms

  The complete motion cannot be represented by single plane (3D motion paths)

- For planar mechanisms :-

  The complete motion can be represented by single plane



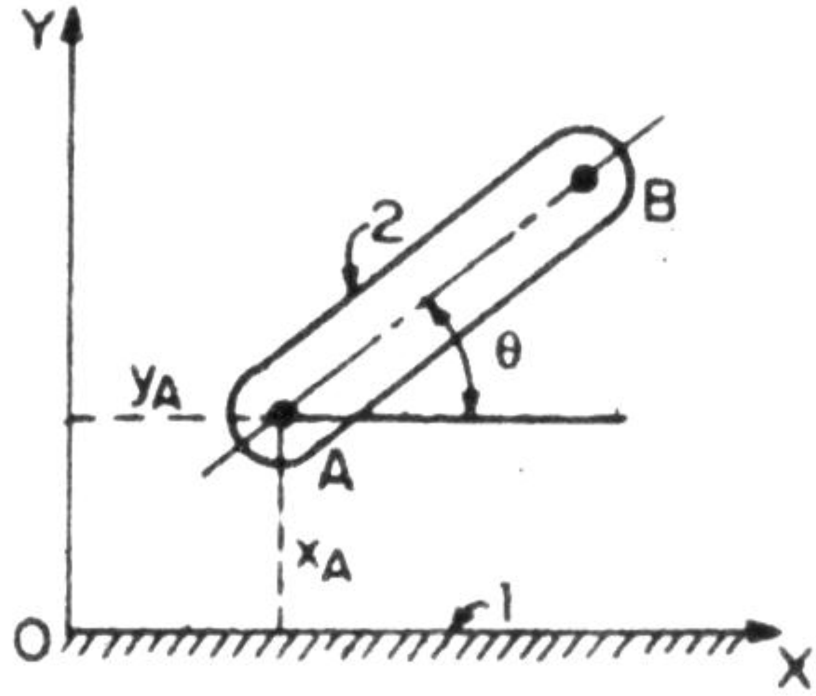
Mobility

- The number of independent input parameters that are to be controlled so that a mechanism can take up a particular position

- The number of inputs required to produce the constrained motion of a mechanism is called DOF. So if only one input is required to produce the constrained motion of a mechanism, then DOF is 1.
- Classification based on no. of restraints:-
  - Zero order mechanism - No restraint
  - First order mechanism - No restraint
  - Second order mechanism - No restraint
  - Third order mechanism - No restraint
  - Fourth order mechanism - No restraint
  - Fifth order mechanism - No restraint

DOF OF PLANAR MECHANISMS

- It can be stated that an unconstrained rigid link in the plane has three degrees of freedom.



KUTZBACH CRITERIA

- Since in a mechanism, one of the links is to be fixed, therefore the number of movable links will be

  (n-1)

- Thus the number of degrees of freedom of a mechanism is given by

$$f = 6\,(n-1)$$

$$f = 6\,(n-1) - 5p_1 - 4p_2 - 3p_3 - 2p_4 - 1p_5 - 0p_6$$

p_1 – No. of pairs having 1 DOF
p_2 – No. of pairs having 2 DOF
p_3 – No. of pairs having 3 DOF
p_4 – No. of pairs having 4 DOF
p_5 – No. of pairs having 5 DOF
p_6 – No. of pairs having 6 DOF

GRUBLER’S CRITERIA

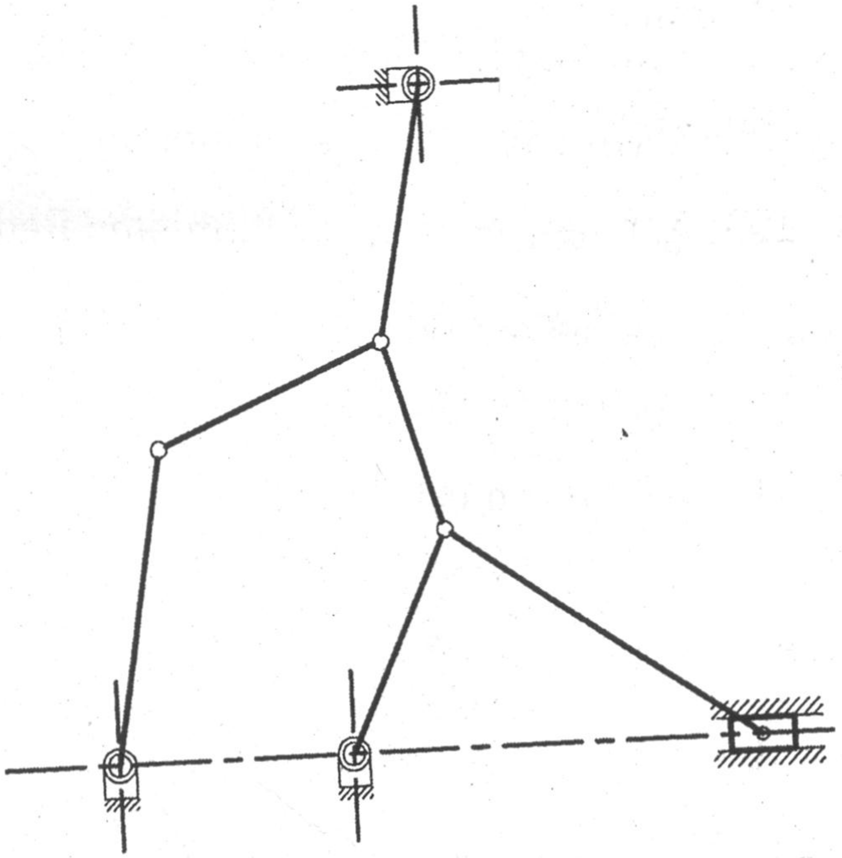
- The Grubler’s criterion applies to mechanisms with only single degree of freedom joints where the overall movability of the mechanism is unity.
- Substituting n = 1 and h = 0 in Kutzbach equation, we have
- $$f = 3(n-1) - 2p_1$$

