Elements of Mechanical Engg.(BMEC-1201)

Course Name: EME

Semester:2nd

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MECHANICS

- Terminologies
  - Machine
  - Mechanism
  - Kinematic Pair
  - Links
  - Kinematic Chain

- DOF(Degree of Freedom)

  Grashoff Law

- Mechanism and Inversions of Mechanisms:
  - Four Bar
  - Single-Slider Crank
  - Double-Slider Chain

MECHANICS

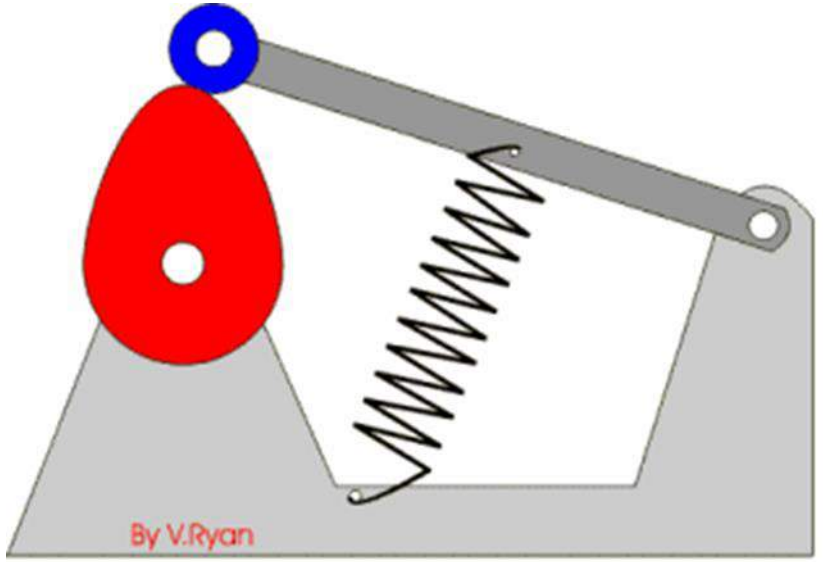
Mechanism – Part of a machine, which transmit motion and power from input point to output point

Planar Mechanism: When all the links of a mechanism have plane motion, it is called as a planar mechanism. All the links in a planar mechanism move in planes parallel to the reference plane

Machine: A machine is a mechanism or collection of mechanisms, which transmit force from the source of power to the resistance to be overcome.

