SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF AGRICULTURE ENGINEERING

R2019-MACHINE DESIGN

II YEAR IV SEM

UNIT 2 –Fundamentals of Theory of Machines

TOPIC –Linkages & Mechanisms

MECHANICS

Science dealing with motion

DIVISIONS OF MECHANICS

Statics – Deals with systems which are not changing with time.

Dynamics – Deals with systems which are changing with time.

DIVISIONS OF DYNAMICS

KINEMATICS – Deals with Motion and Time

(Kinema – Greek Word – Motion)

KINETICS – Deals with Motion, Time and Forces.

Statics	Kinematics	Kinetics
STRUCTURE	MECHANISM	MACHINE

Some Definitions

- Machine – device to transfer or transform energy to do useful work.
- Mechanism – device to transfer or transform given input motion to specified output motion
- Structure – a single body with no motion / combination of bodies with no relative motion

Classification of Mechanisms

Based on the nature of output speed

Uniform motion mechanism

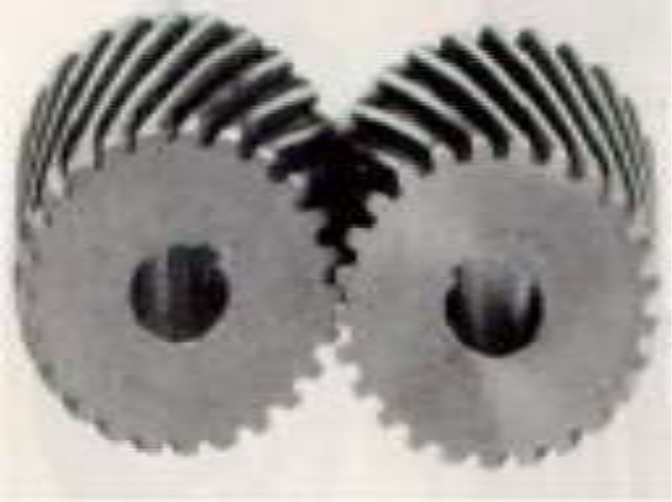
Non-uniform motion mechanism

Uniform Motion Mechanisms

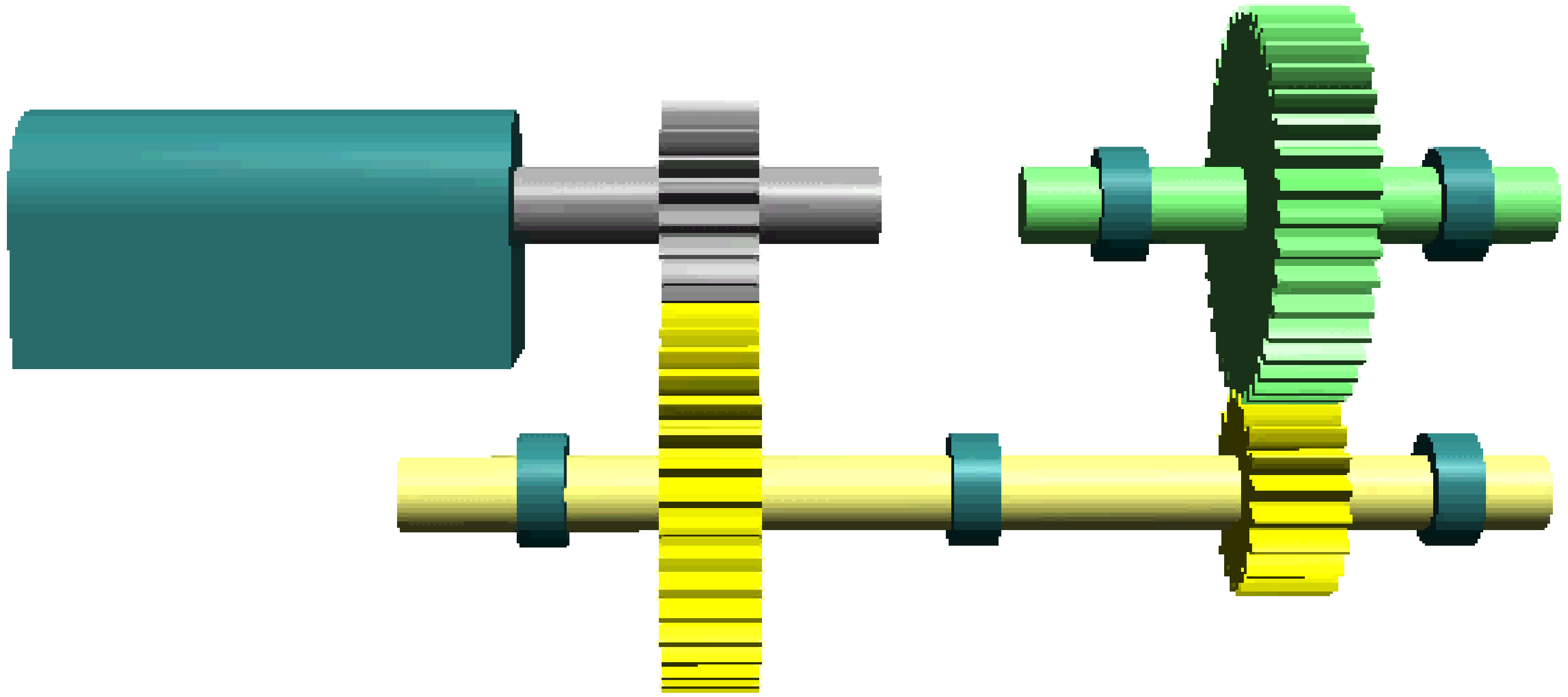
Uniform Motion – Equal Displacement For
Equal Time Interval

Examples : All Gear Drives
All Chain Drives
Belt Drives without slip


C7




C9



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gear_train

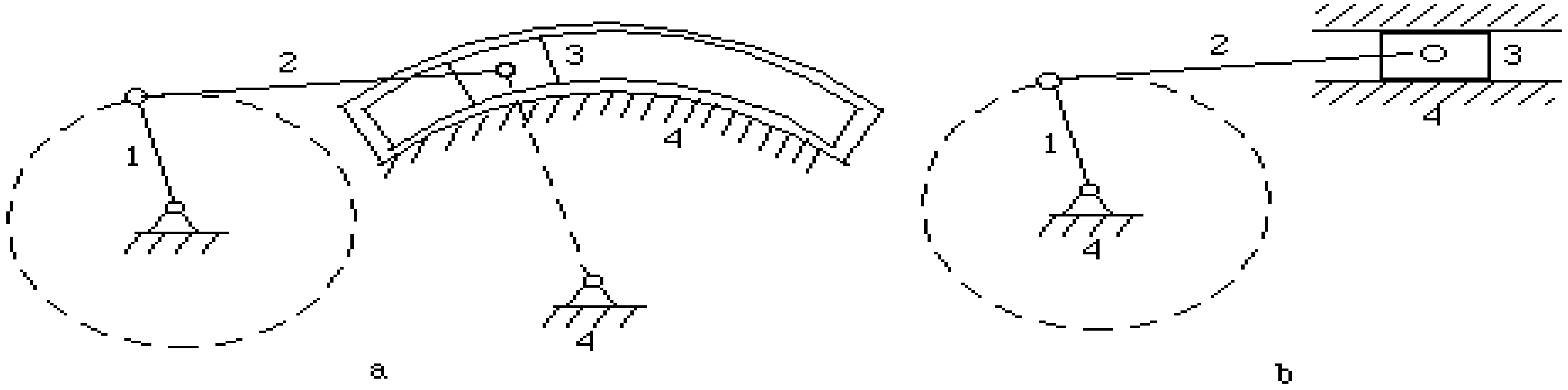
Non-Uniform Motion Mechanisms

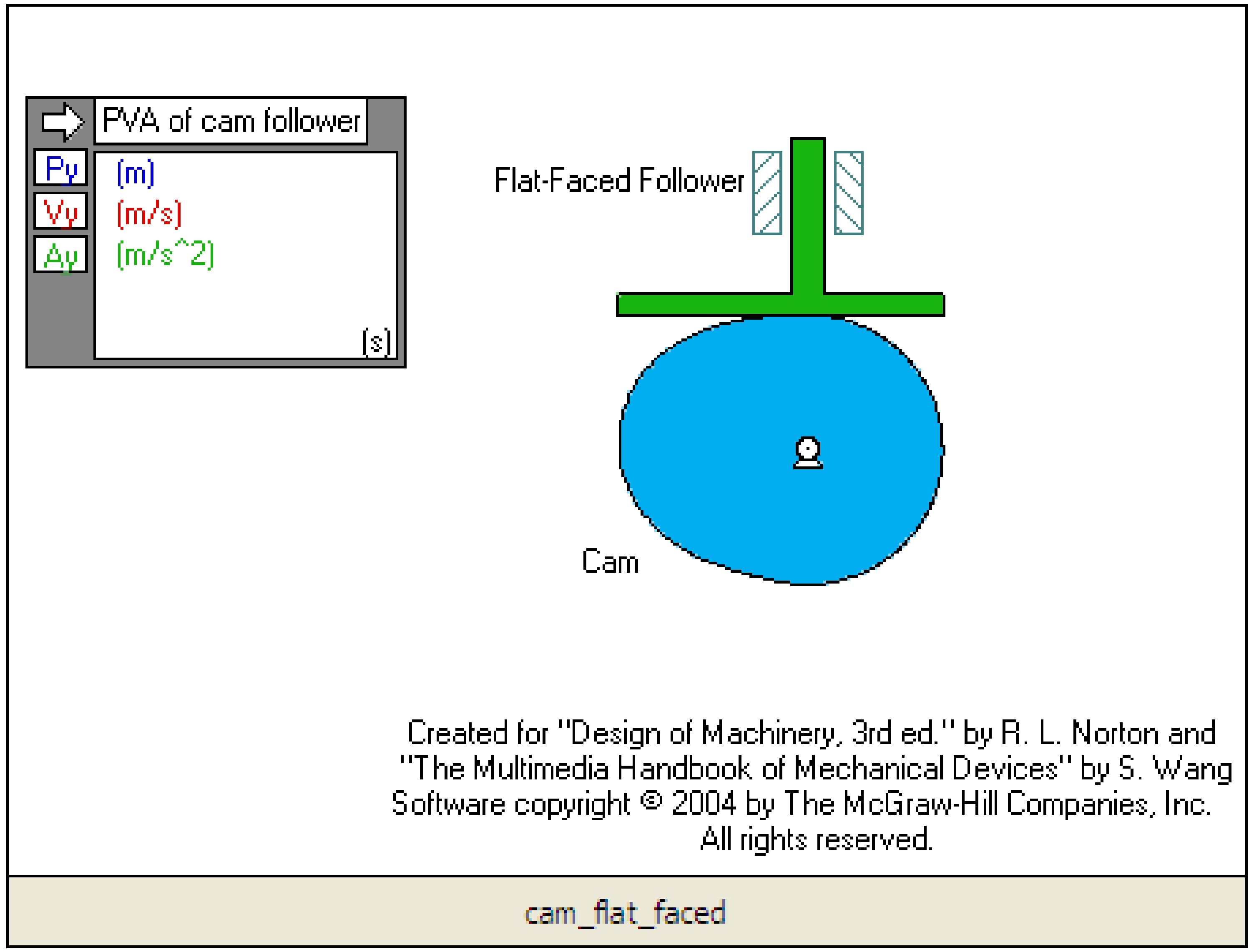
Non-Uniform Motion – Unequal Displacement For Equal Time Interval