$$f = 3(n-1) - 2p_1 - 1p_2$$

PROBLEM M-09

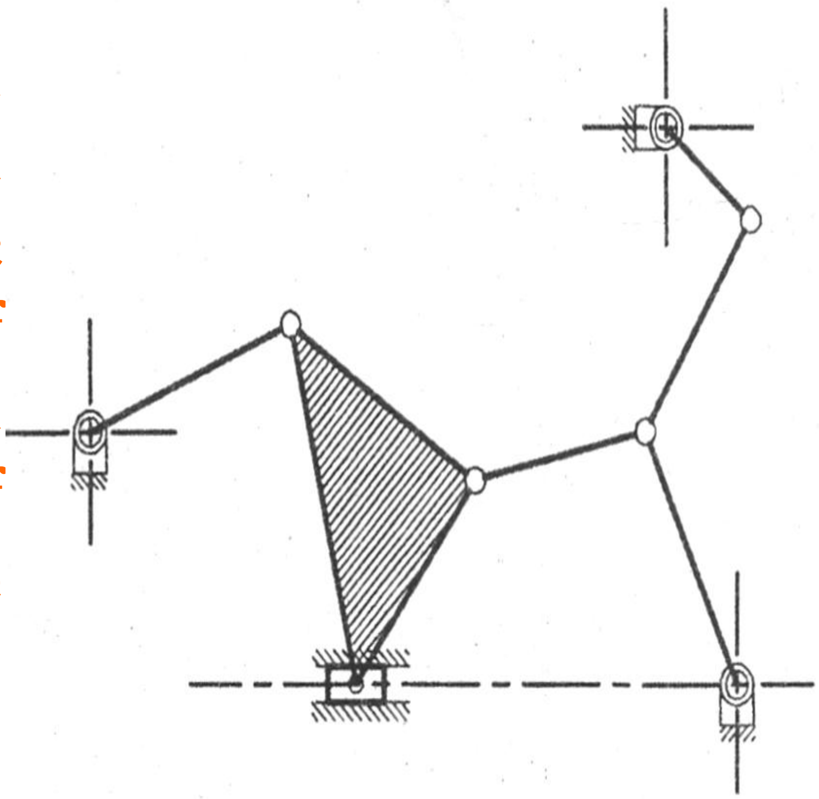
- Q1(c) Fig. shows schematic of a mechanism. Redraw the free-hand sketch on the answer book. Find out the total number of kinematic links and number of kinematic pairs. Hence find out the degrees of freedom for the mechanism

  [4 MARKS]
- (n=8;p1=10;dof=1)



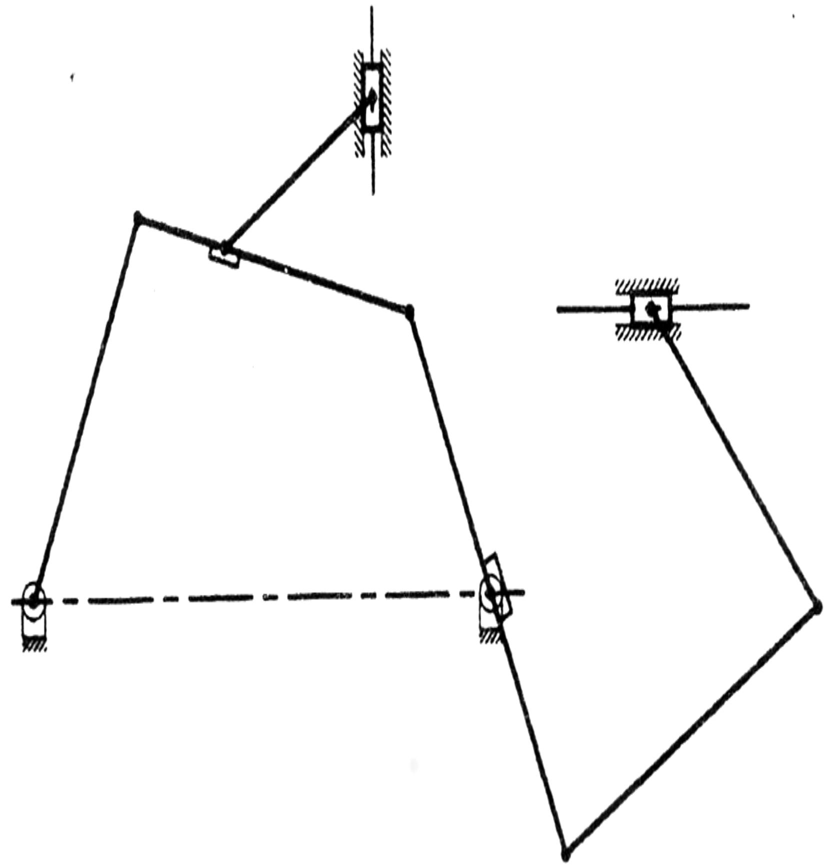
PROBLEM M-09

- Q 2C)Fig. shows schematic of a mechanism. Redraw the free-hand sketch on the answer book. Find out the total number of kinematic links and number of kinematic pairs. Hence find out the degrees of freedom for the mechanism. [4]
- (n=8;p1=10;dof=1)



