Force Analysis

Static Force analysis in simple machine members

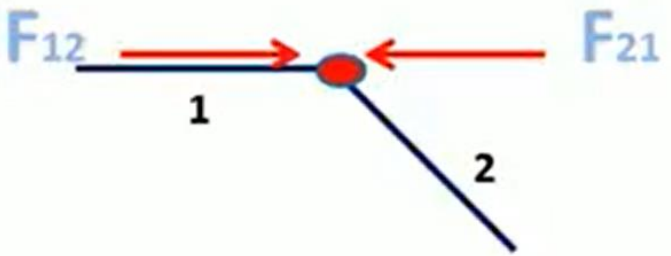
CONTENTS

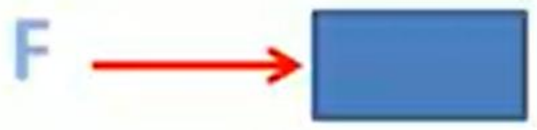
CONSTRAINT AND APPLIED FORCES

A pair of action and reaction forces which constrain two connected bodies to behave in a particular manner depending upon the nature of connection are known as constraint forces whereas forces acting from outside on a system of bodies are called applied forces.

Constraint forces- As the constraint forces at a mechanical contact occur in pairs, they have no net force effect on the system of bodies. However, for an individual body isolated from the system, only one of each pair of constraint forces has to be considered.

- When two or more bodies are connected together to form a group or system, the pair of action and reaction forces between any two of the connecting bodies is called constrained forces.
- These forces constrain the connected bodies to behave in a specific manner defined by the nature of the connection.





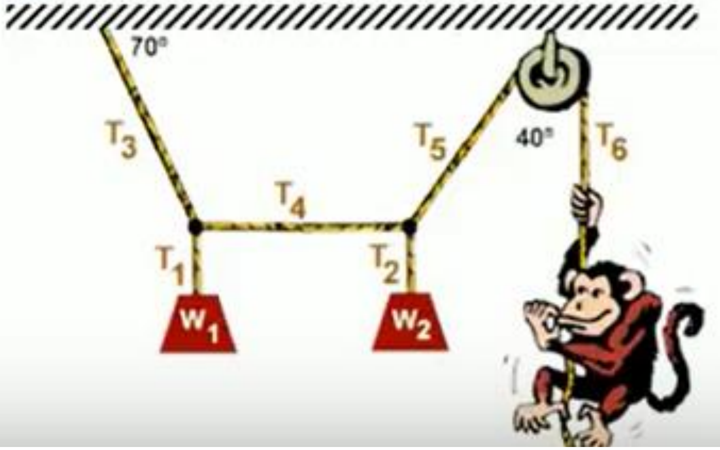
Applied forces- Forces acting on the system of bodies from outside the system are called applied forces. These forces are applied through direct physical or mechanical contact. However forces like electric, magnetic and gravitational are applied without actual physical contact.

STATIC EQUILIBRIUM

Any body is said to be in static equilibrium, if it posses a state of rest or motion until and unless some external effect acts on it.

i.e.

If a body is at rest it tends to remain at rest and if a body is in motion it tends to remain in the state of motion until and unless an external force is applied on it.



CONDITIONS REQUIRED FOR A BODY TO BE IN STATIC EQUILIBRIUM

The vector sum of all the forces acting on a body is zero, and
The vector sum of all moments about any arbitrary point is zero.
Mathematically,

$$\sum F = 0$$

$$\sum T = 0$$

In a planer system, forces can be described by two dimensional vectors and, therefore,

