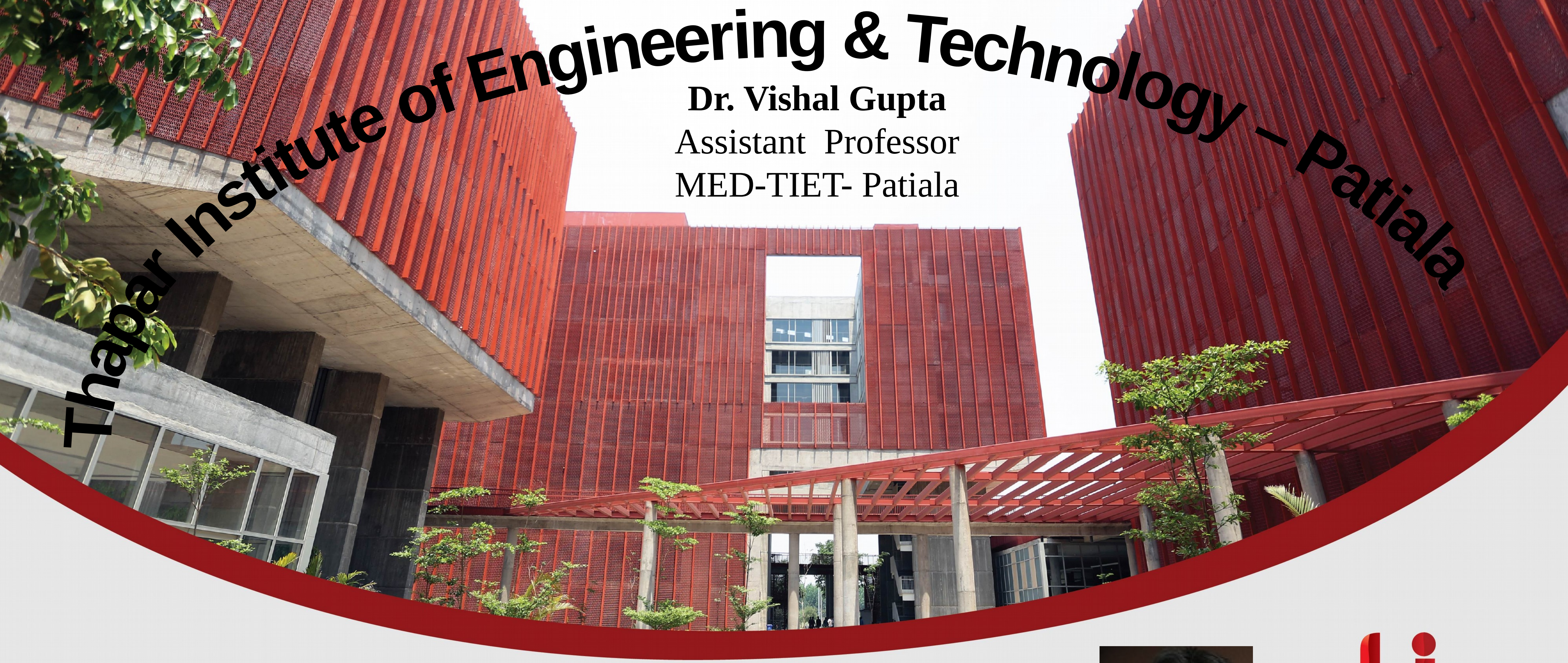

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Mechanics of Machines
UME 306

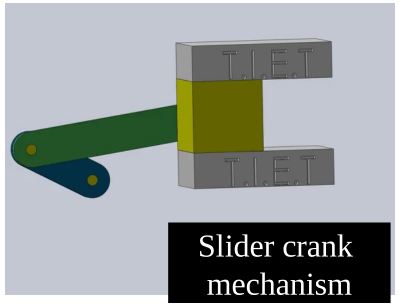
Module - 1
Lecture - 4

Instructional objective

- Kinematic fundamentals
- Types of joint in a chain
- Classification of kinematic pair
- Concept of mobility
- Criterion to plane mechanisms

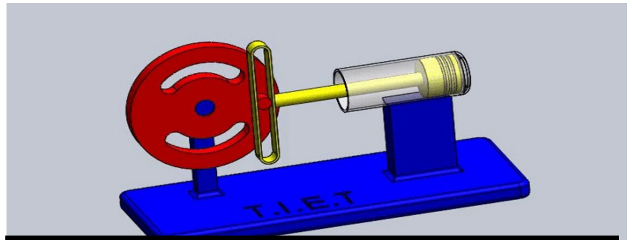
Kinematic Fundamentals

A Kinematic chain: An assemblage of links and joints, interconnected in a way to provide a controlled output motion in response to a supplied input motion.



