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:-

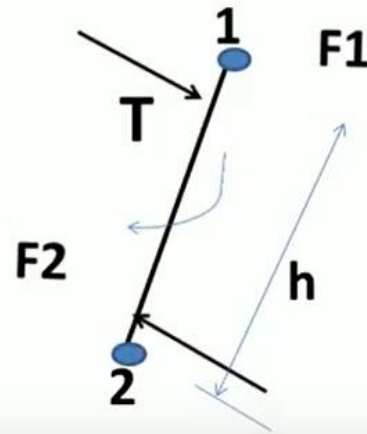$|F1| = |F2|$ (Forces have same magnitude)

$F1 = -F2$ (Opposite in directions)

$F1 || F2$ (Parallel in senses)

And

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

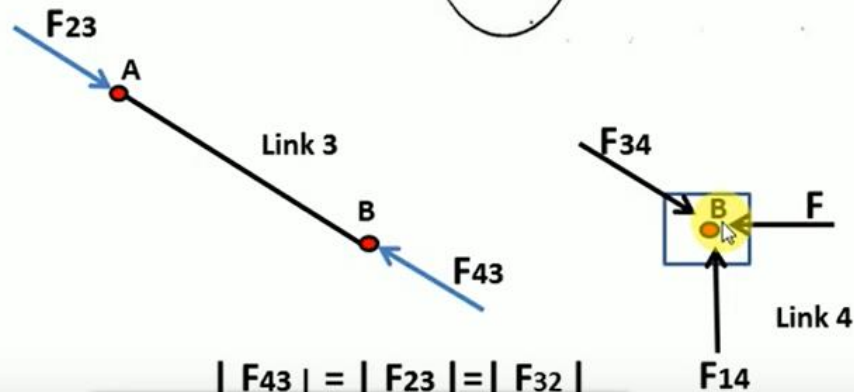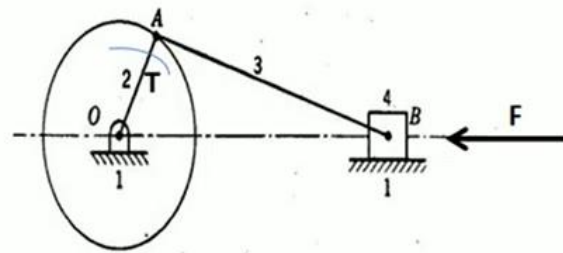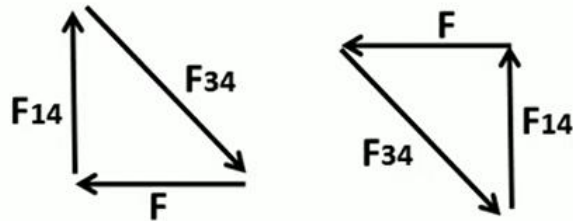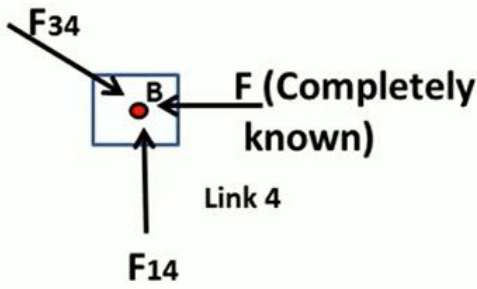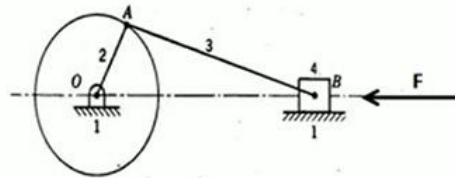$T = F1 \times h = F2 \times h$

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.
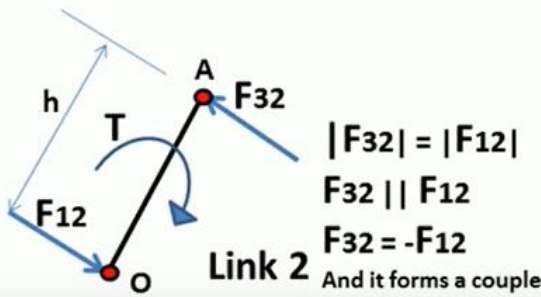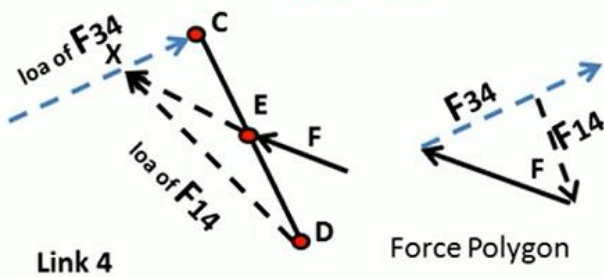
Let F = External force on slider along l.o.a.

F_{23}

A

Link 3

B

F_{43}

F_{34}

B

F

Link 4

F_{14}

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

Solving the problem...