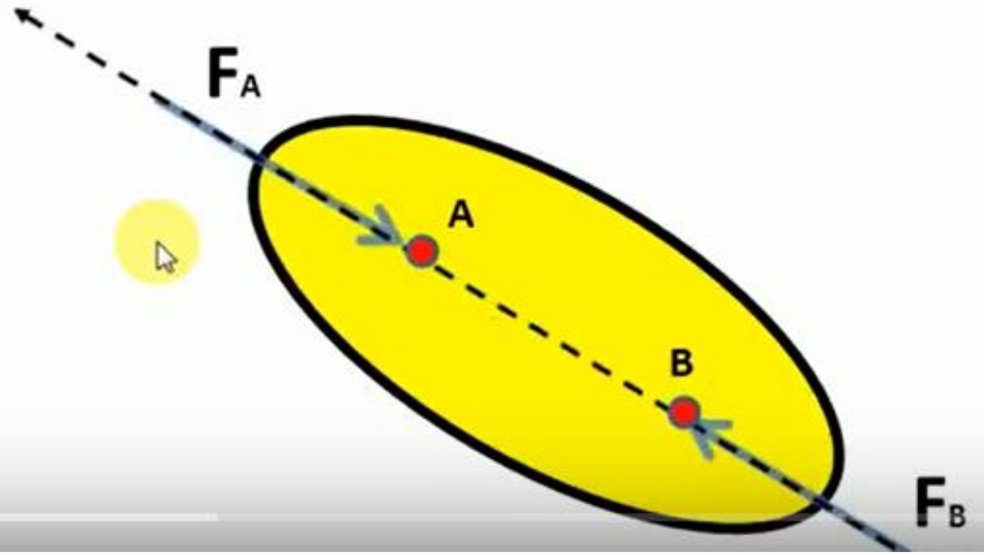
$$\sum Fx = 0$$

$$\sum Fy = 0$$

$$\sum Tz = 0$$

CONDITION OF EQUILIBRIUM OF TWO FORCE MEMBER

- $|F_A| = |F_B|$ (Same Magnitude)
- $F_A = -F_B$ (Opposite in Direction)
- And, lies on same line of Action



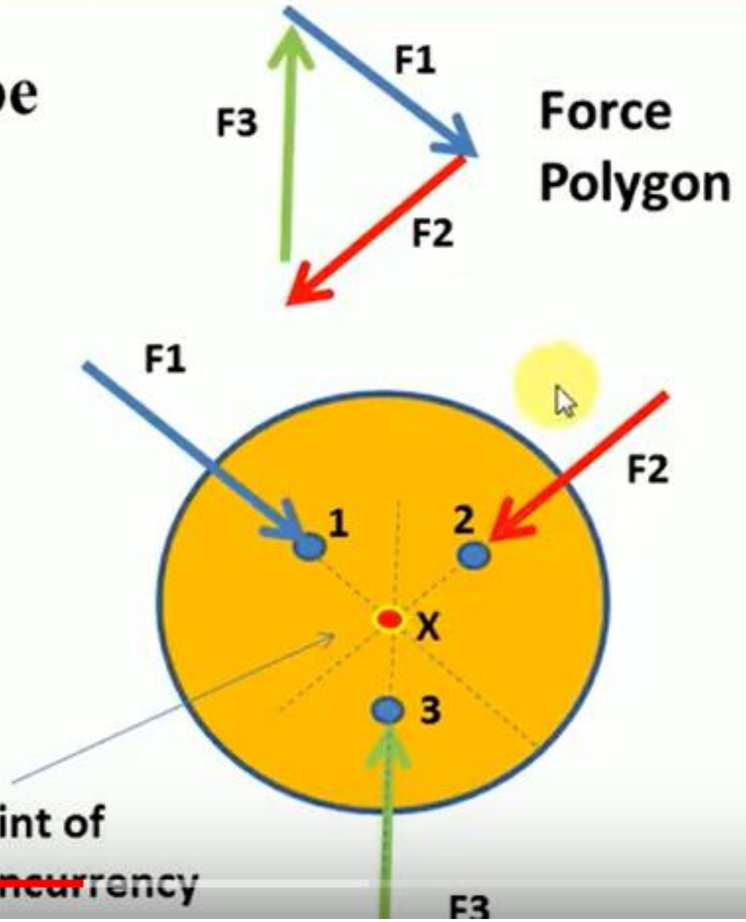
CONDITION OF EQUILIBRIUM OF THREE FORCE MEMBER

The body with 3 forces will be in static equilibrium when:-

$\sum F = 0 = F1 + F2 + F3 = 0$

I.e. Vector sum of all the 3 forces = 0

Line of action of all the three forces meet at a point, known as POINT OF CONCURRENCY (SAY X, As shown in figure)



CONDITION OF EQUILIBRIUM OF MEMBER WITH TWO FORCES AND A TORQUE

A body with two forces and a torque will be in static Equilibrium when:-

|F1| = |F2| (Forces have same magnitude)

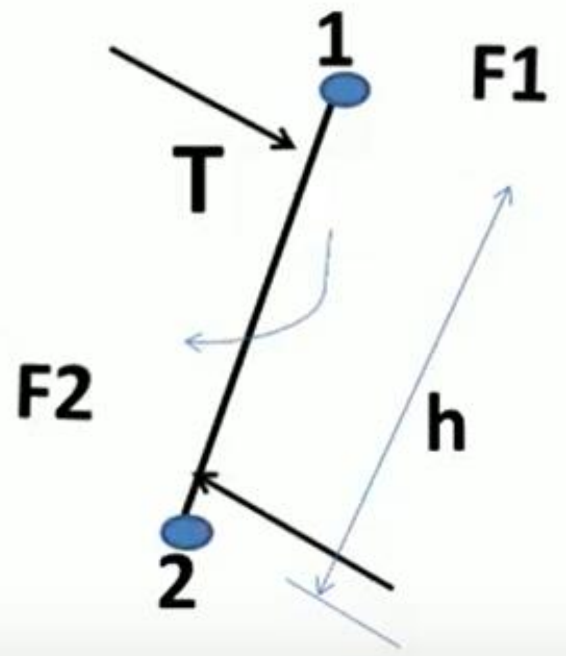
F1 = -F2 (Opposite in directions)