Examples : Linkage Mechanisms
Cam Mechanisms
Geneva Wheel


C1


C3


1
2
3
4
4
a
1
2
3
4
4
b


PVA of cam follower
Py
Vy
Ay
(m)
(m/s)
(m/s^2)
(s)
Flat-Faced Follower
Cam
Created for "Design of Machinery, 3rd ed." by R. L. Norton and
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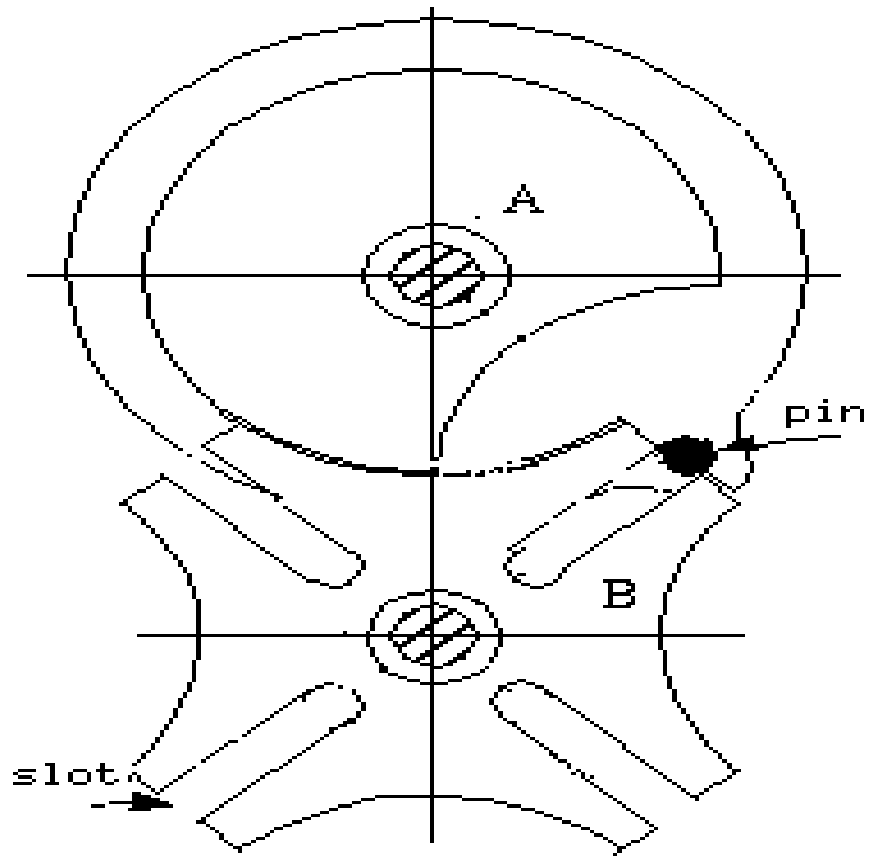
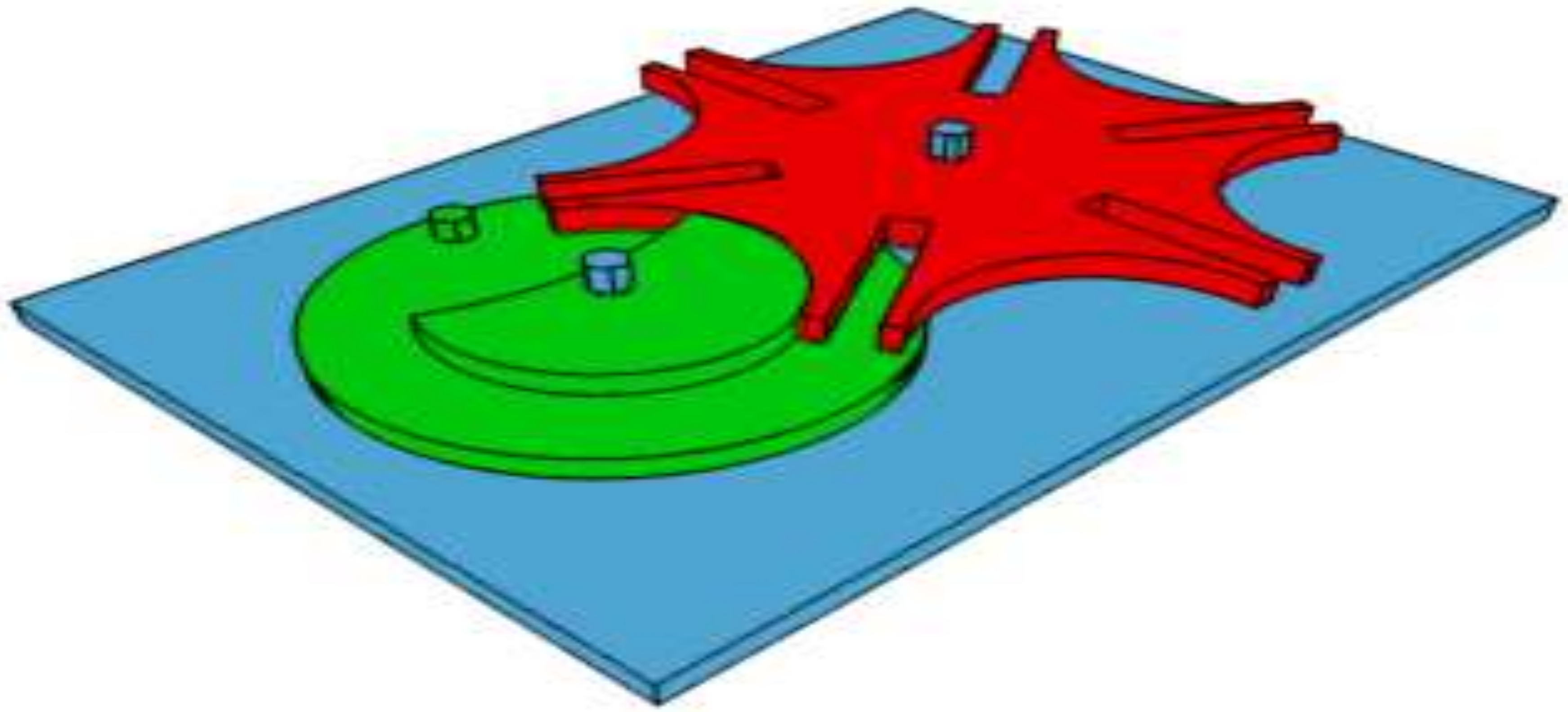
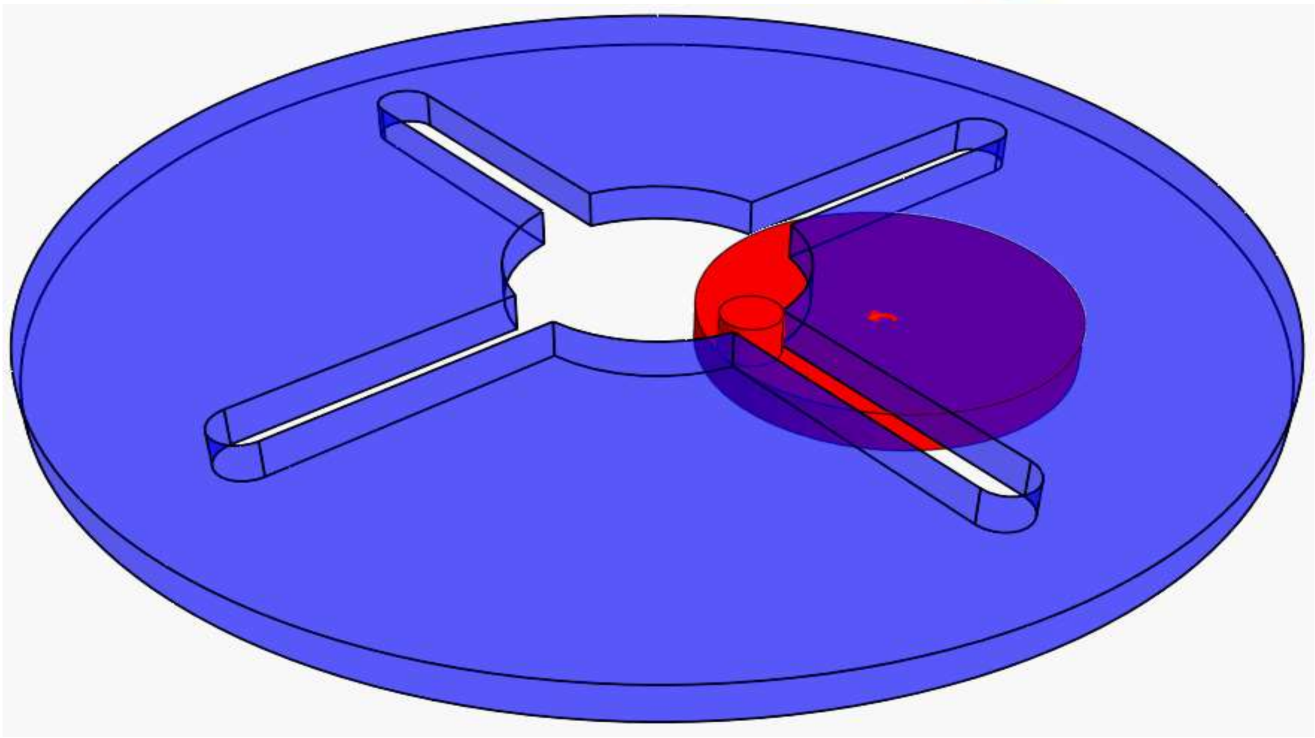
cam_flat_faced


A
pin
B
slot





Classification of mechanisms

Based on mobility (D.O.F) of the mechanism

1. Considering the D.O.F. of output only
    a) Constrained Mechanism
    b) Unconstrained Mechanism
2. Considering the sum of the D.O.F. Of input and output motions
    a) Single (one) d.o.f. mechanism
    b) Multi-d.o.f. mechanism

Constrained Mechanism

- One independent output motion. Output member is constrained to move in a particular manner only.