Slider crank mechanism

Mechanism: When one of the links of a kinematic chain is fixed, the chain is known as mechanism.



Scotch yoke Mechanism

Simple Mechanism: A mechanism with four links.

Compound Mechanism: mechanism with more than four links.

Machine : A combination of resistant bodies arranged to compel the mechanical forces of nature to do work accompanied by determinate motion.

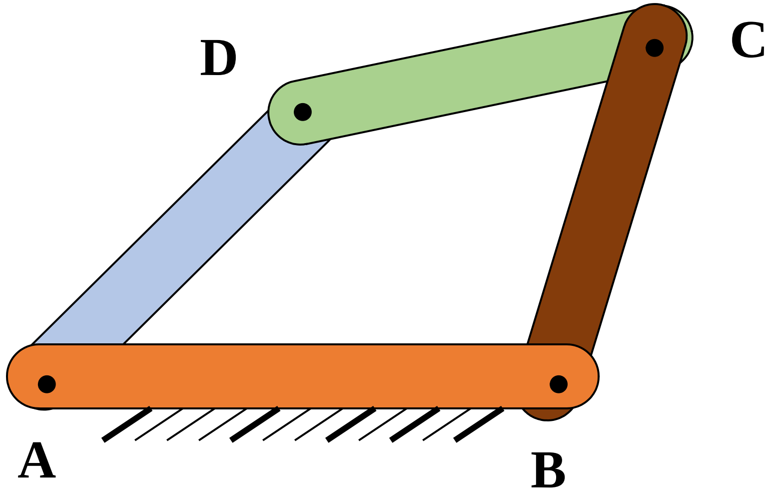
Types of joints in a chain

1. *Binary joint*.

$$j + 0.5h = 1 \cdot 5l - 2$$

Where:
j = Number of binary joints,
h = Number of higher pairs, and
l = Number of links

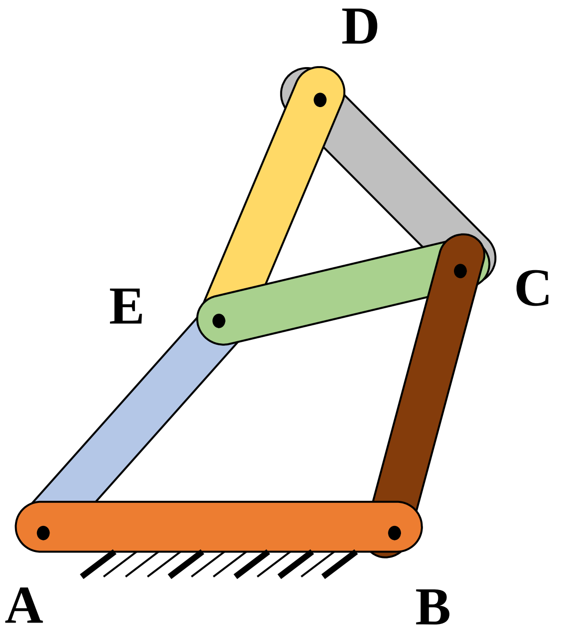
If there is no any higher pair, h = 0



$j = 4$
$h = 0$
$l = 4$

If LHS = RHS , Kinematic chain or constrained chain chain

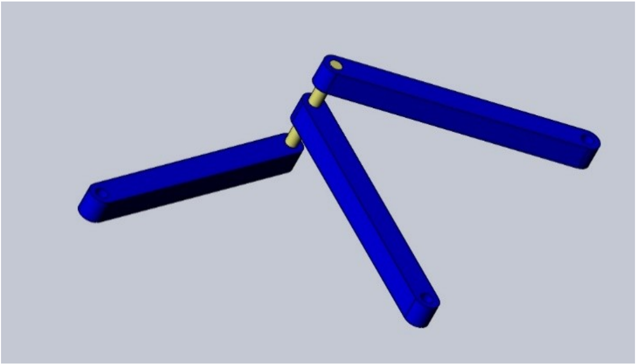
2. Ternary joint .