F1 || F2 (Parallel in senses)

And

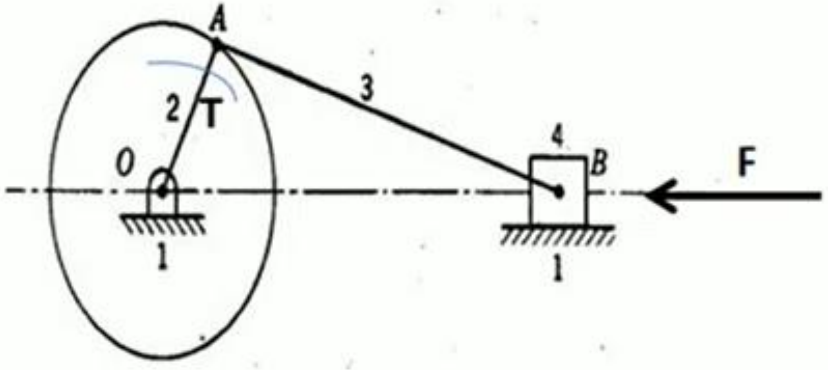
The combination of forces forms a couple, which is equal and opposite to applied torque.

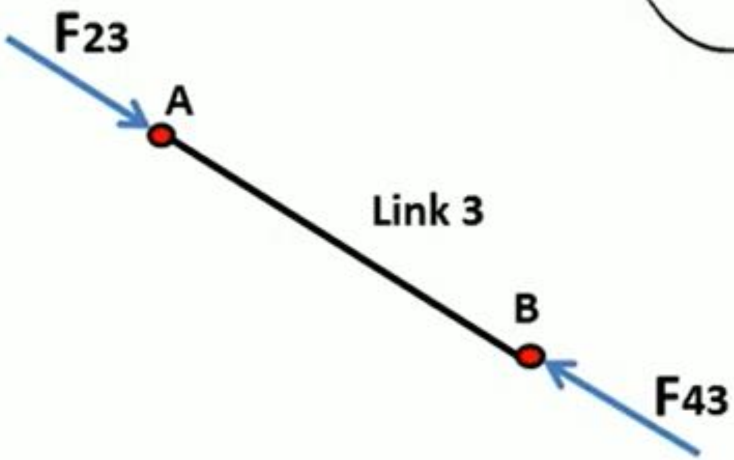
T = F1 x h = F2 x h

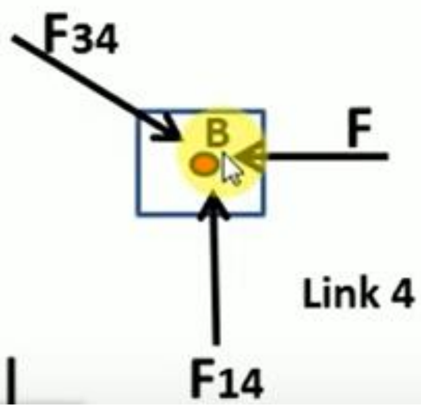


FREE BODY DIAGRAM- SLIDER CRANK MECHANISM

Consider a slider crank mechanism with,
AB as connecting rod (3), OA as crank (2), B as slider (4) and OB as l.o.a of slider.
Let F = External force on slider along l.o.a.