Example: Four-bar mechanism

Slider Crank Mechanism

Five-bar mechanism with two inputs

Unconstrained mechanism

- Output motion has more than one D.O.F.

Example: Automobile Differential during turning the vehicle on a curve

Five-bar mechanism with one input

Single D.O.F Mechanism

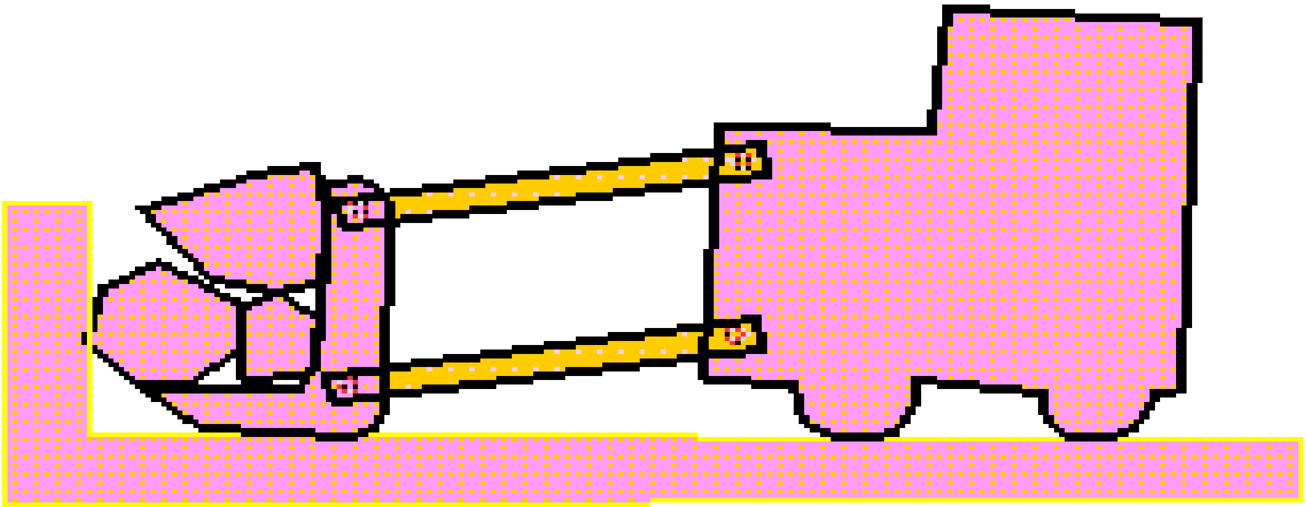
Sum of the input and output D.O.F. is two.

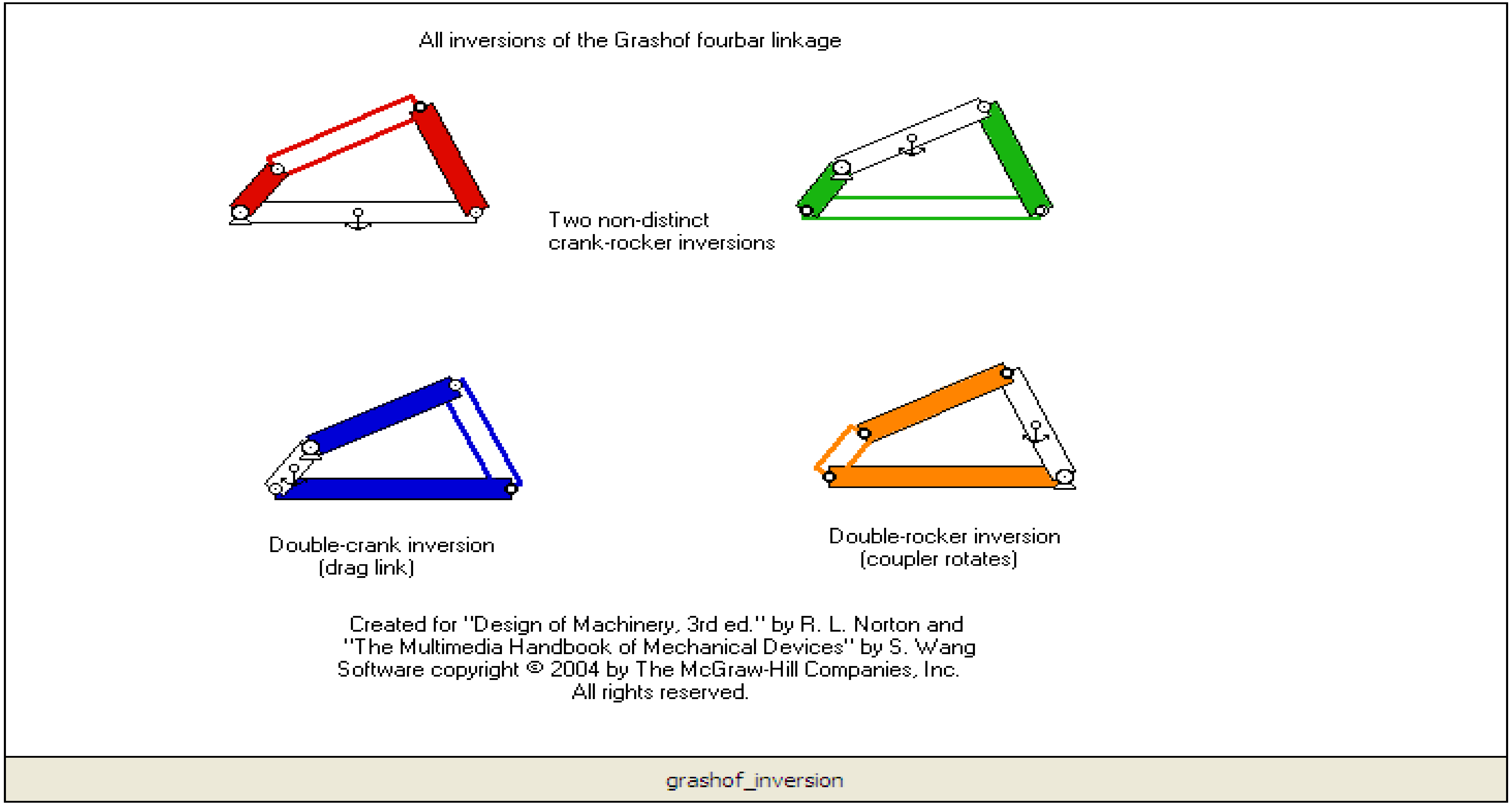
Single D.O.F. Motion - One Independent Input motion and one independent output motion

Examples : Four-Bar Mechanism

Cam-Follower Mechanism


Kurbelviereck
räumliches Kurbelviereck




All inversions of the Grashof fourbar linkage
Two non-distinct
crank-rocker inversions
Double-crank inversion
(drag link)
Double-rocker inversion
(coupler rotates)
Created for "Design of Machinery, 3rd ed." by R. L. Norton and
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grashof_inversion