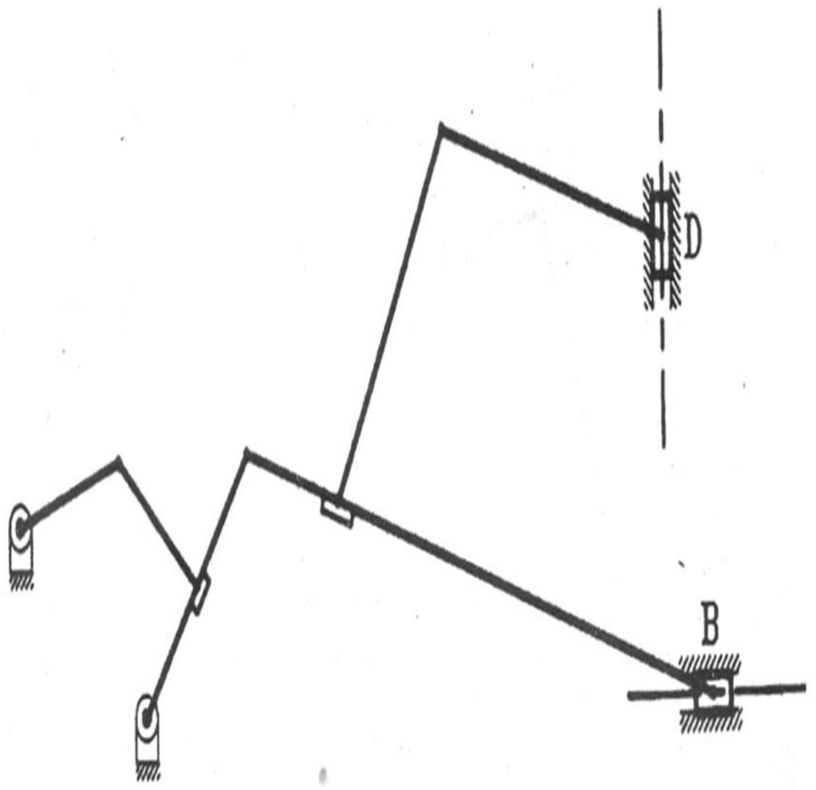
PROBLEM M-07

- (b) Figure shows schematic of a mechanism. Redraw the free hand sketch on the answer-book. Find out the total number of kinematic links and number of kinematic pairs. Hence find out degrees of freedom for the mechanism. [
- (n=9;p1=11;dof=2)



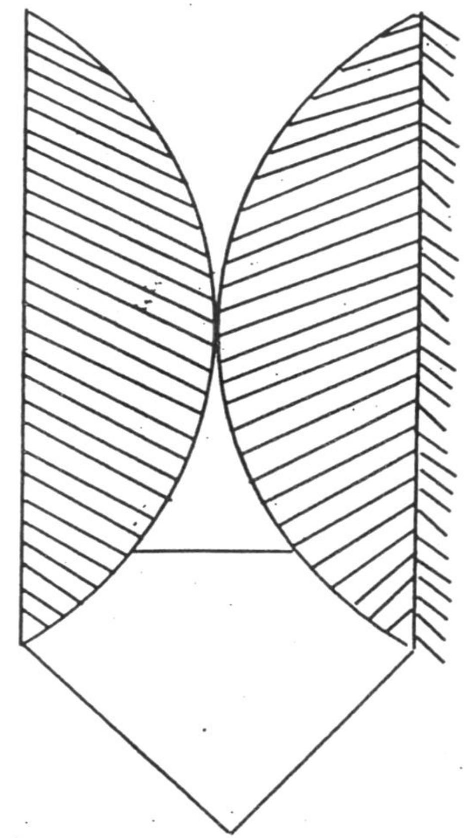
PROBLEM M-07

- Q2C) Figure shows schematic of a mechanism. Redraw the free hand sketch on the answer-book. Find out the total number of kinematic links and number of pairs. Hence find out degrees of freedom for the mechanism. [4]
- (n=9;p1=11;dof=2)



PROBLEM D-05

- Justify the linkages shown in Fig. is a mechanism with single degree of freedom.
- (n=5;p1=5;p2=1;dof=1)



PROBLEM DO-04

- Define degrees of freedom of a mechanism and find degrees of freedom for the following cases (Fig. 1 and Fig. 2). [8 MARKS]