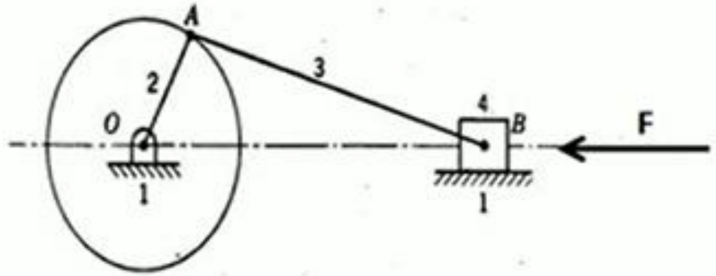


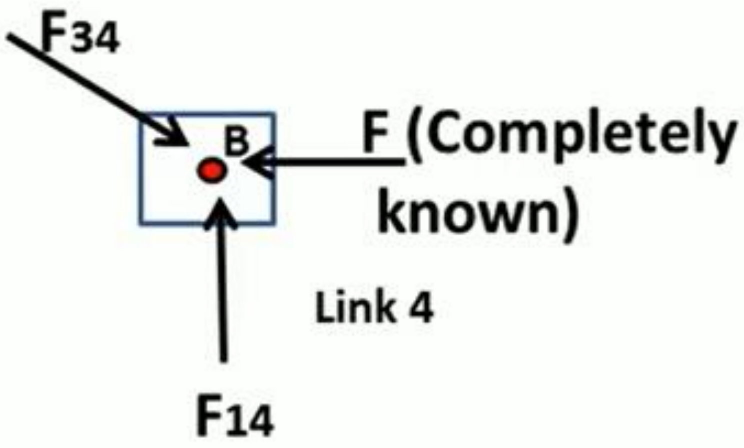


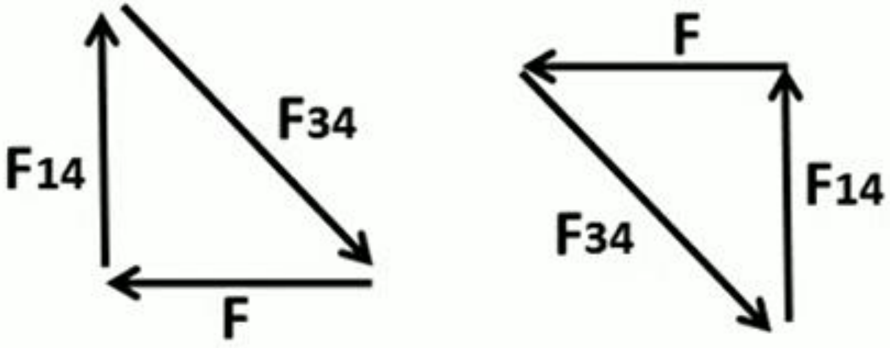


$$| F_{43} | = | F_{23} | = | F_{32} |$$

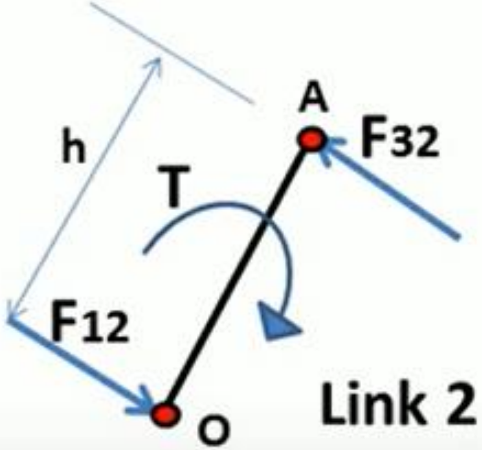
Solving the problem...