F34

B

F (Completely known)

Link 4

F14

$|F32| = |F12|$

F32 || F12

F32 = -F12

And it forms a couple

Link 2

F32

T

h

A

F12

O

F14

F34

F

F

F34

F14

Force Polygon

$| F43 | = | F23 |=| F32 |= | F34 |$

Also, $F23 = -F32$

FREE BODY DIAGRAM- FOUR BAR MECHANISM

F43

C

F23

B

Link 3

$| F43 | = | F23 |=| F32 |$

Also, $F23 = -F32$

And $F43 = -F34$

loa of F34

X

C

E

F

loa of F14

D

Link 4

F34

F14

F

Force Polygon

B

3

C

T

4

2

E

F

A

1

D

B

F32

T

h

A

F12

$|F32| = |F12|$

F32 || F12

F32 = -F12

And it forms a couple

Link 2
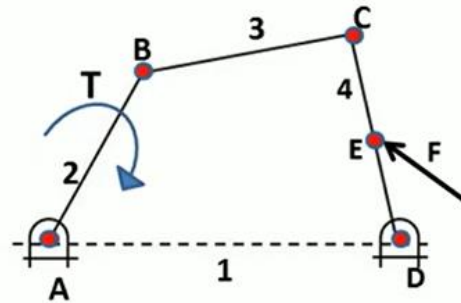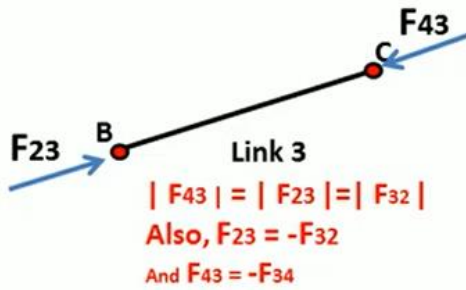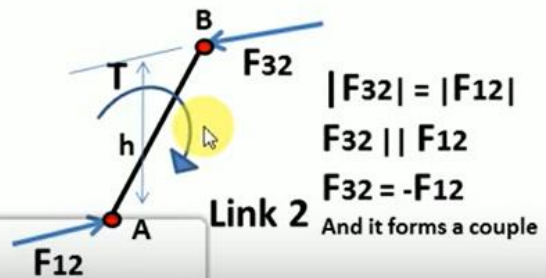
-Consider the figure shown, and determine the input torque T on link AB for the Static Equilibrium of the mechanism for the given configuration.

C

1000mm

B 21.5°

750mm

E

400mm F = 80N

350mm

120°

72°

500mm D

A

Link 3
=1000mm

C

Link 4
=750mm

B

21.5°

E

Link 2
=400mm T F = 80N
@150°

350mm

120°

Link 1
=500mm

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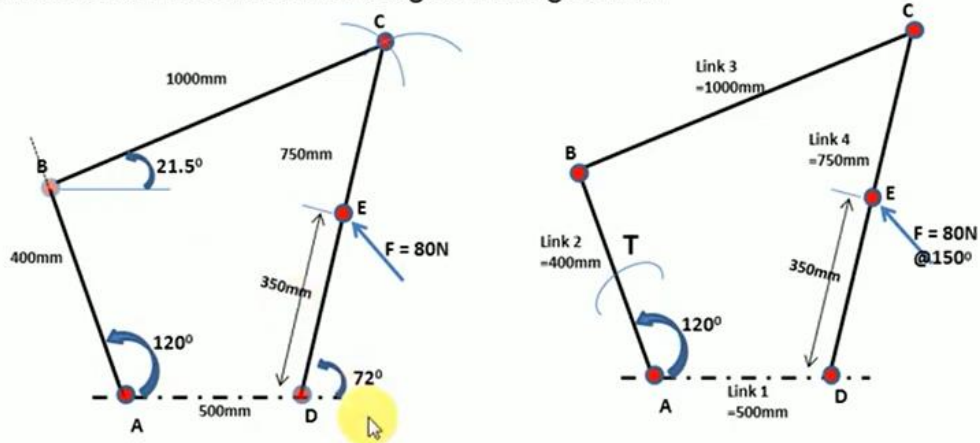
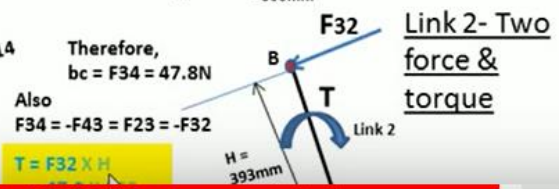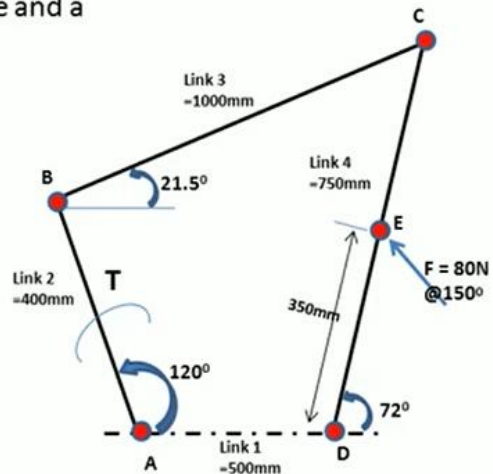Solution: As per the figure shown, lets 1st draw schematic diagram.