Multi D.O.F. Mechanism

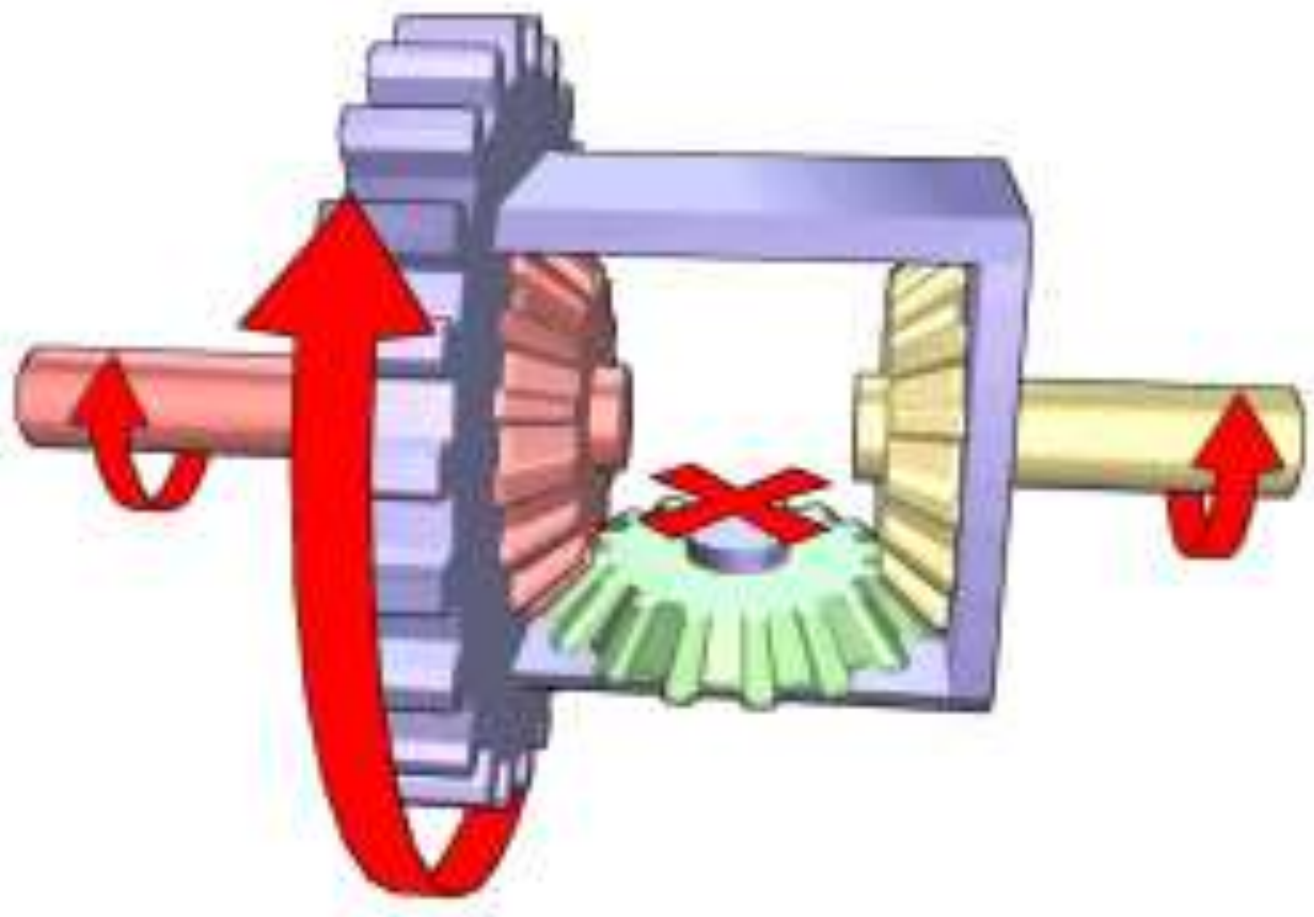
Sum of the input and output motion D.O.F. is more than two.

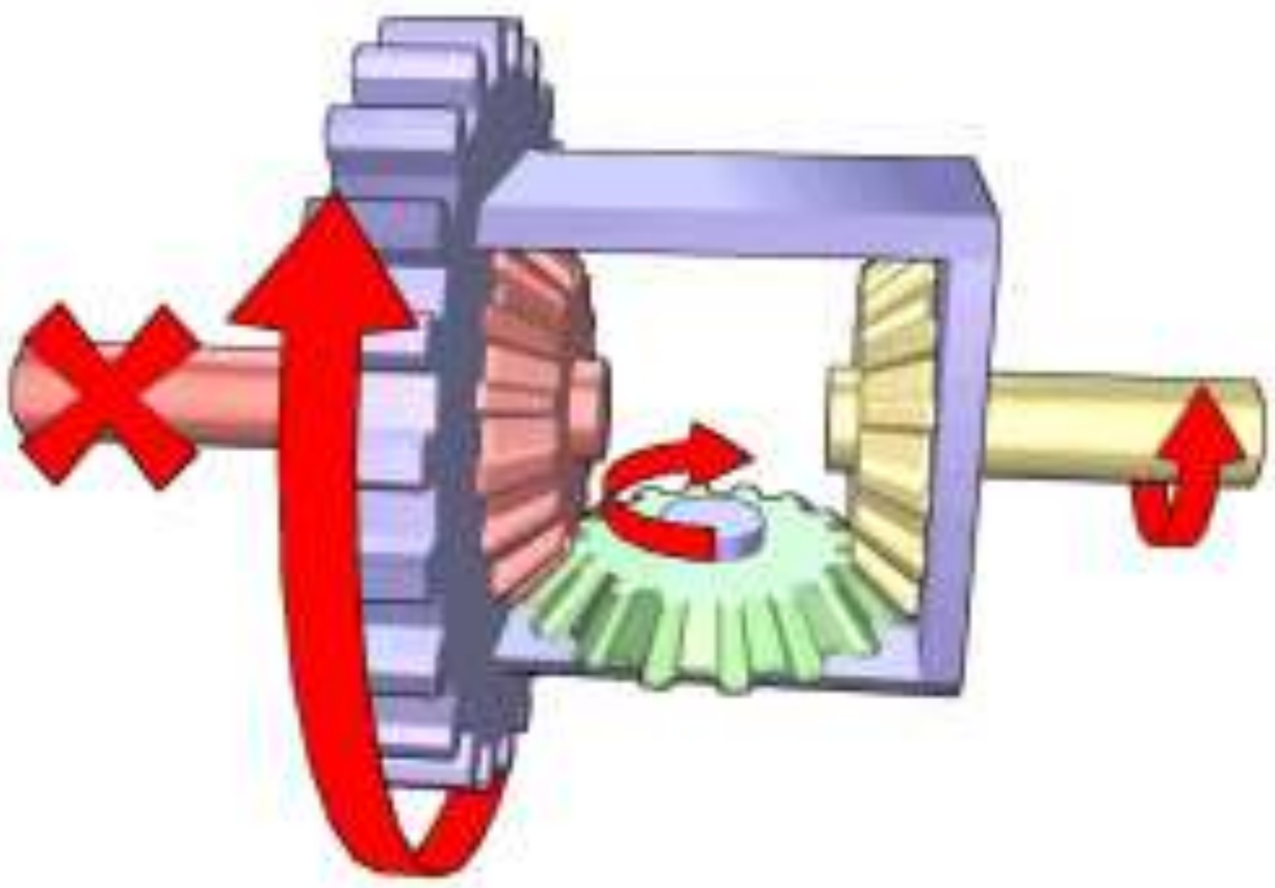
Multi D.O.F. Motion – More than one Independent Output / Input Motions

Examples : Automobile Differential

3-D Cam Mechanism (Camoid)