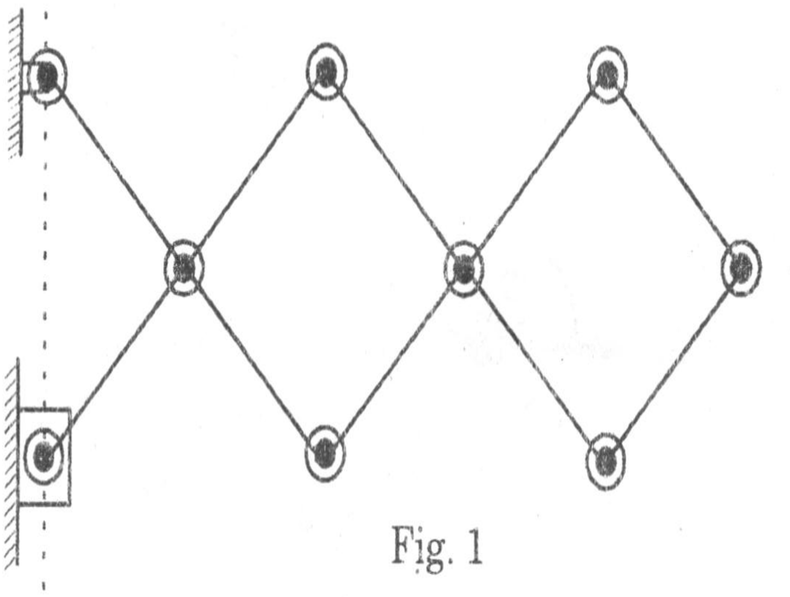


Fig. 1

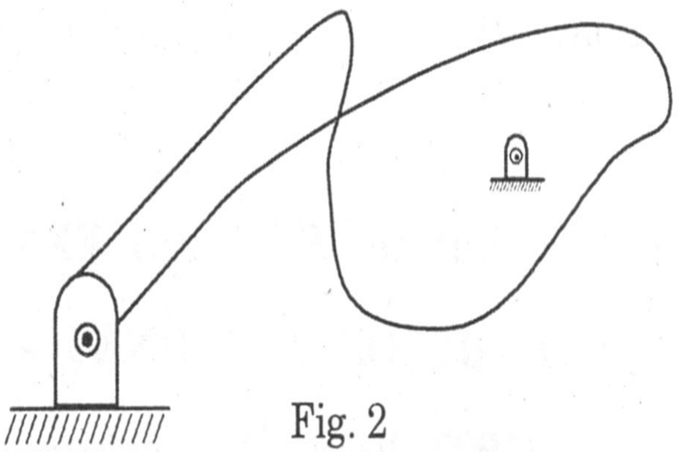
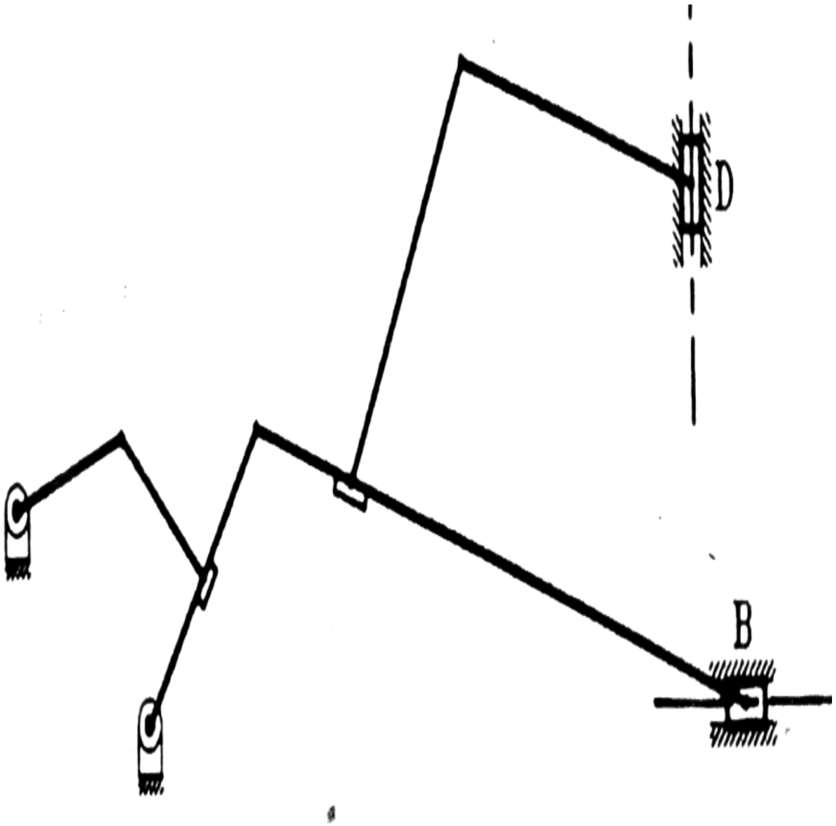


Fig. 2

PROBLEM

- Figure shows schematic of a mechanism. Redraw the freehand sketch on the answer-book. Find out the total number of kinematic links and number of pairs. Hence find out degrees of freedom for the mechanism. [4]



EQUIVALENT LINKAGE OF MECHANISMS

- Many times the physical shape of the connection between the links is such that the actual nature and function of the connection are not immediately noticed. This is mainly on account that the centre of a revolute pair is not directly apparent..