Though all machines are mechanisms,

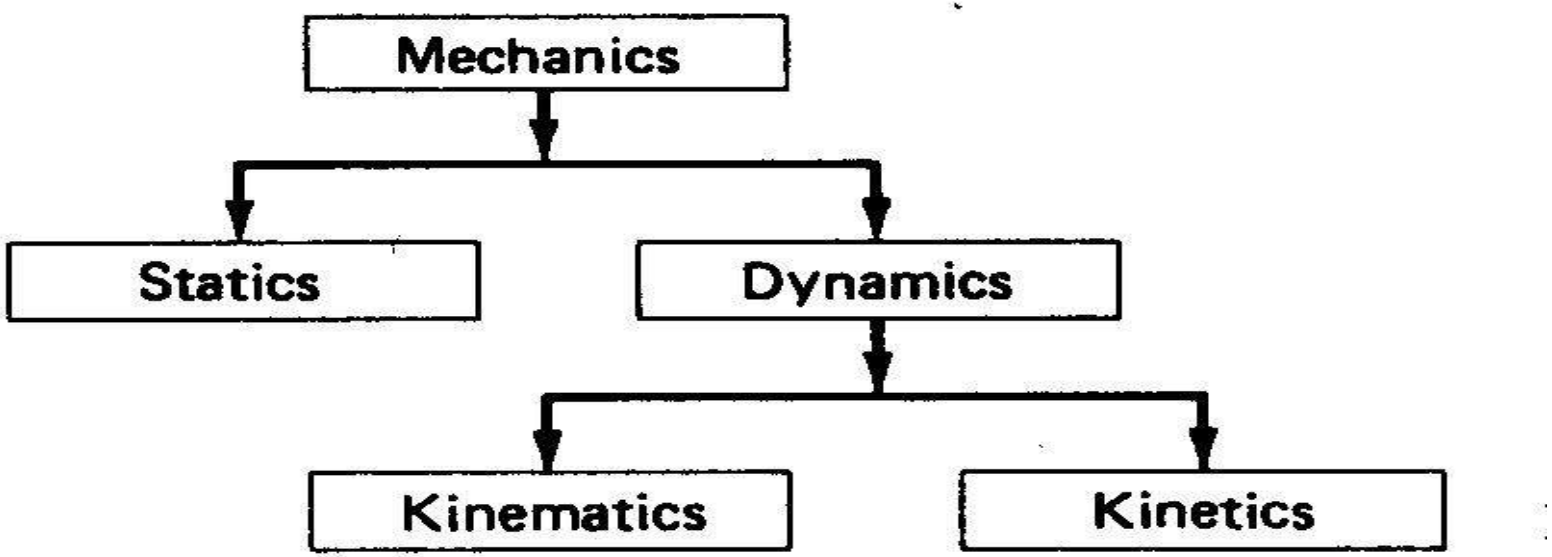
all mechanisms are not machines



Dynamics – Deals with systems which are changing with time. Time

(Kinema – Greek Word – Motion)

MECHANICS

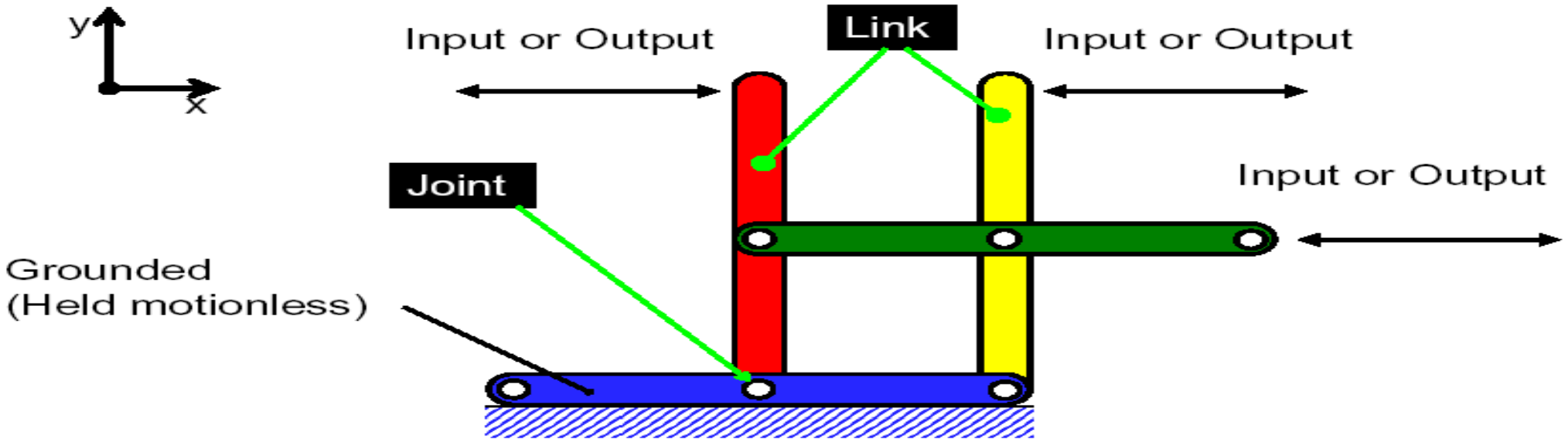


DYNAMICS

What is a linkage?

What is a linkage?

A mechanism used to define motion (kinematics) &/or transfer energy using links & joints