Five-Bar Mechanism





Classification of Mechanisms

Based on position occupied in space

- Planar Mechanism
- Spherical Mechanism
- Spatial Mechanism

Planar Mechanism

Planar Motion – Particles/Points of Members move in parallel planes

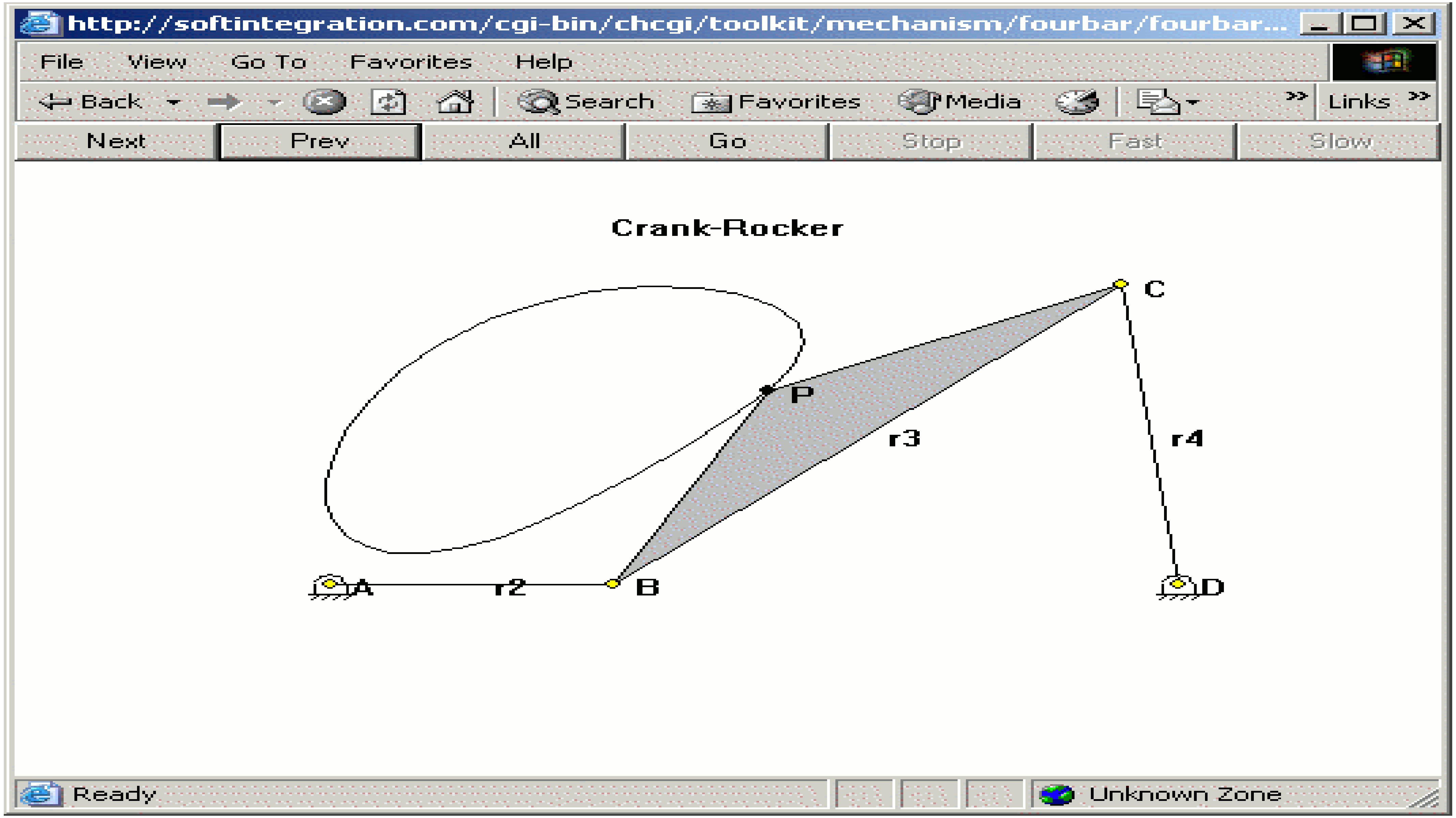
Examples : Planar Four-Bar Mechanism

Slider Crank Mechanism

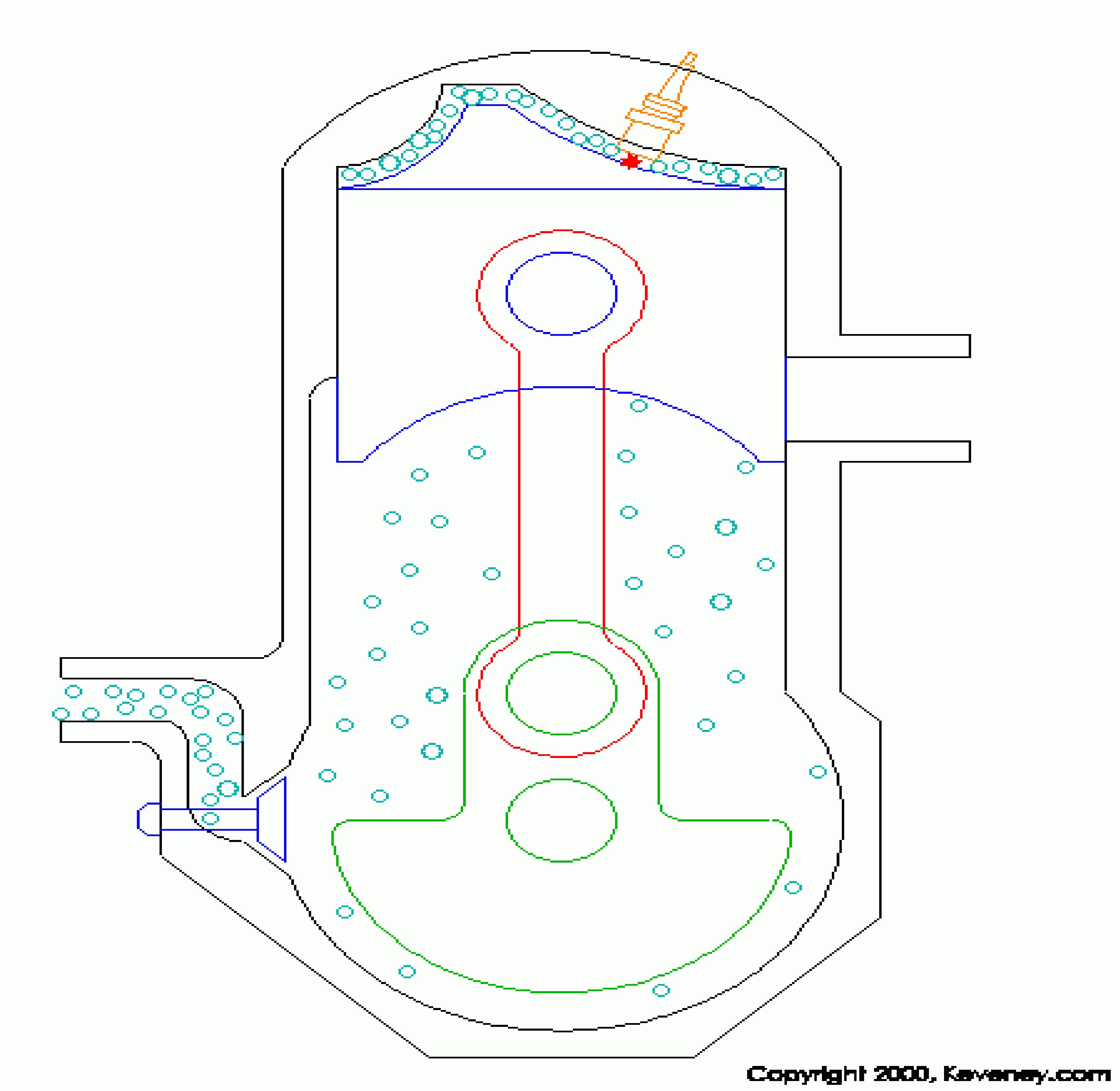
Cam-Follower Mechanism

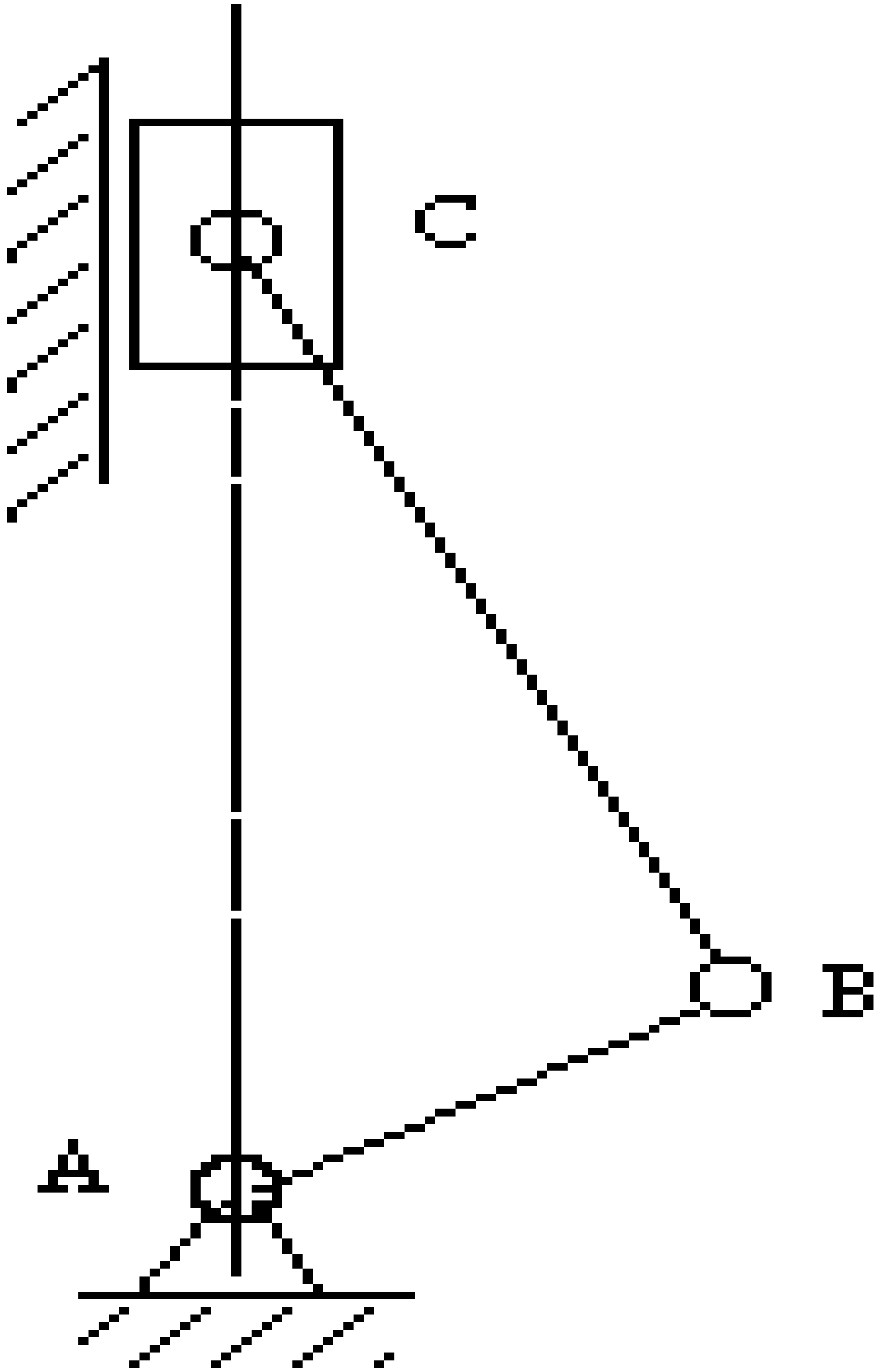
Spur/Helical Gear Drives

Four-bar Crank Rocker and Coupler Curve



Two Stroke Engine





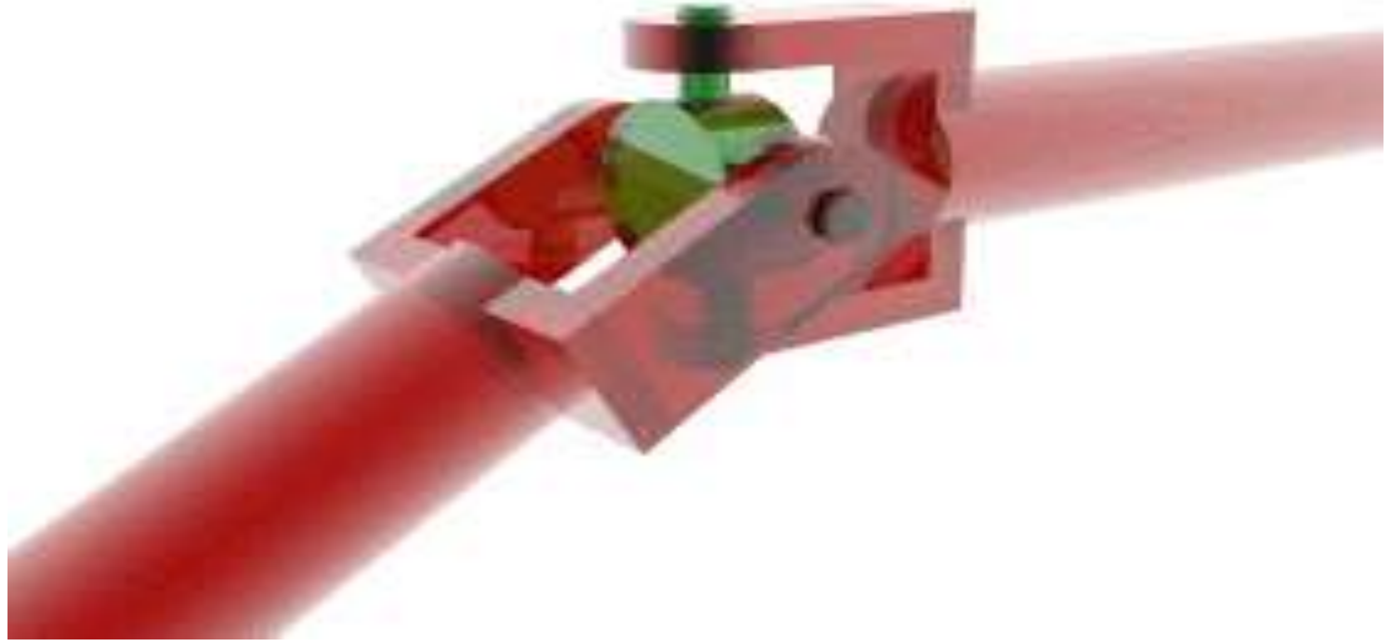
Spherical Mechanism

Spherical Motion – Points maintain Constant Distance w.r.t. a Common Centre Point in any position during motion.