1T = 2B

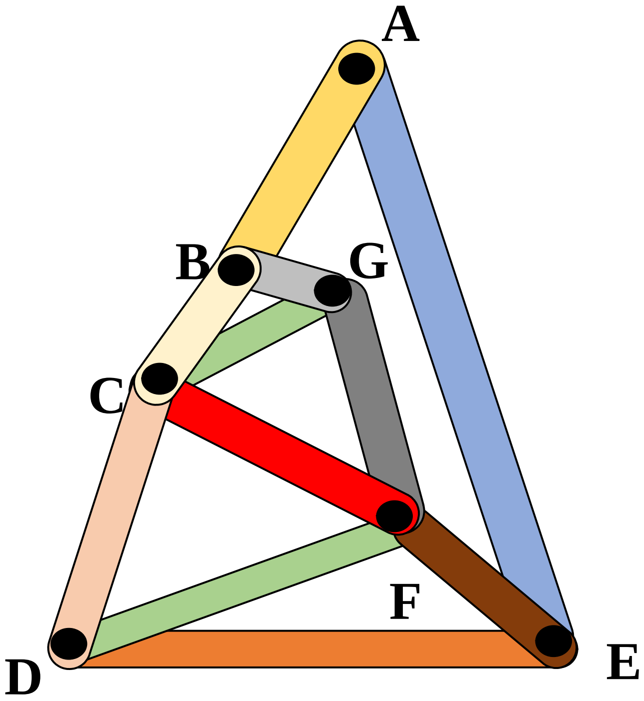
$J = 7$
$h = 0$
$L = 6$

LHS = RHS



$$J + 0.5h = 1 \cdot 5L - 2$$

3. Quaternary joint



1Q = 3B

$J = 15$
$h = 0$
$L = 11$

L.H.S. > R.H.S.

Note : In general, when l number of links are joined at the same connection, the joint is equivalent to (l – 1) binary joints.