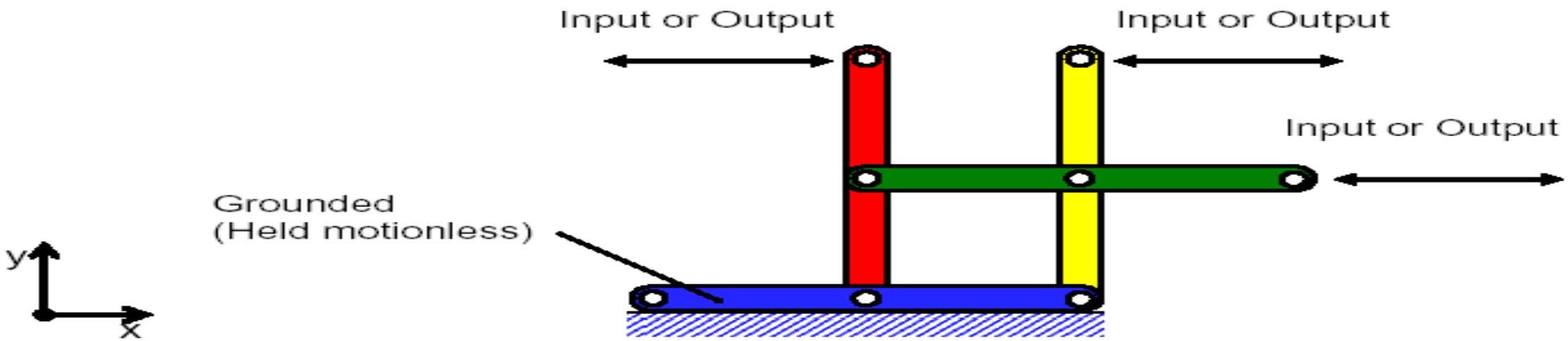


DYNAMICS

Linkage classification

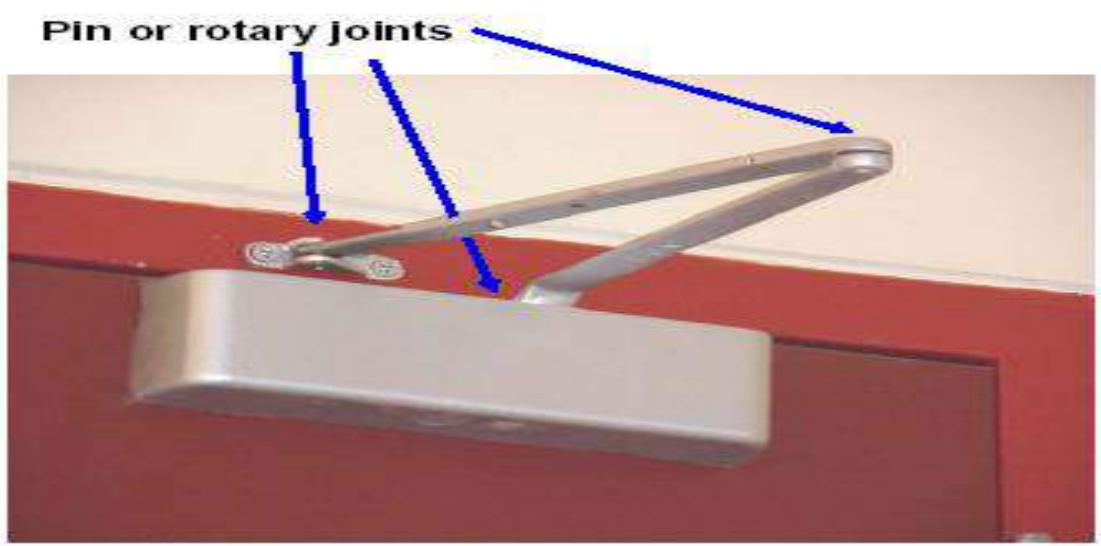
Linkages are classified by:

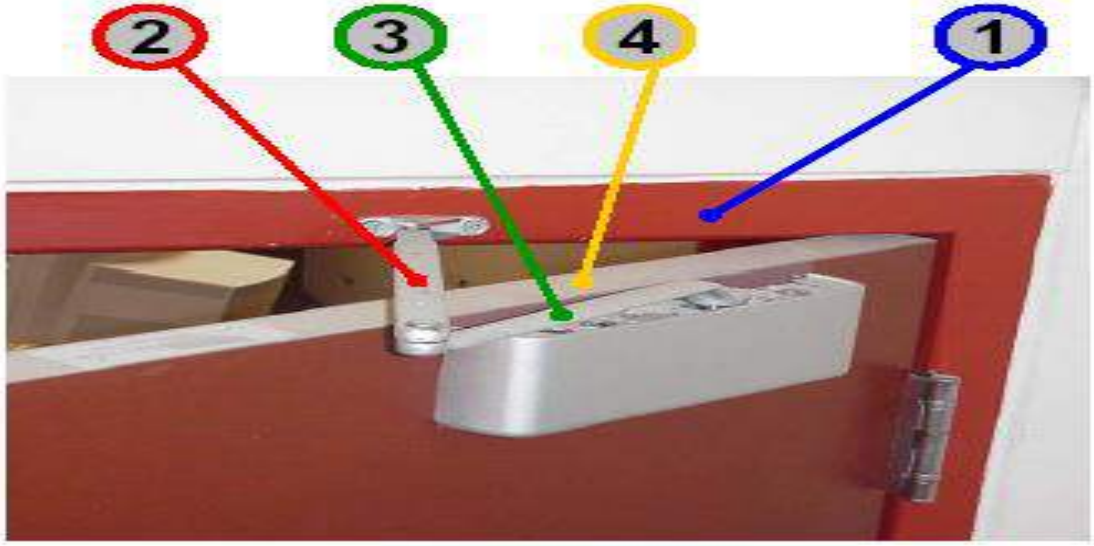
- The number of links (we will deal with 4-bar linkages)
- Type of links (we will deal with bars and sliders)
- Connection between links (we will deal with pinned, spherical and sliding joints)