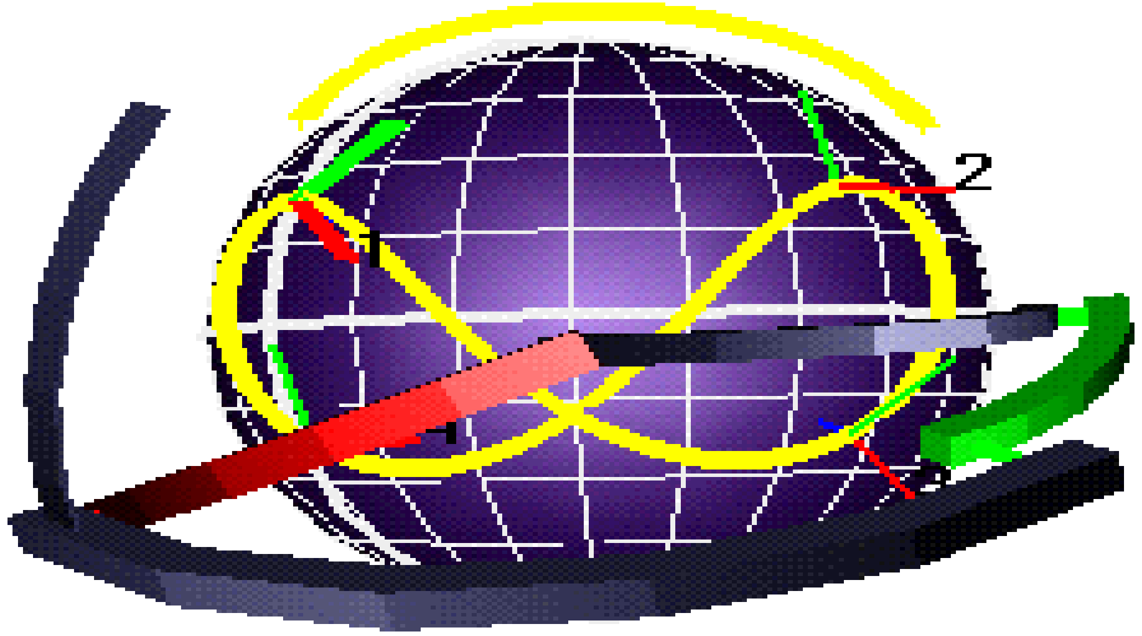
Examples : Universal Joint

Bevel Gear Drive

Spherical Four-Bar Mechanism




C3


2

Spatial Mechanism

- Spatial Motion – Points can occupy any position in space

- Examples : Spatial Four-Bar Mechanism
  Worm Gear Drive
  Serial Manipulators

Classification of mechanisms

- Based on the connection of the output member

Open mechanism

Closed mechanism

Open Mechanism

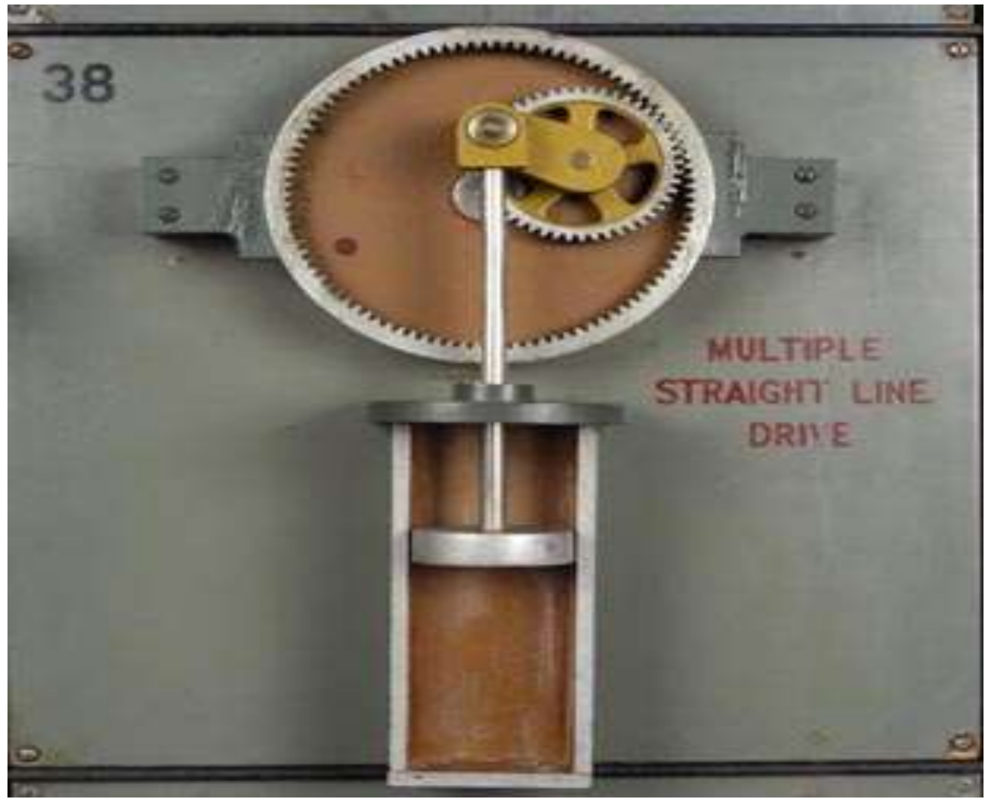
- Output member not connected to the fixed link / frame

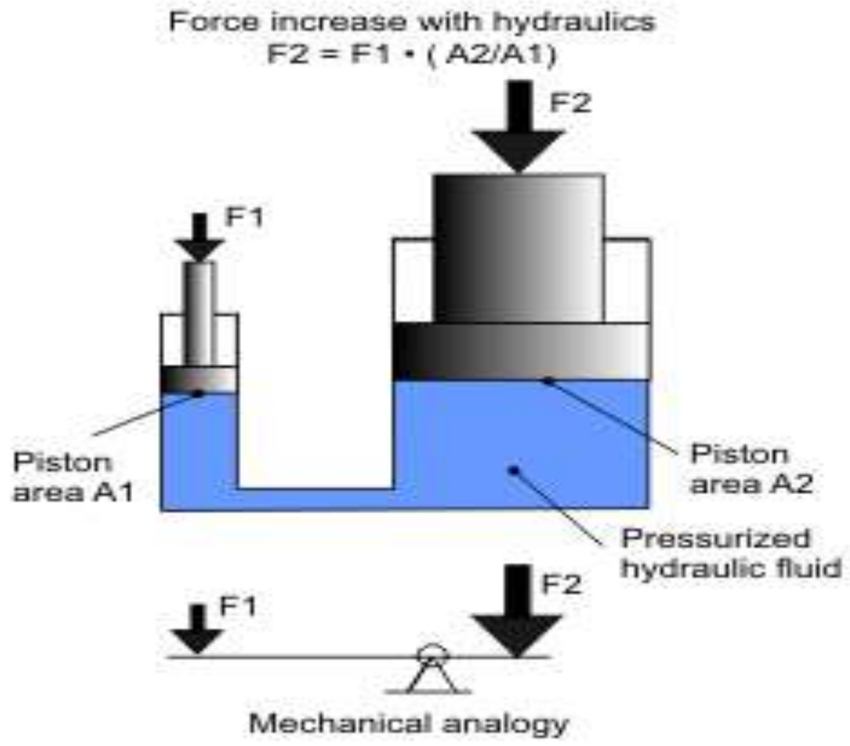
Robot arms

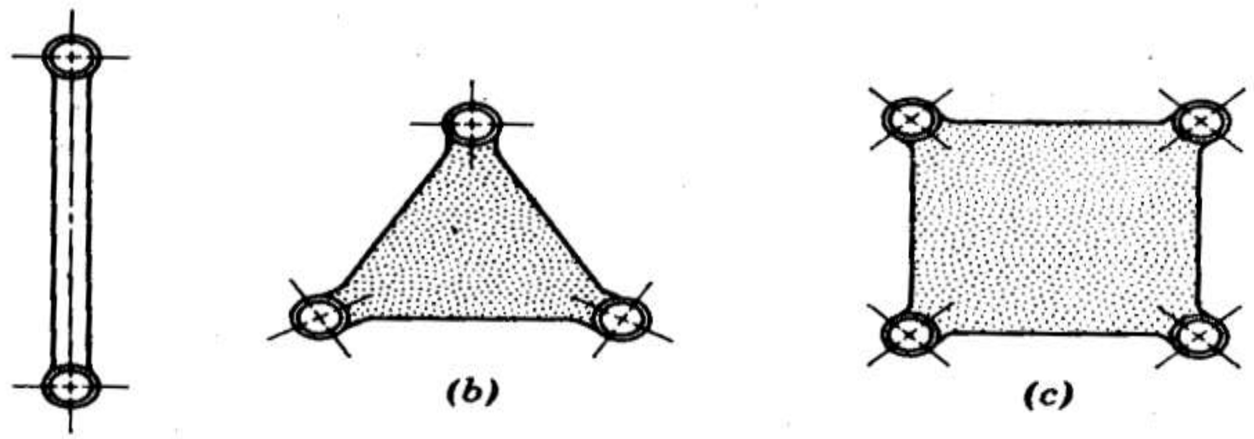
Arms of earth movers




Link / Element



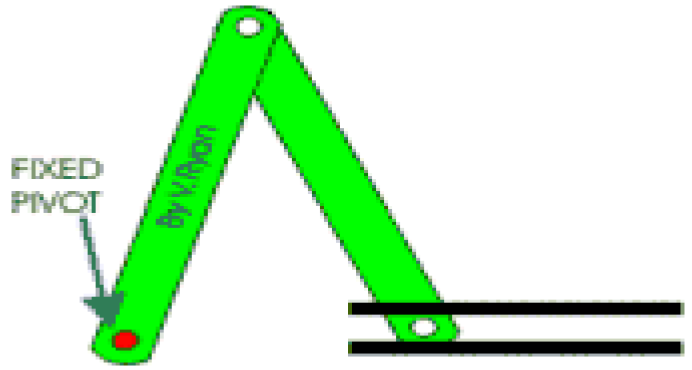


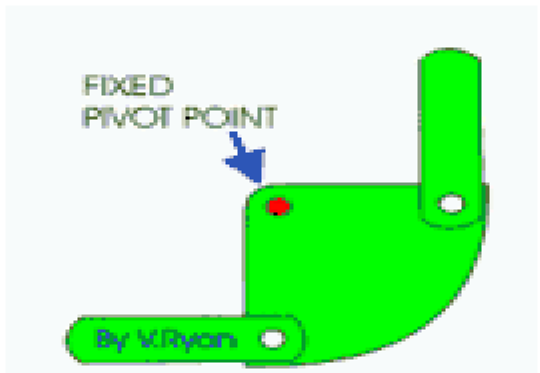


(b)