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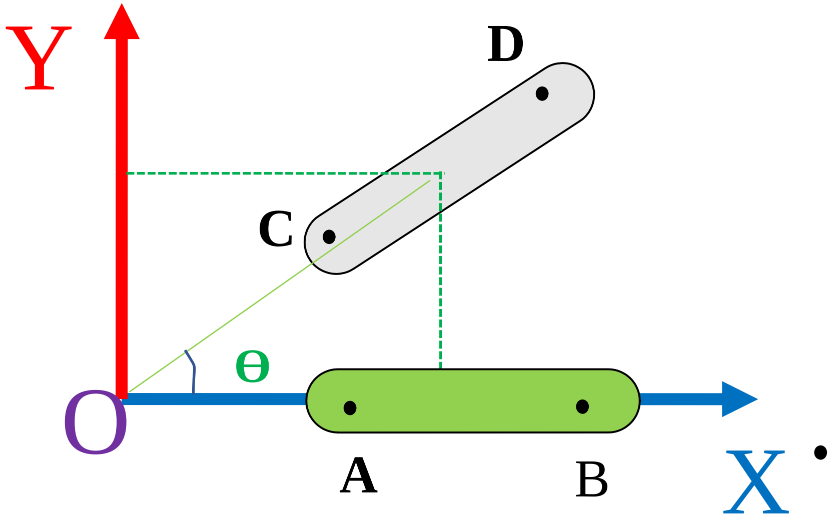
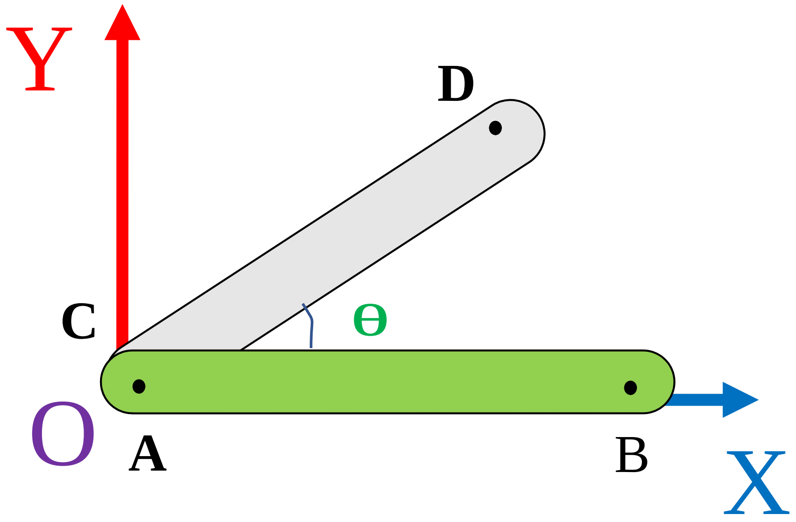
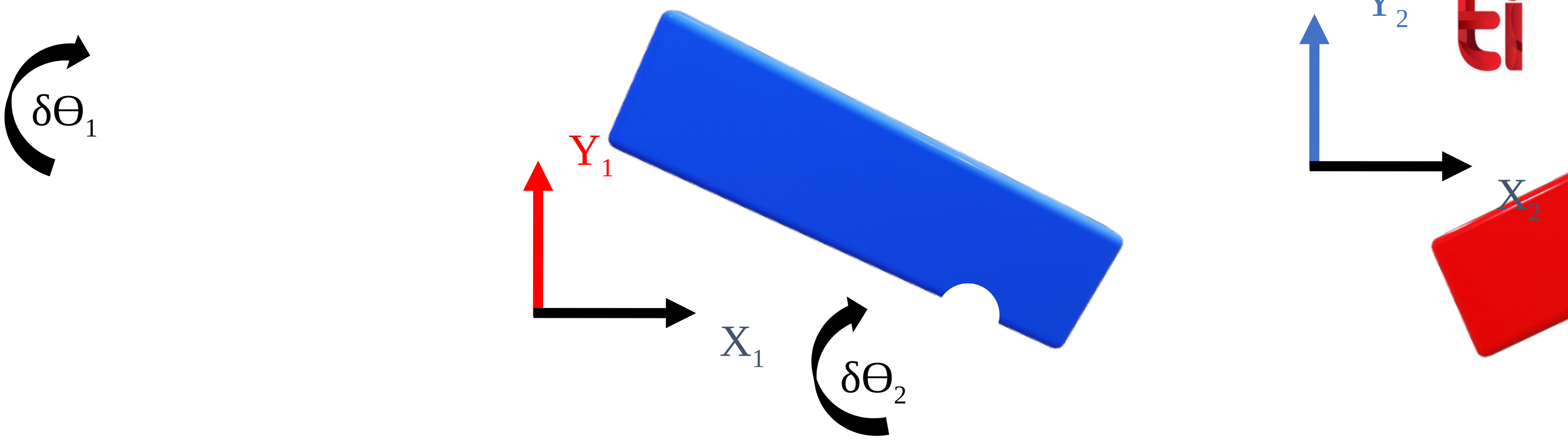
Number of Degrees of Freedom for Plane Mechanisms (Mobility)