DYNAMICS

Example: 4 bar door damper linkage



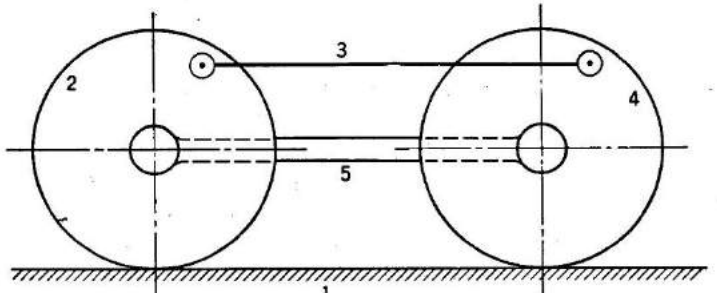


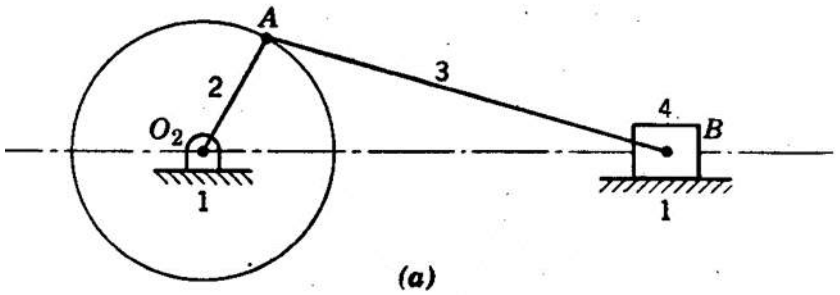
1	= Wall	or	Link 1	This is the grounded (held still)
2	= Bar 2	or	Link 2	
3	= Bar 3	or	Link 3	
4	= Door	or	Link 4	

Links

Any body (normally rigid) which has motion relative to another

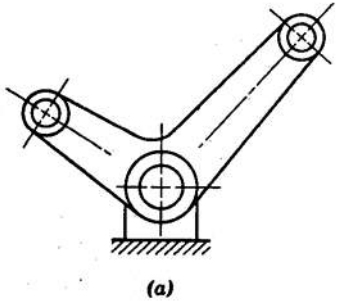
- **Binary link**
- **Ternary link**
- **Quaternary link**

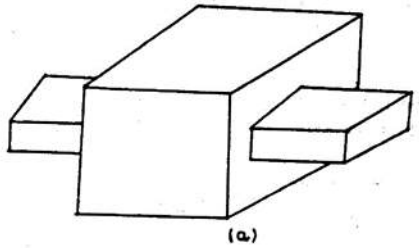




DYNAMICS

Pairing elements: the geometrical forms by which two members of a mechanism are joined together, so that the relative motion between these two is consistent. Such a pair of links is called **Kinematic Pair**.





KINEMATIC PAIRS

A mechanism has been defined as a combination so connected that each moves with respect to each other. A clue to the behavior lies in in the nature of connections, known as kinetic pairs.

The degree of freedom of a kinetic pair is given by the number independent coordinates required to completely specify the relative movement.

KINEMATIC PAIRS

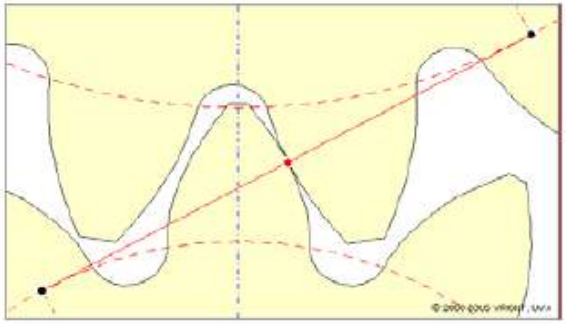
Based on nature of contact between elements