EQUIVALENT LINKAGE OF MECHANISMS

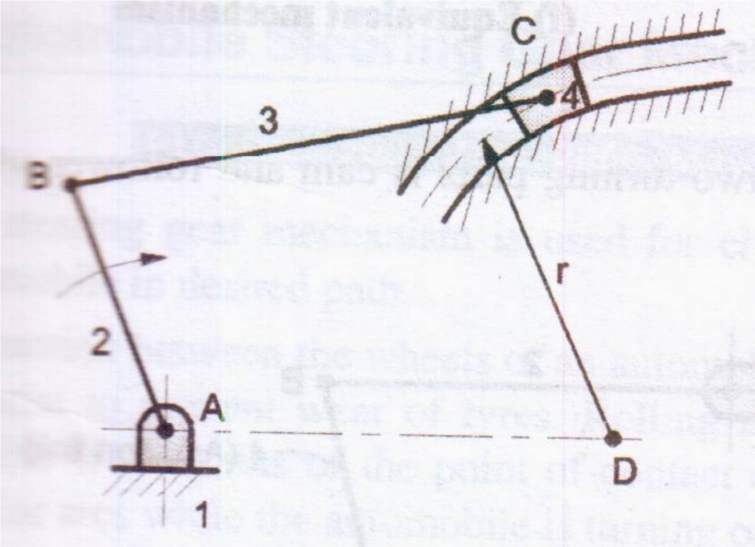
- Very often, a mechanism with higher pairs can be replaced by an equivalent mechanism with lower pairs.

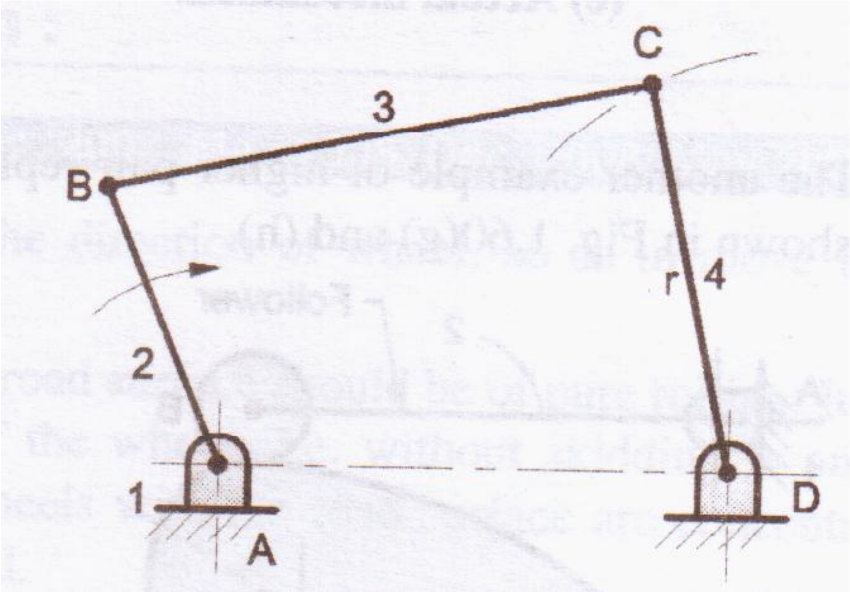
- This equivalence is valid for studying only the instantaneous characteristics.

- The equivalent lower pair mechanism facilitates analysis as a certain amount of sliding takes place between connected links in a higher-pair mechanism.

Equivalent Linkages of Mechanism

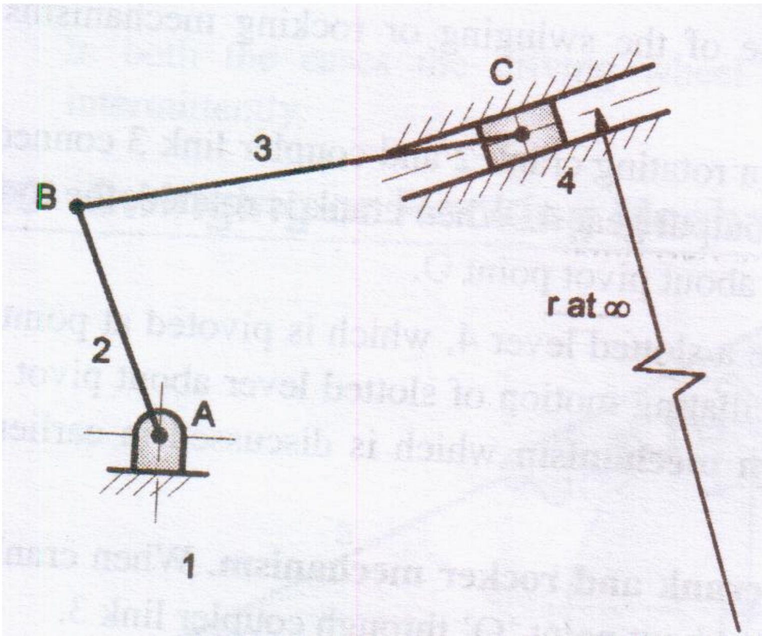
1] Turning Pair in Place of Sliding Pair