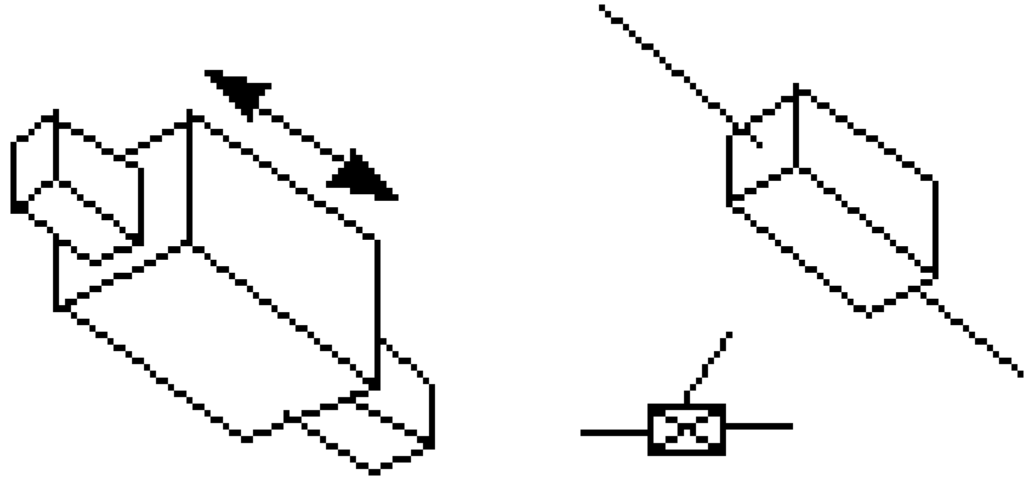
(c)

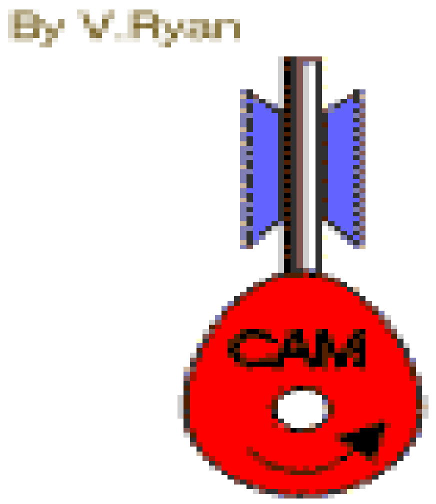
(a)