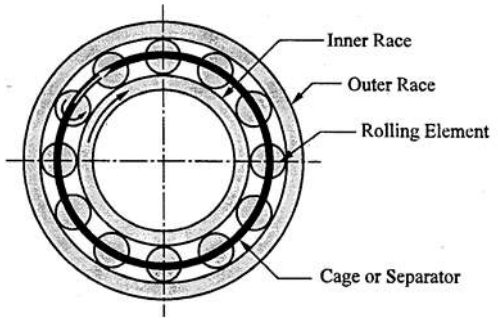
Lower pair : The joint by which two members are connected has surface contact. A pair is said to be a lower pair when the connection between two elements are through the area of contact. Its 6 types are

- Revolute(Or)Turning Pair,
- Sliding Pair
- Screw Pair
- Cylindrical Pair
- Spherical Pair
- Flat or Planar Pair

HIGHER PAIRS

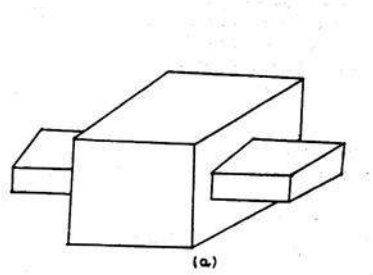
Higher pair: The contact between the pairing elements takes place at a point or along a line.

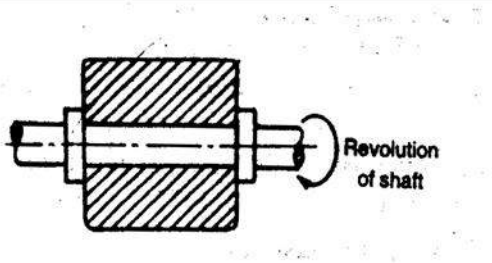




DYNAMICS

- Based on relative motion between pairing elements
- (a) Siding pair [DOF = 1]
- (b) Turning pair (revolute pair)
- [DOF = 1]



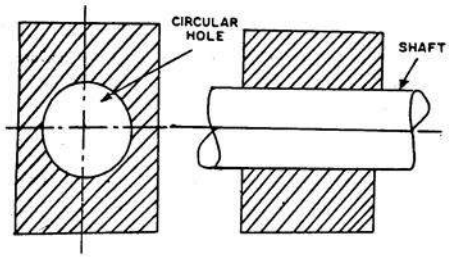


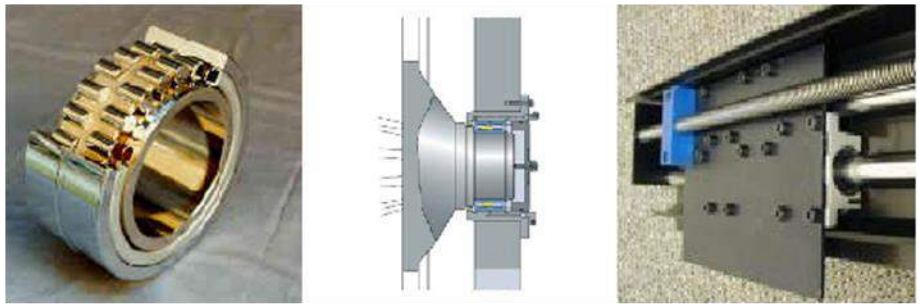
RELATIVE MOTION

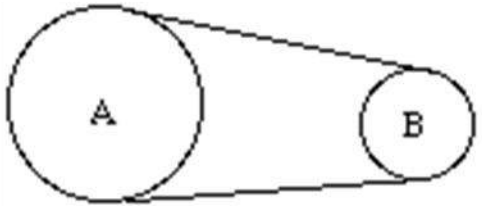
Based on relative motion between pairing elements

(c) Cylindrical pair [DOF = 2]

(d) Rolling pair [DOF = 1]



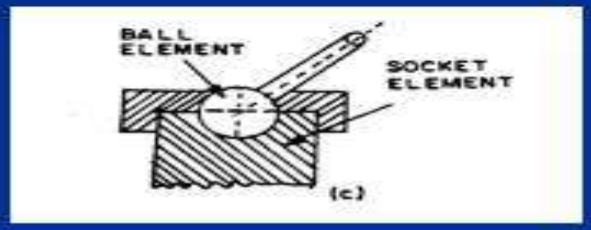




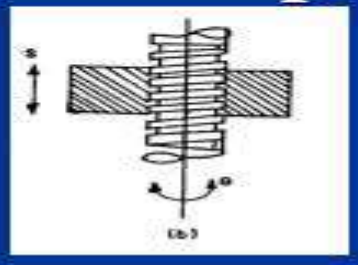
Types of Pairs

Based on relative motion between pairing elements

(e) Spherical pair [DOF = 3]