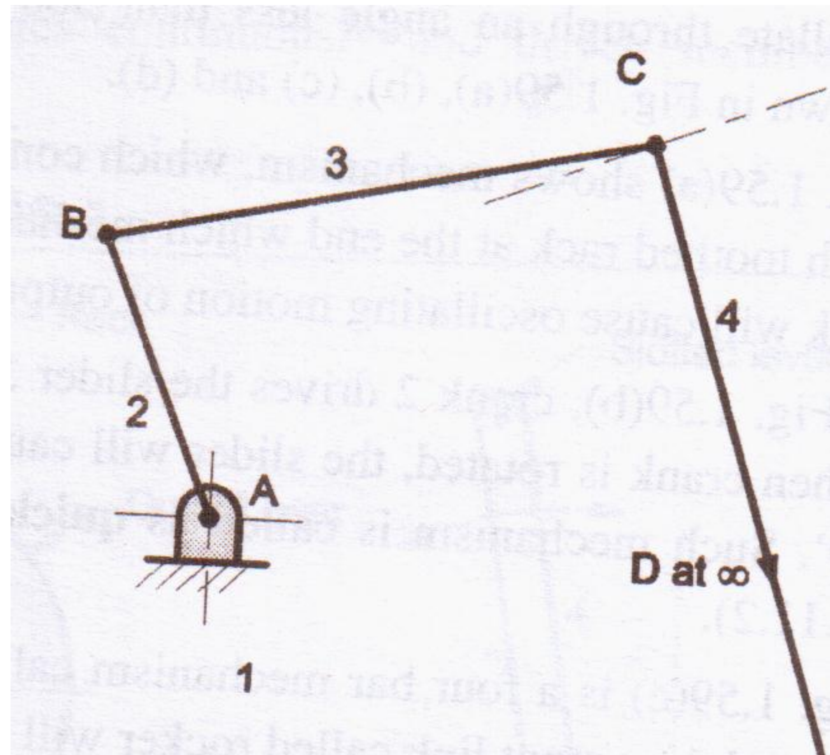




Equivalent Linkages of Mechanism

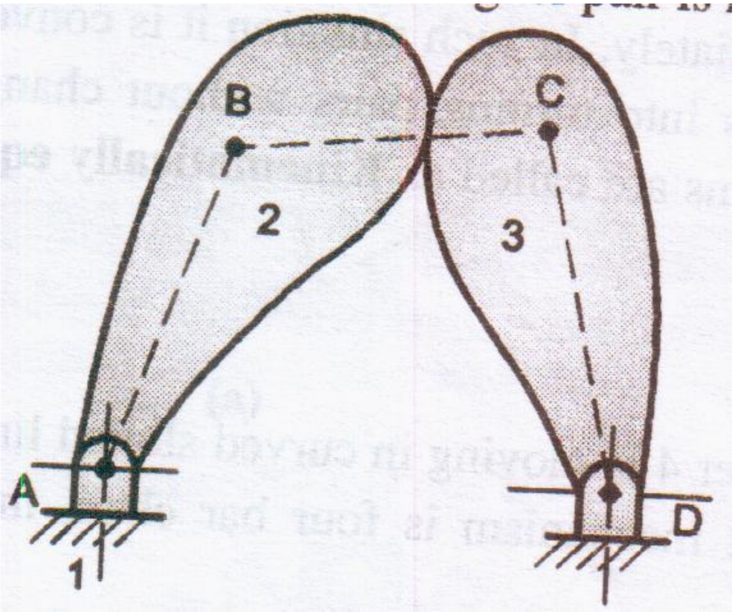
1] Turning Pair in Place of Sliding Pair