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

Link 3- Two force member

C

F43

Link 3

B 21.5° |F23 |= |F43|

F23

Link 4- Three force member

Loa of F34 x

C

Link 4

E

Loa of F14 150°

72° F

b

Loa of F34 c

Loa of F14

F=80N

a

Force Polygon

Therefore,
bc = F34 = 47.8N

Also
F34 = -F43 = F23 = -F32

T = F32 X H

Link 3
=1000mm

C

Link 4
=750mm

B 21.5°

E

Link 2
=400mm T F = 80N
@150°

350mm

120° 72°

Link 1
=500mm

A D

F32 ### Link 2- Two force & torque

B

T Link 2

H =
393mm
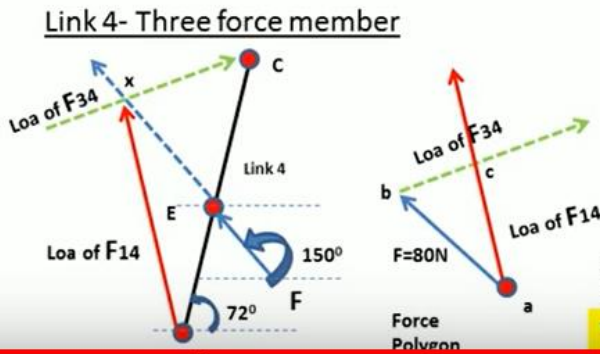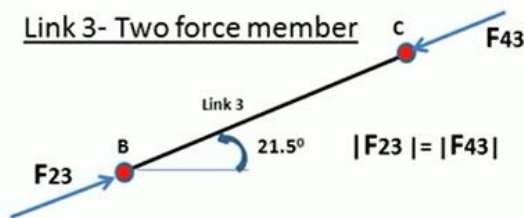
PROBLEM :02

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

A

LINK 3
450mm

T

LINK 4

LINK 2
100mm

120°

P=2kN

O

B

LINK 1

A

LINK 3=450mm

Link 2 =
100mm

120°

11.1°

P=2kN

O

B

LINK 1

Schematic Diagram
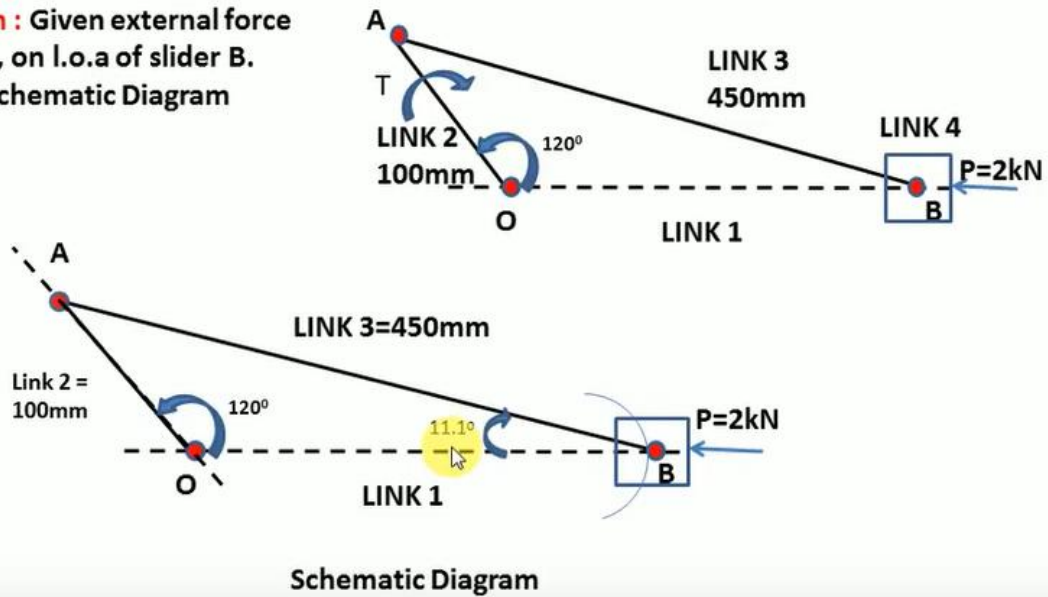
Solution:

Free body Diagram

A

LINK 3
450mm

T

LINK 4

LINK 3 = 2 force Member

LINK 2
100mm

120°

11.1°

P=2kN

F23   A

B

O

LINK 1

|F43| = |F23|

B

F43

F43 = -F34

LINK 4 = 3 force Member

l.o.a of F34

LINK 2 = 2 force & Torque

c

A   F32

P=2kN

F34

h=75mm

F14

B

T

l.o.a of F14

b

P=2kN

a

F12   O

Force Polygon

ac= F34 = 2.04kN = -F43 = F23 = -F32

T = F32 X h
Or = F12 X h