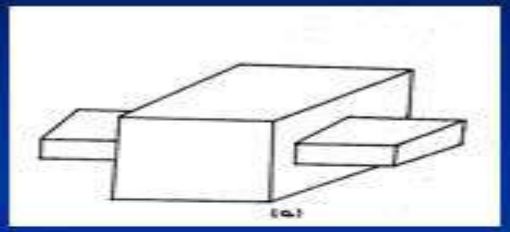
(f) Helical pair or screw pair [DOF = 1]



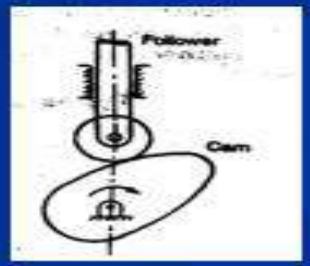
DYNAMICS

Based on the nature of mechanical constraint

(a) Closed pair



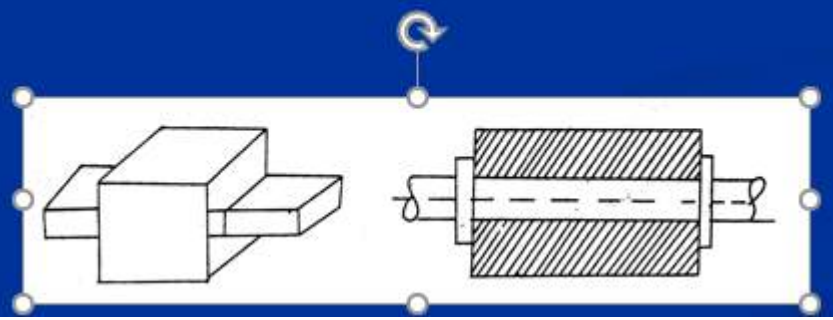
(b) Unclosed or force closed pair



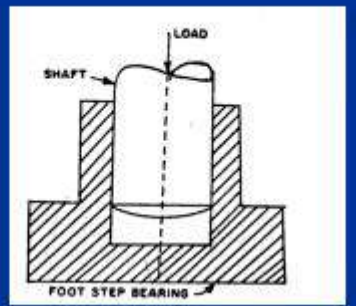
CONSTRAINED MOTION

one element has got only one definite motion relative to the other

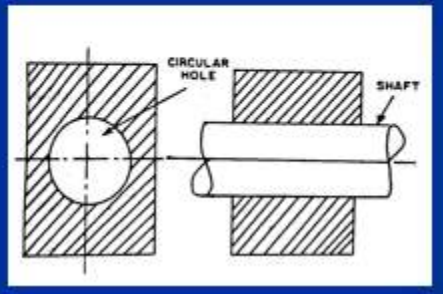
(a) Completely constrained motion



(b) Successfully constrained motion



(c) Incompletely constrained motion



KINEMATIC CHAIN

Group of links either joined together or arranged in a manner that permits them to move relative to one another.

Relation between Links, Pairs and Joints

L=2P-4

J=(3/2) L – 2

L => No of Links

P => No of Pairs

J => No of Joints

L.H.S > R.H.S => Locked chain

L.H.S = R.H.S => Constrained Kinematic Chain

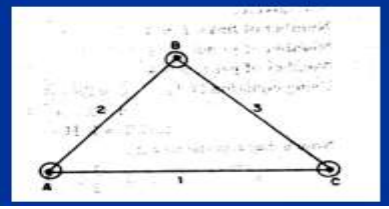
L.H.S < R.H.S => Unconstrained Kinematic Chain

DYNAMICS

LOCKED CHAIN (Or) STRUCTURE

Links connected in such a way that no relative motion is possible.