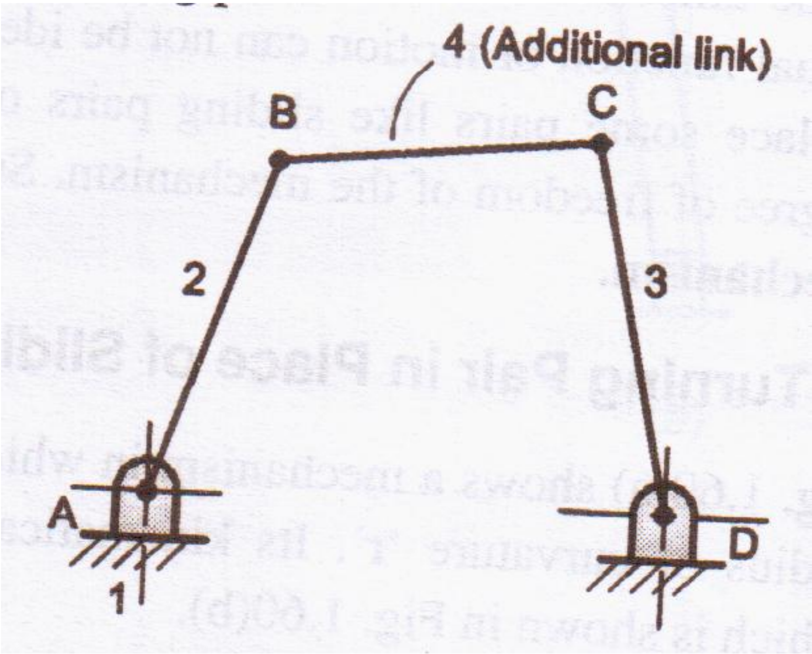




Equivalent Linkages of Mechanism

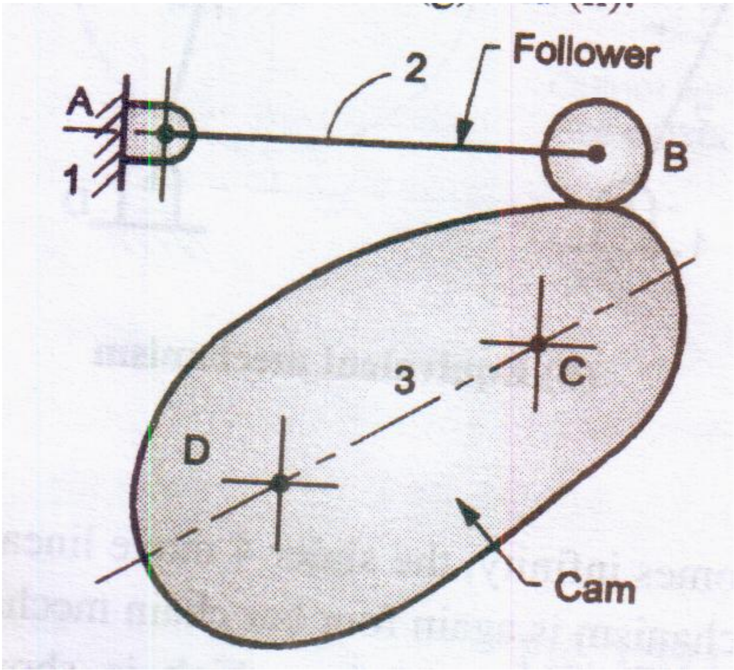
2] Turning Pair in Place of Higher Pair

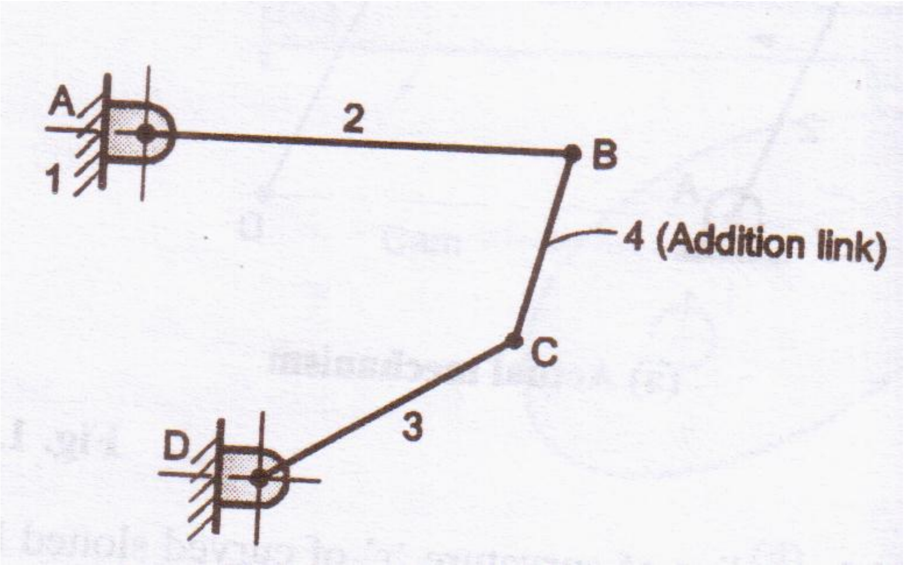




Equivalent Linkages of Mechanism

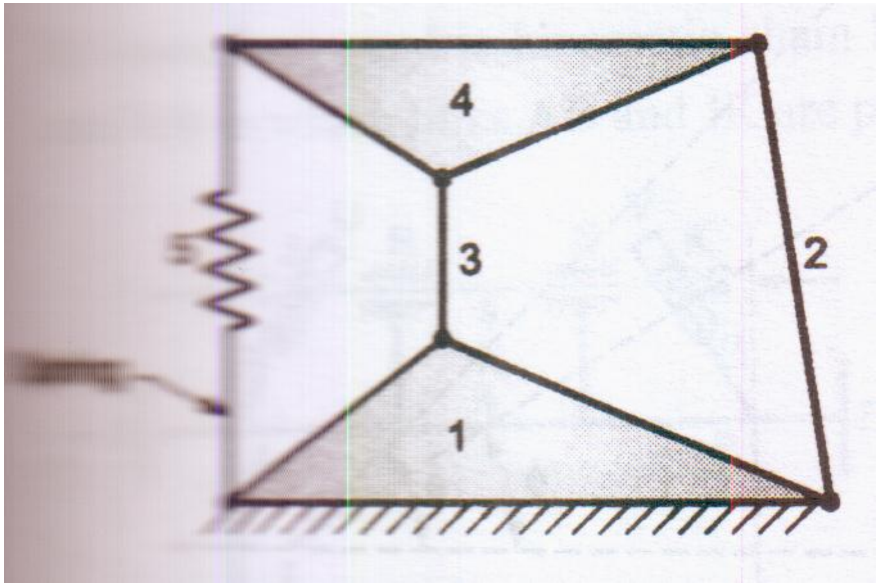
2] Turning Pair in Place of Higher Pair