Force Polygon



Link 2

$|F_{32}| = |F_{12}|$

$F_{32} \parallel F_{12}$

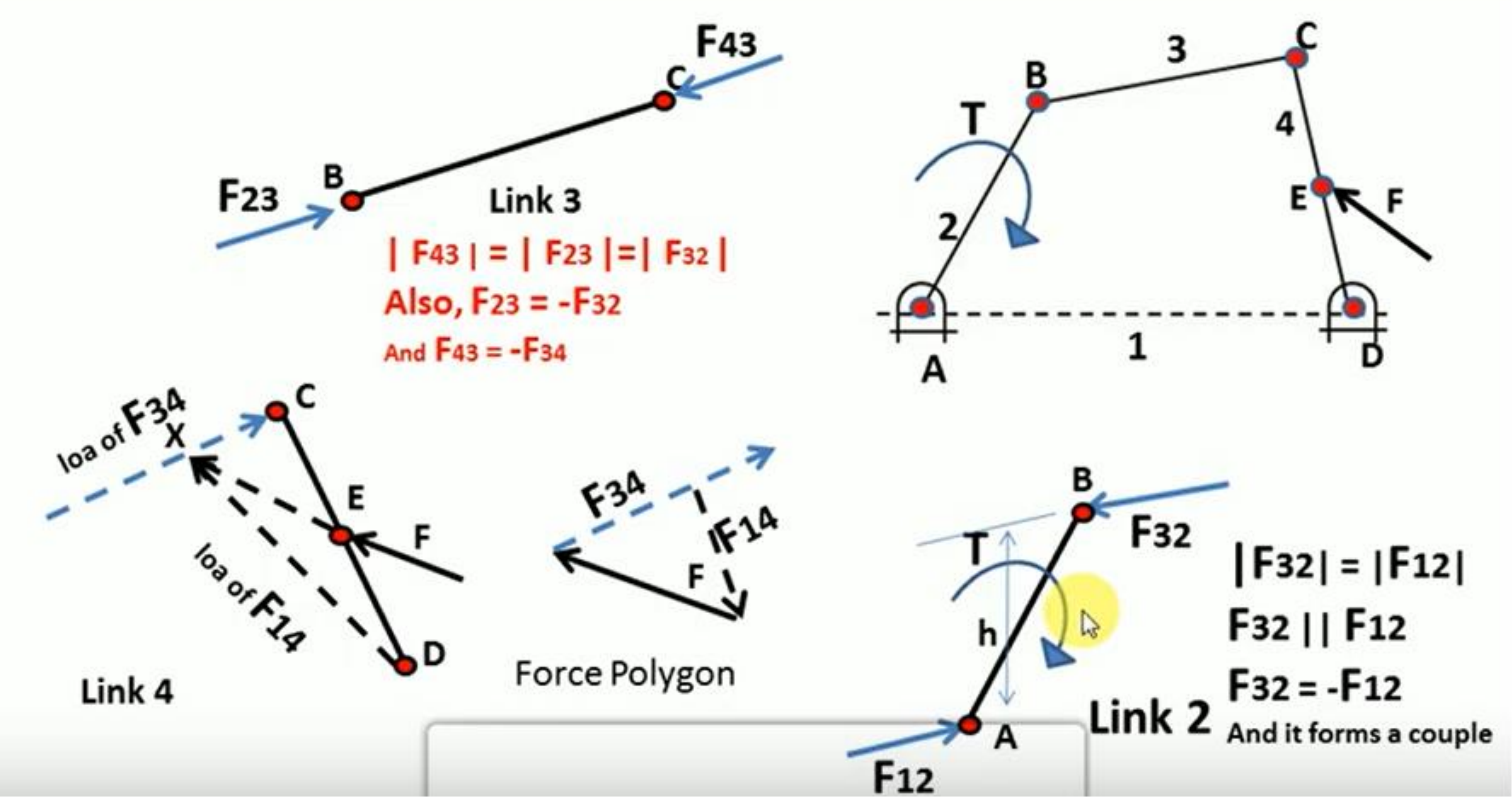
$F_{32} = -F_{12}$

And it forms a couple

$|F_{43}| = |F_{23}| = |F_{32}| = |F_{34}|$

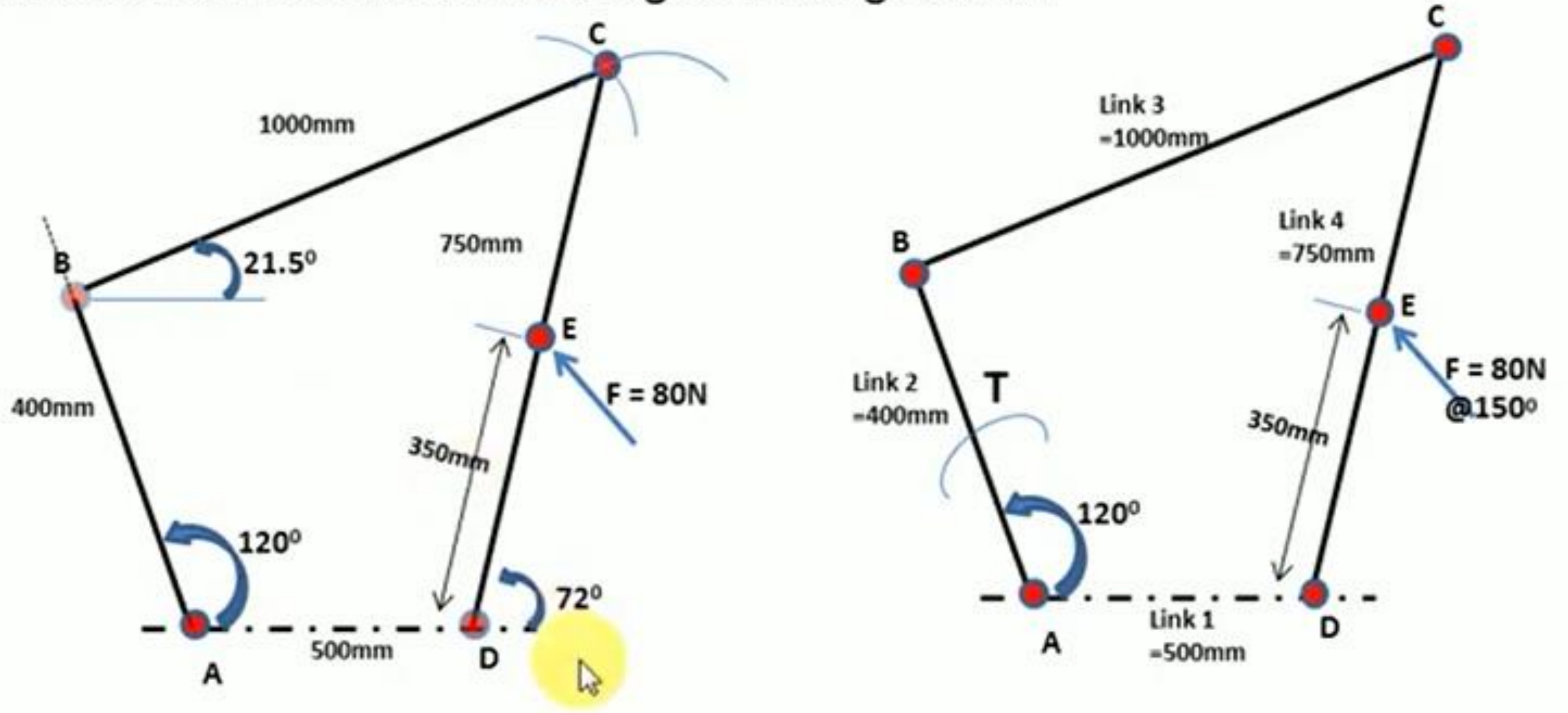