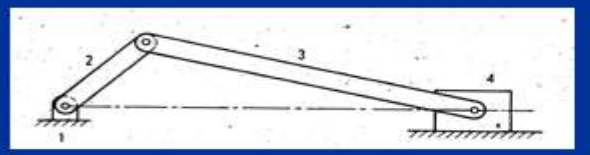
L=3, J=3, P=3 L.H.S>R.H.S

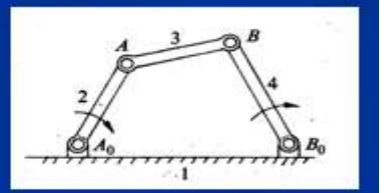


Slider crank and four bar mechanisms

L=4, J=4, P=4

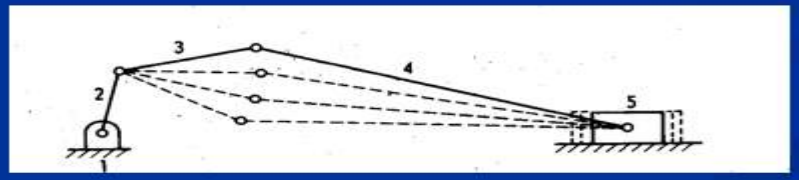
L.H.S=R.H.S





L=5,P=5,J=5

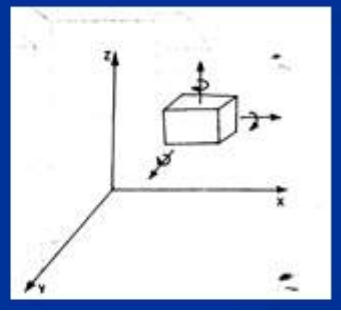
L.H.S < R.H.S



DEGREE OF FREEDOM(D.O.F)

DEGREES OF FREEDOM (DOF):

It is the number of independent coordinates required to describe the position of a body.



Degrees of freedom/mobility of a mechanism

It is the number of inputs (number of independent coordinates) required to describe the configuration or position of all the links of the mechanism, with respect to the fixed link at any given instant.

GRUBLER'S CRITERION

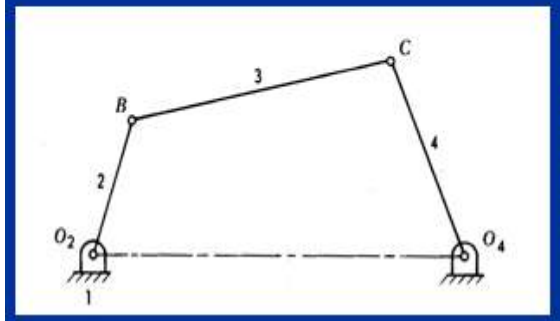
Number of degrees of freedom of a mechanism is given by

$F = 3(n-1)-2l-h$. Where,

- F = Degrees of freedom
- n = Number of links in the mechanism.
- l = Number of lower pairs, which is obtained by counting the number of joints. If more than two links are joined together at any point, then, one additional lower pair is to be considered for every additional link.
- h = Number of higher pairs

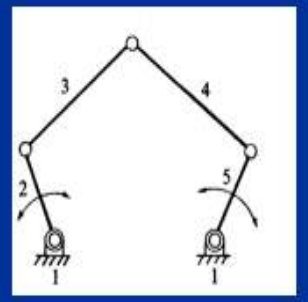
DEGREE OF FREEDOM(D.O.F)

Examples - DOF



- F = 3(n-1)-2l-h
- Here, n = 4, l = 4 & h = 0.
- F = 3(4-1)-2(4) = 1
- I.e., one input to any one link will result in definite motion of all the links.

Examples - DOF



- F = 3(n-1)-2l-h
- Here, n = 5, l = 5 and h = 0.
- F = 3(5-1)-2(5) = 2
- I.e., two inputs to any two links are required to yield definite motions in all the links.

INVERSION

INVERSIONS OF MECHANISM

A mechanism is one in which one of the links of a kinematic chain is fixed. Different mechanisms can be obtained by fixing different links of the same kinematic chain. These are called as inversions of the mechanism.