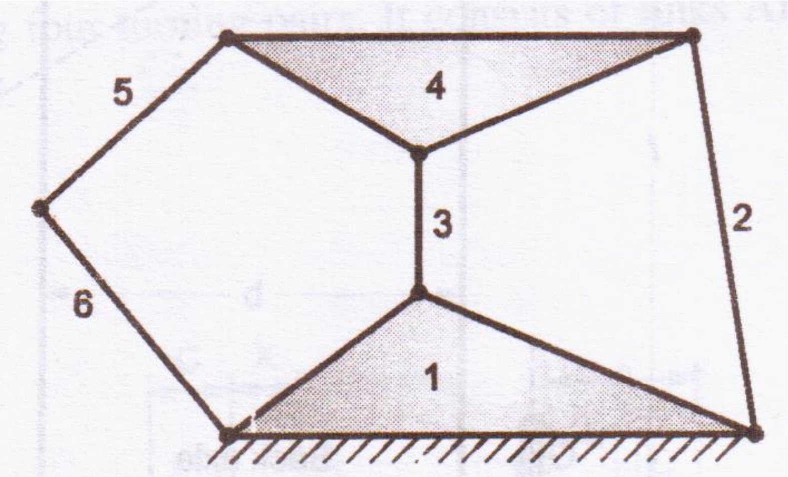




Equivalent Linkages of Mechanism

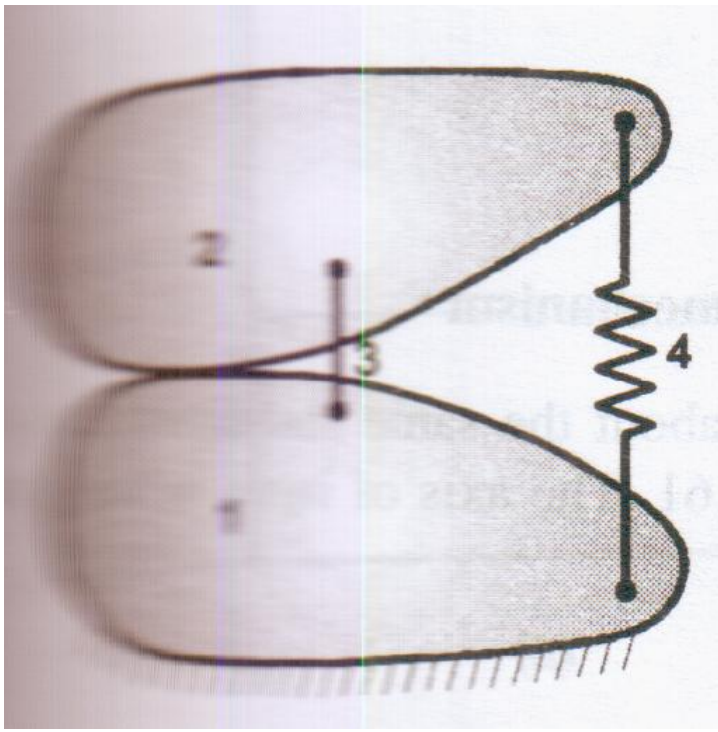
3] Turning Pair in Place of Spring

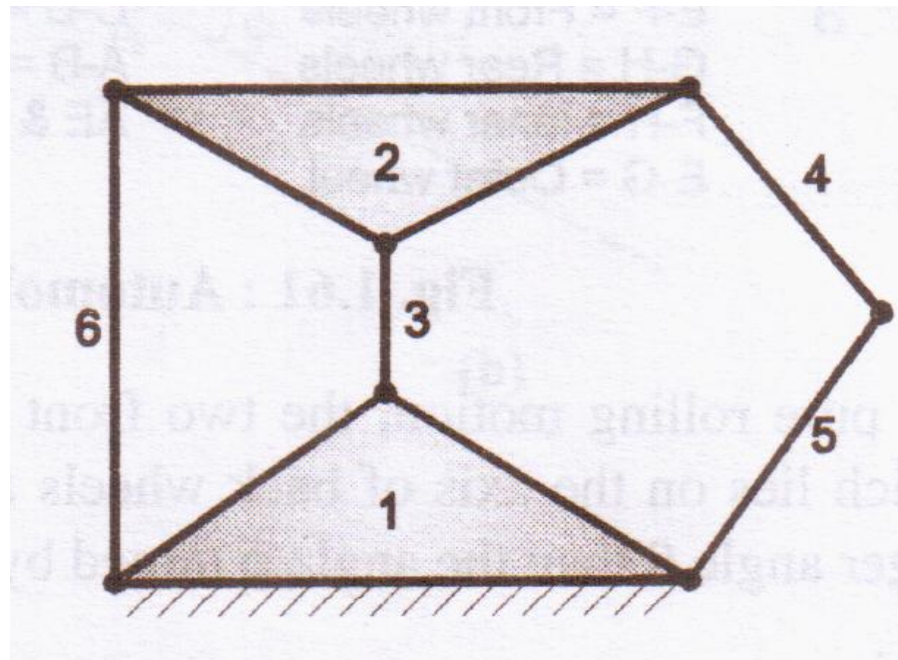




Equivalent Linkages of Mechanism

3] Turning Pair in Place of Spring






Time
is
money
10
9
8
7
6
5