Also, $F_{23} = -F_{32}$

FREE BODY DIAGRAM- FOUR BAR MECHANISM



PROBLEM :01

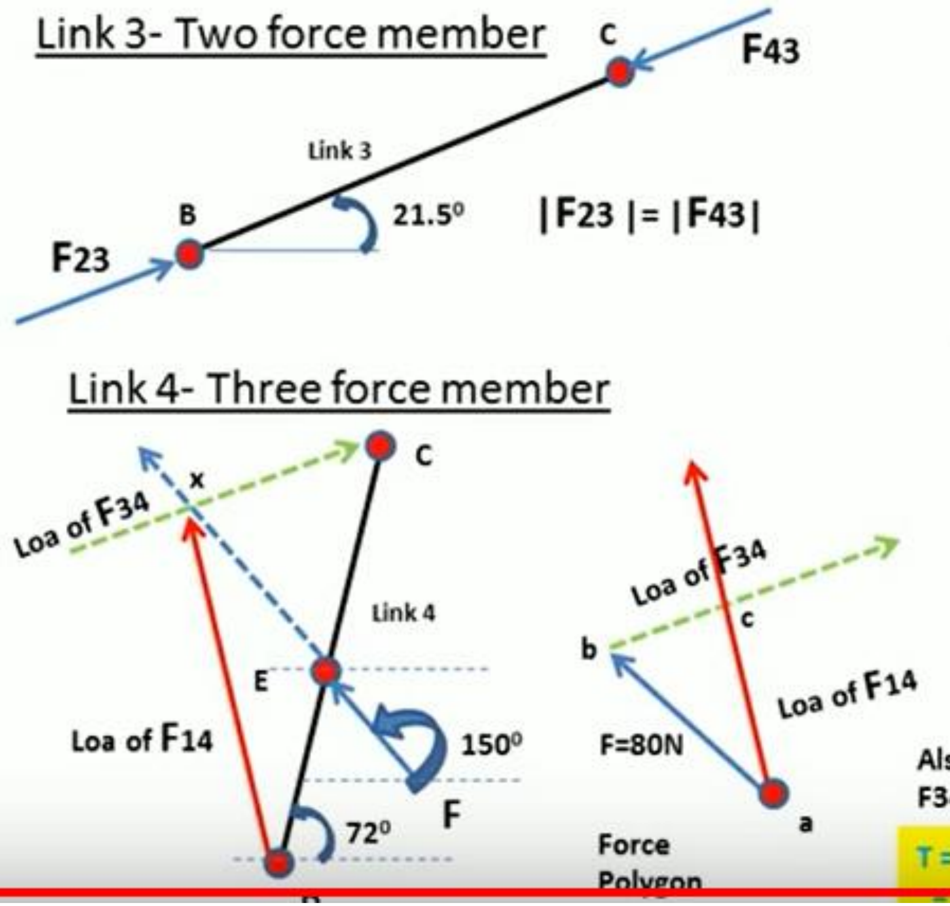
-Consider the figure shown, and determine the input torque T on link AB for the Static Equilibrium of the mechanism for the given configuration.