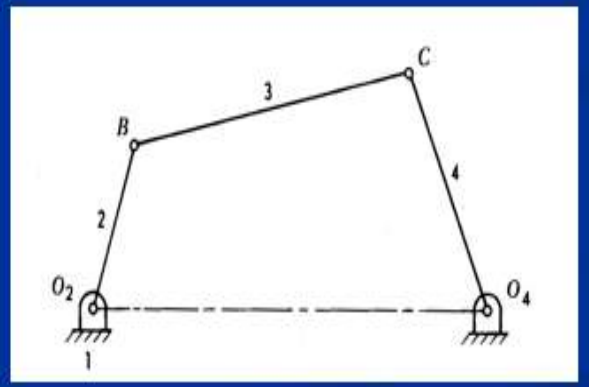
INVERSIONS OF MECHANISM

- 1.Four Bar Chain
- 2.Single Slider Crank
- 3.Double Slider Crank

INVERSION

1. FOUR BAR CHAIN

- (link 1) frame
- (link 2) crank
- (link 3) coupler
- (link 4) rocker



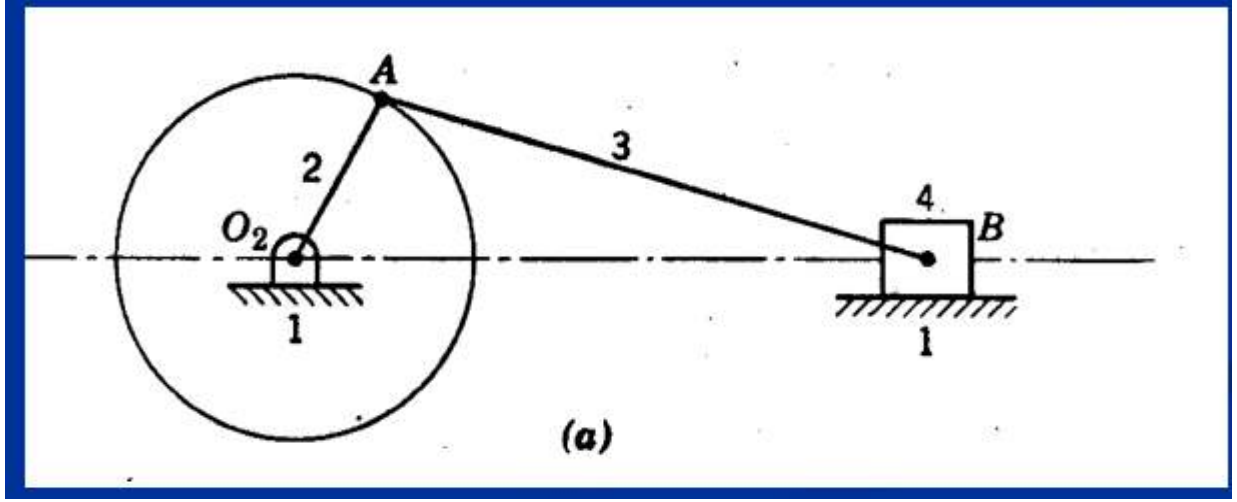
2.SLIDER CRANK CHAIN

Link1=Ground

Link2=Crank

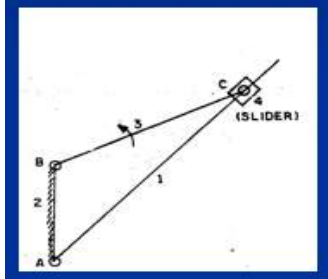
Link3=ConnectingRod

Link4=Slider

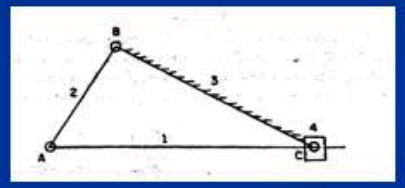


INVERSIONS

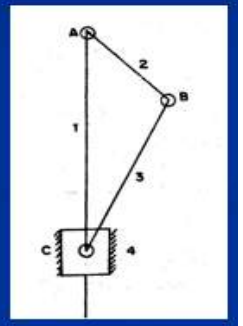
Inversions of slider crank chain



crank fixed
Link 2 fixed



(b) connecting rod fixed
Link 3 fixed



(c) slider fixed
Link 4 fixed

3. DOUBLE SLIDER CRANK CHAIN

It is a kinematic chain consisting of two turning pairs and two sliding pairs.

Link 1 Frame

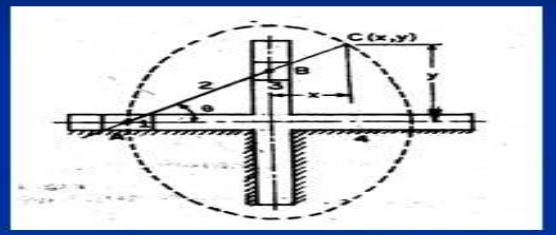
Link 2 Slider -I

Link 3 Coupler

Link 4 Slider - II

Inversion I – Frame Fixed
Double slider crank mechanism

Elliptical trammel
AC = p and BC = q, then,
x = q.cosθ and y = p.sinθ.
Rearranging,



$$\left(\frac{x}{q}\right)^2 + \left(\frac{y}{p}\right)^2 = \cos^2\theta + \sin^2\theta = 1$$

Summary

- Following points to be concluded from the topic of Linkage and Mechanisms;

➢ Different types of Links and mechanisms

➢ Degree of Freedom

➢ Inversion and its types

Topics to be Discussed in Next Lecture

- Fluid and its various types
- Properties of Fluids
- Pascal's Law
- Archimedes Principle
- Bernoulli's Equation
- Continuity Equation