Link CD, 3 DOF



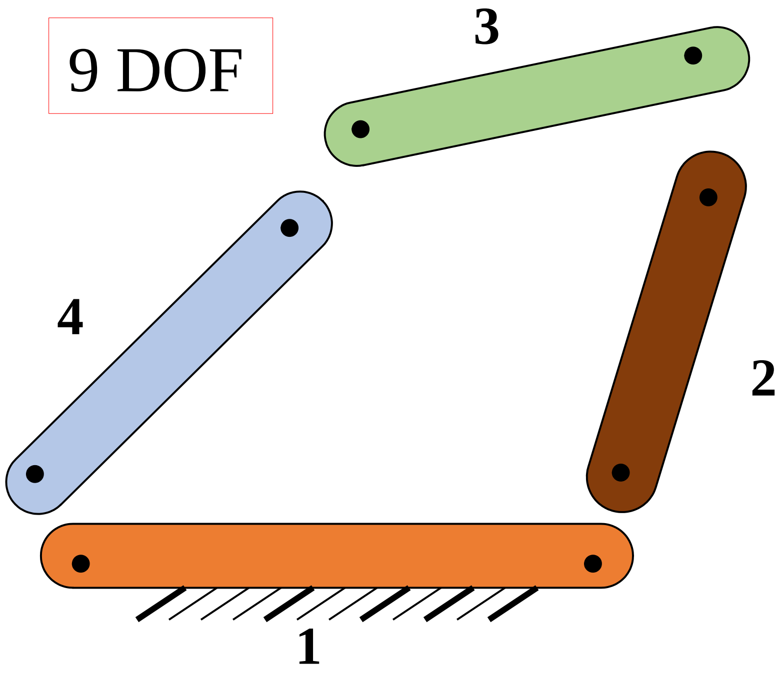


Restricted to 1 DOF



Two unconnected links:
6 DOF
(each link has 3 DOF)

9 DOF



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Criterion to plane mechanisms

Kutzbach Criterion to plane mechanisms:

$$M = 3\,(L - 1) - 2\,J - h$$

If there is no any higher pair, h = 0

M = degree of freedom or mobility
L = number of links / lower pair
J = number of full joints
h = number of higher pair

$$M = 3\,(L - 1) - 2\,J$$

Gruebler's Criterion to plane mechanisms:

- This criterion is used to find out whether an assembly of links with 1 d.o.f.
- Lower pairs is a constrained mechanism or not.

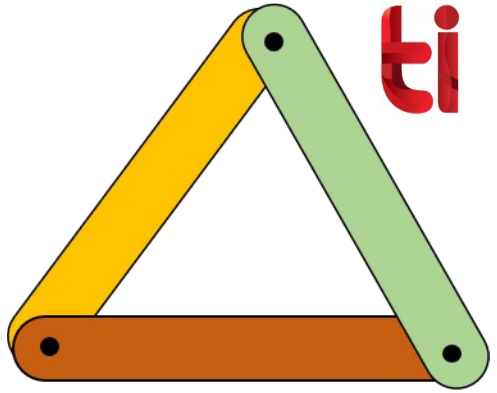
So here , M = 1

$$3L - 2\,J - 4 = 0$$

Special Note :

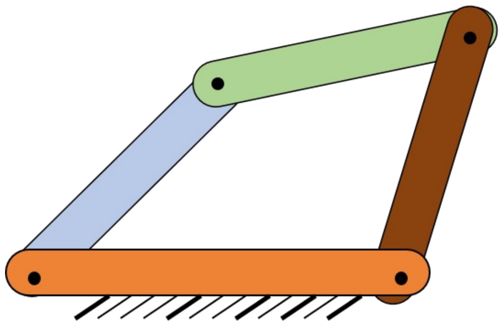
1. If DOF (M) = 0 :

- <u>*structure*</u>, no relative motion between the link is possible



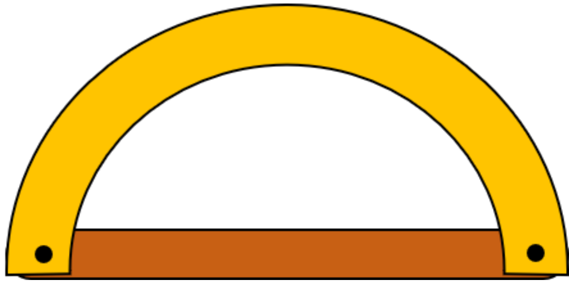
2. If DOF (M) = +ve

- DOF = 1 <u>*mechanism*</u>, then the mechanism can be driven by a single input motion
- DOF = 2 then two separate input motions are necessary to produce constrained motion for the mechanism.



3. If DOF (M) = -ve

- <u>*preloaded structure*</u>, there are redundant constraints in the chain and it forms a statically <u>*indeterminate structure*</u>.
- No motion is possible. *Or* <u>*superstructure*</u>



Reference Books

1. *Uicker, John Joseph, Gordon R. Pennock, and Joseph Edward Shigley. Theory of machines and mechanisms. Vol. 1. New York: Oxford University Press.*
2. *Norton, Robert L. Design of machinery: an introduction to the synthesis and analysis of mechanisms and machines. Boston: McGraw-Hill Higher Education.*
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Thanks for watching this video