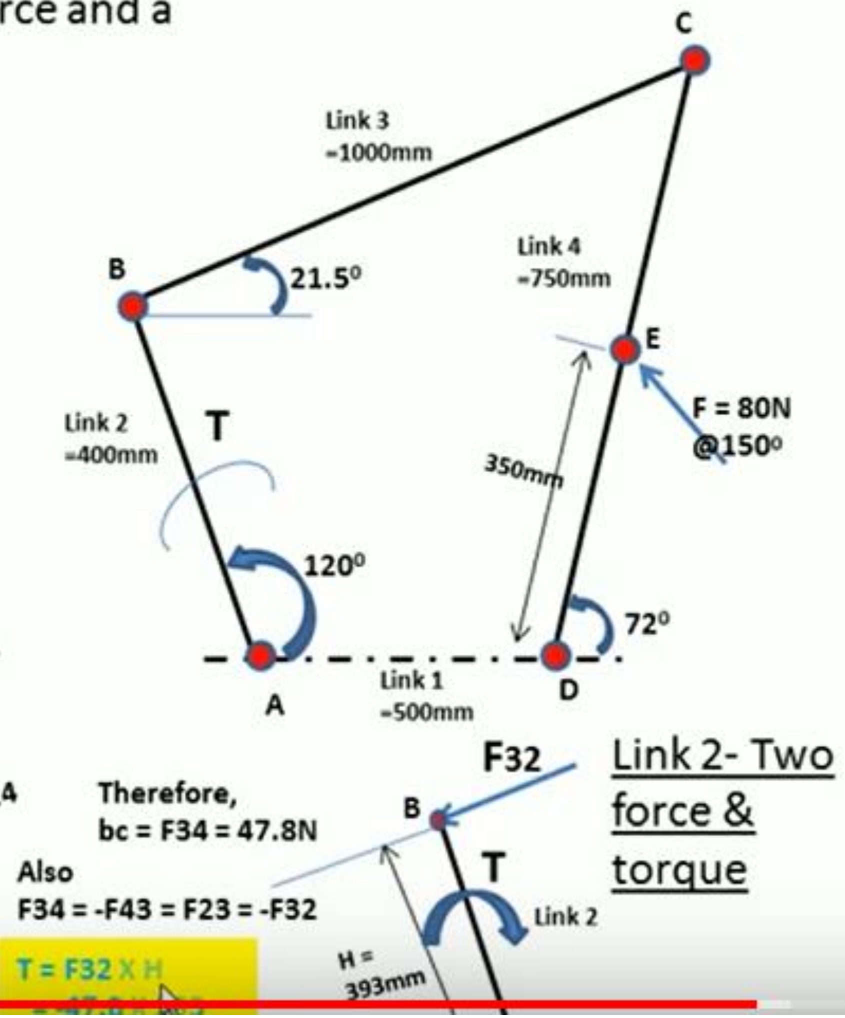


Solution: As per the figure shown, lets 1st draw schematic diagram.

Solution:

Now for FBD, First Identify member with 2 force member, than 3 force member and than member with 2 force and a torque



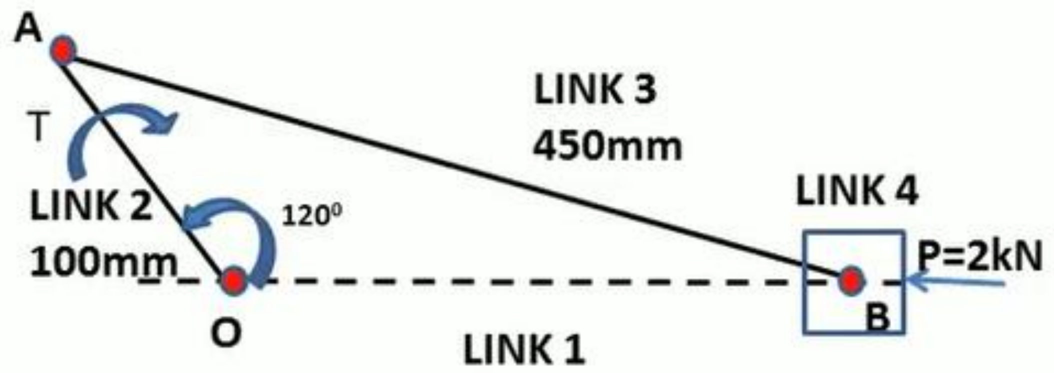


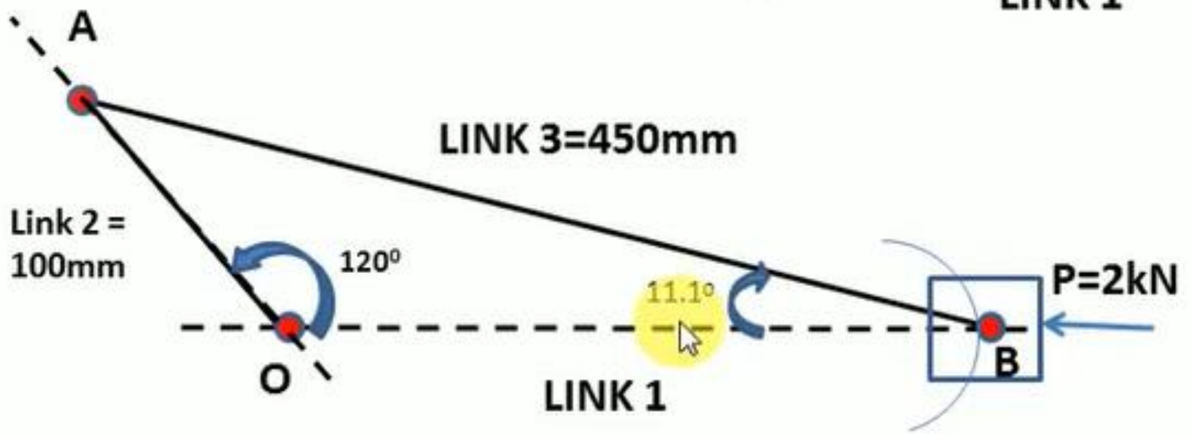
PROBLEM :02

In the following configuration, determine torque T on link 2 for static equilibrium of the mechanism

Solution : Given external force P = 2kN, on l.o.a of slider B.

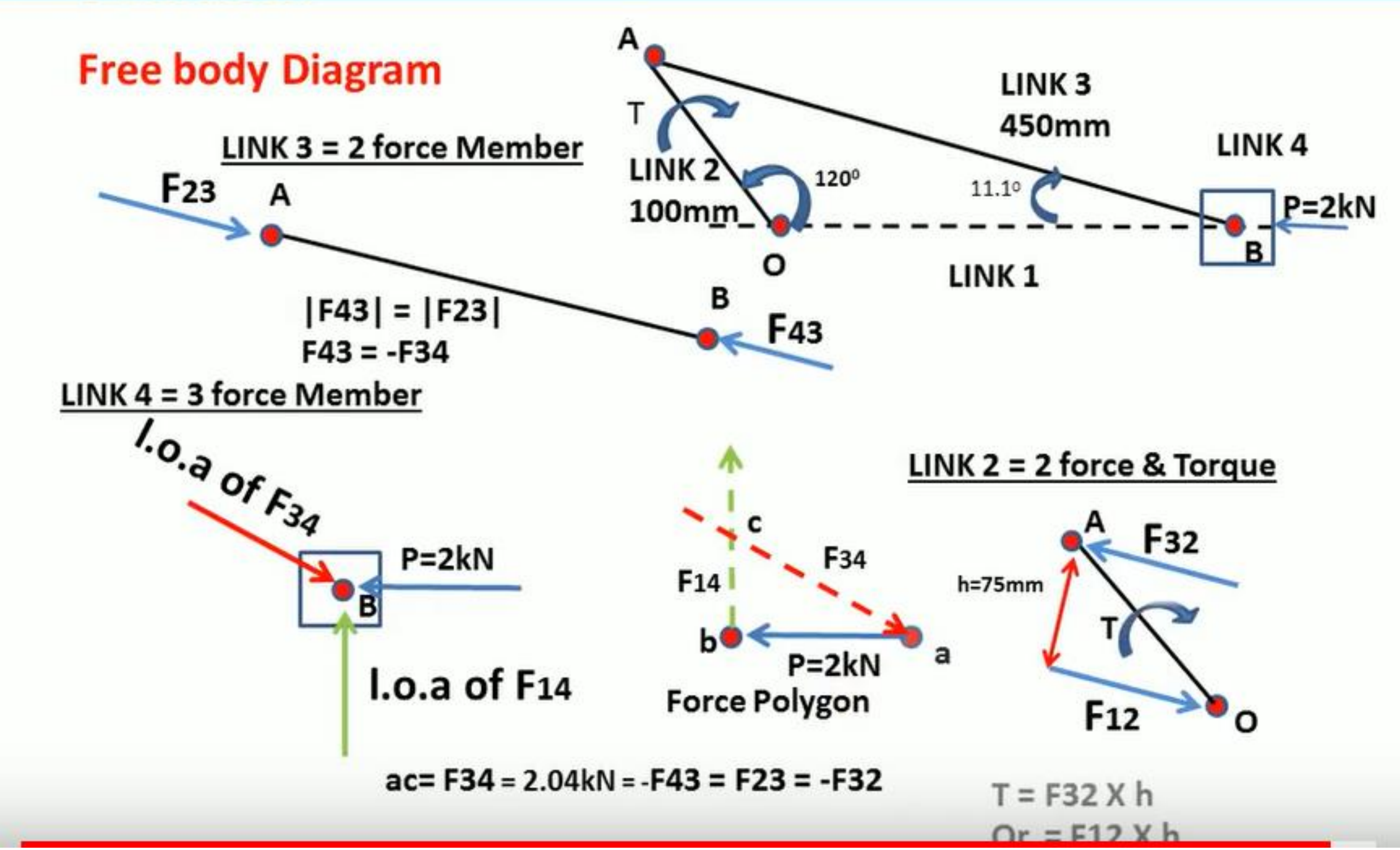
Draw Schematic Diagram





Schematic Diagram

Solution:


Free body Diagram
A
LINK 3
450mm
T
LINK 4
LINK 3 = 2 force Member
LINK 2
100mm
120⁰
11.1⁰
P=2kN
F23
A
B
O
LINK 1
B
|F43| = |F23|
F43 = -F34
F43
LINK 4 = 3 force Member
l.o.a of F34
LINK 2 = 2 force & Torque
c
A
F32
P=2kN
F34
F14
h=75mm
B
T
b
a
P=2kN
l.o.a of F14
Force Polygon
F12
O
ac= F34 = 2.04kN = -F43 = F23 = -F32
T = F32 X h
Or = F12 X h