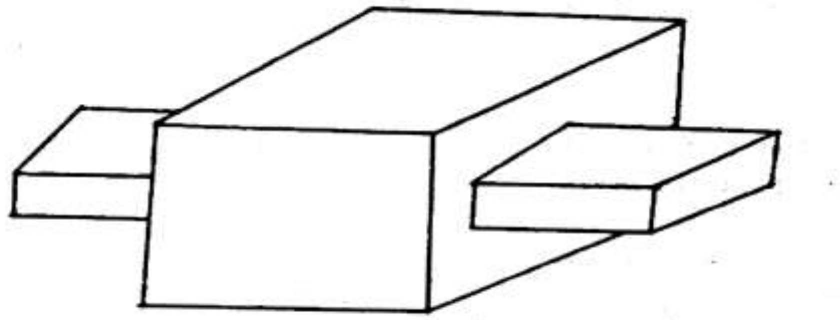

FIXED
PIVOT
By V.Ryan
CRANK AND SLIDER LINKAGE

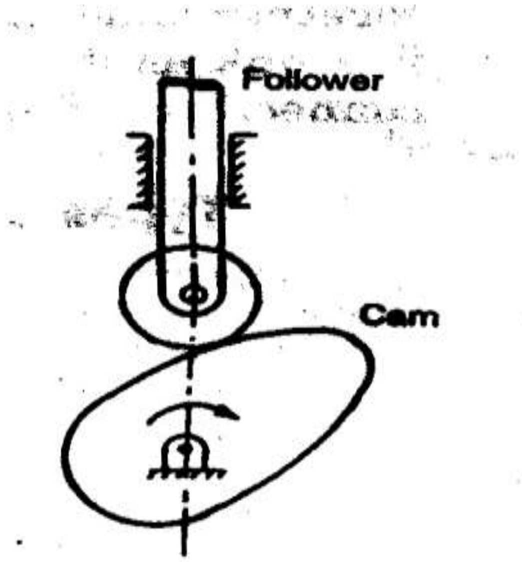

FIXED
PIVOT POINT
By V.Ryan
BELL CRANK LINKAGE

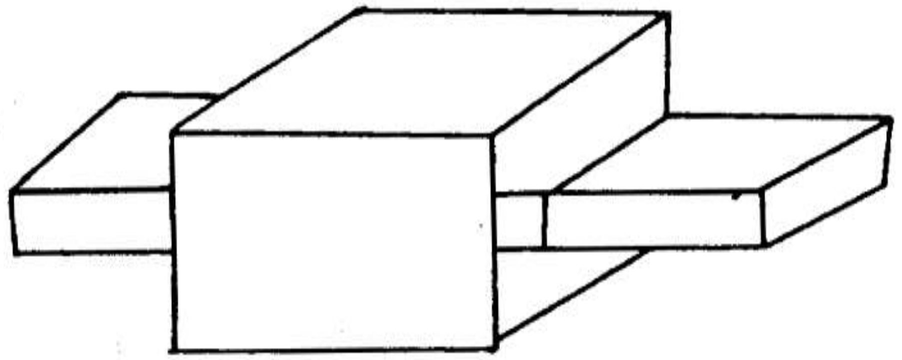
Classification of Pairs

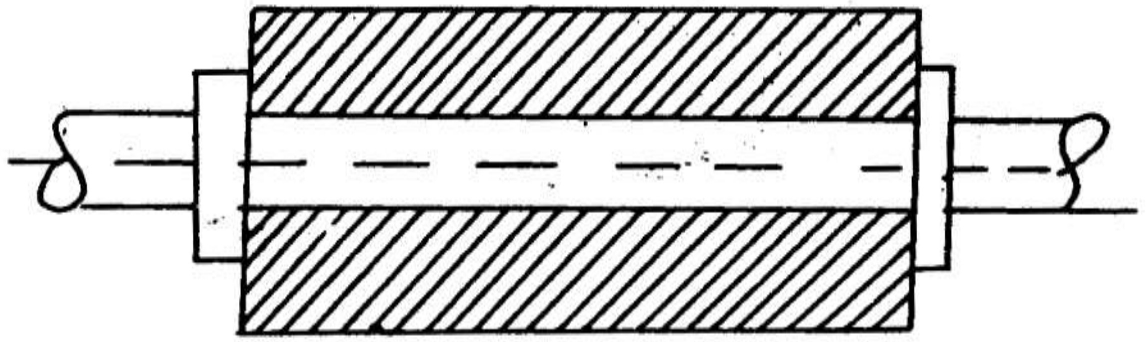


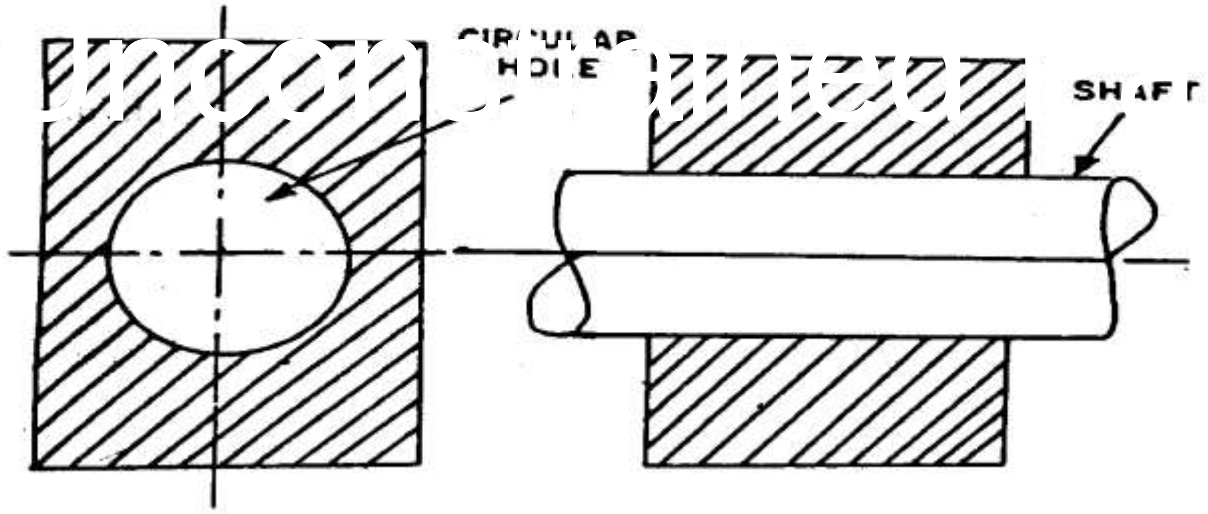


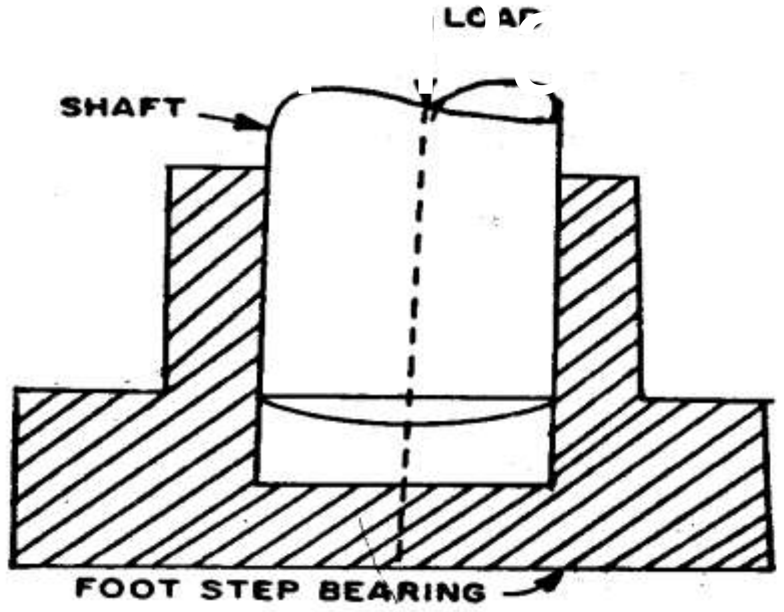

(a)

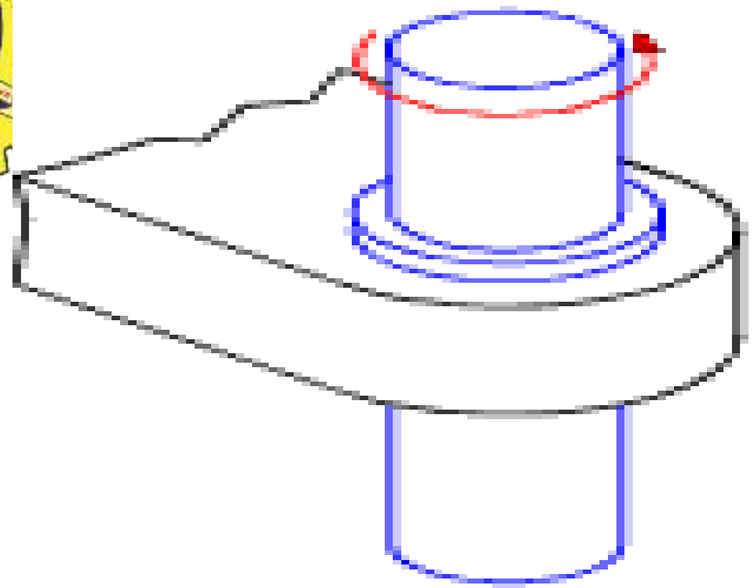




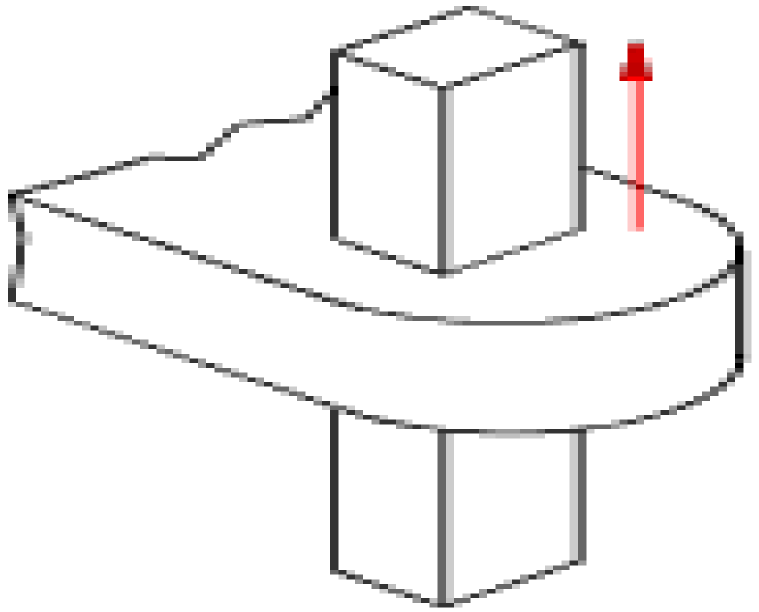



CIRCULAR HOLE
SHAFT

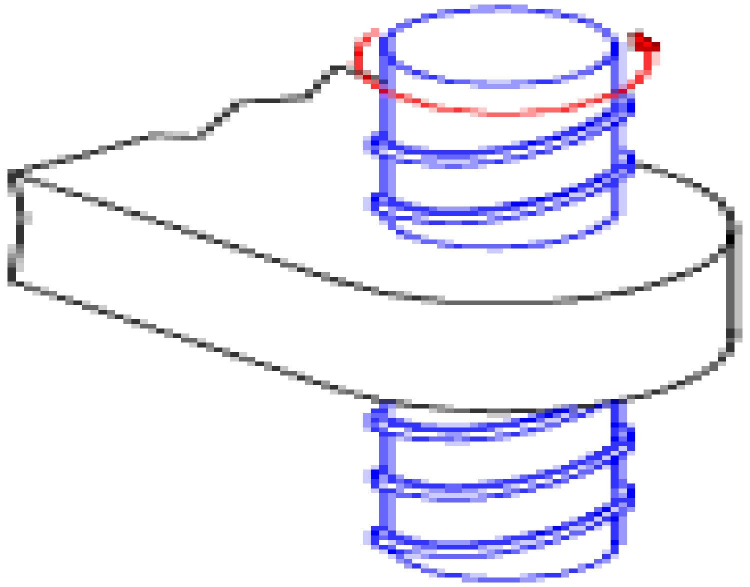

LOAD
SHAFT
FOOT STEP BEARING



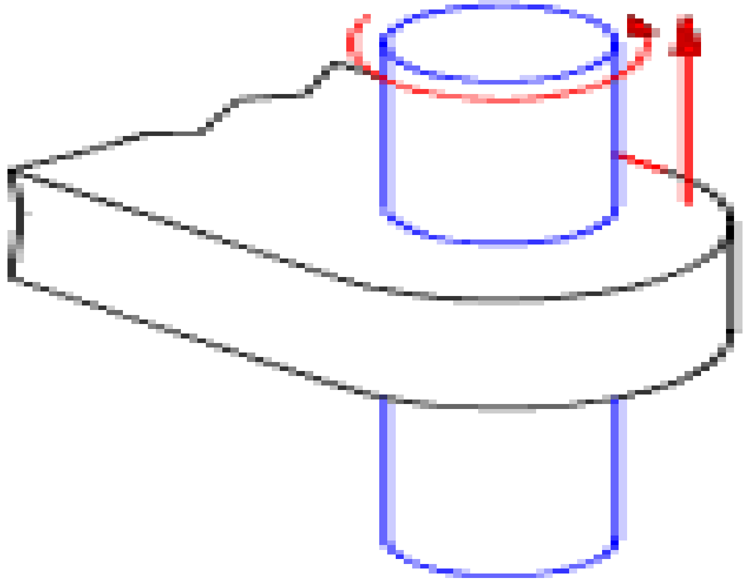
Turning Pair....1-DOF



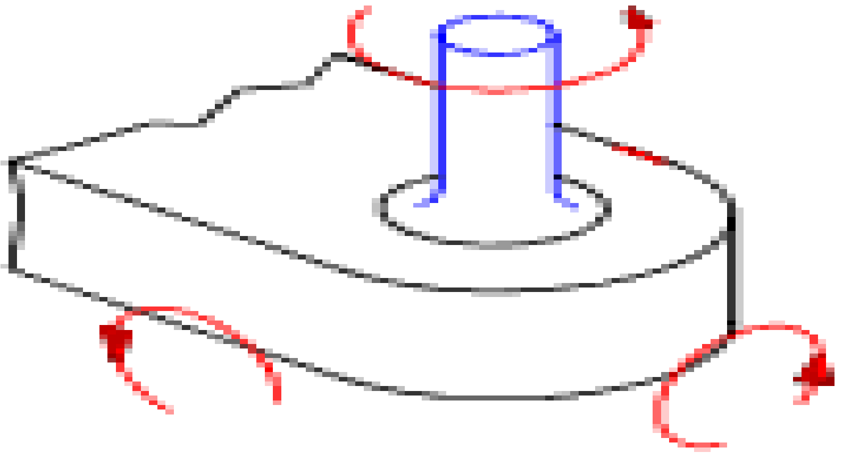
Prismatic (Sliding) Pair....1-DOF



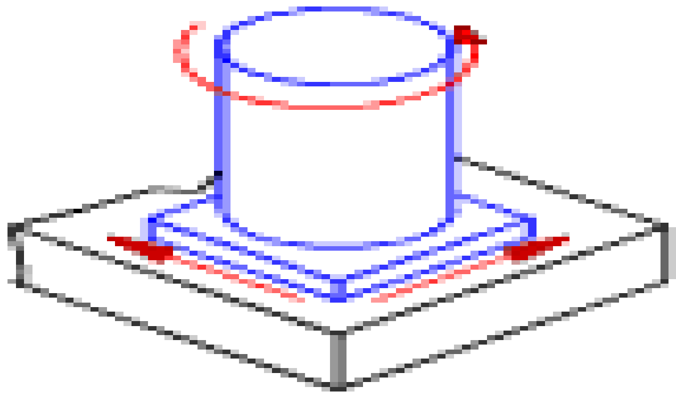
Screw Pair 1-DOF



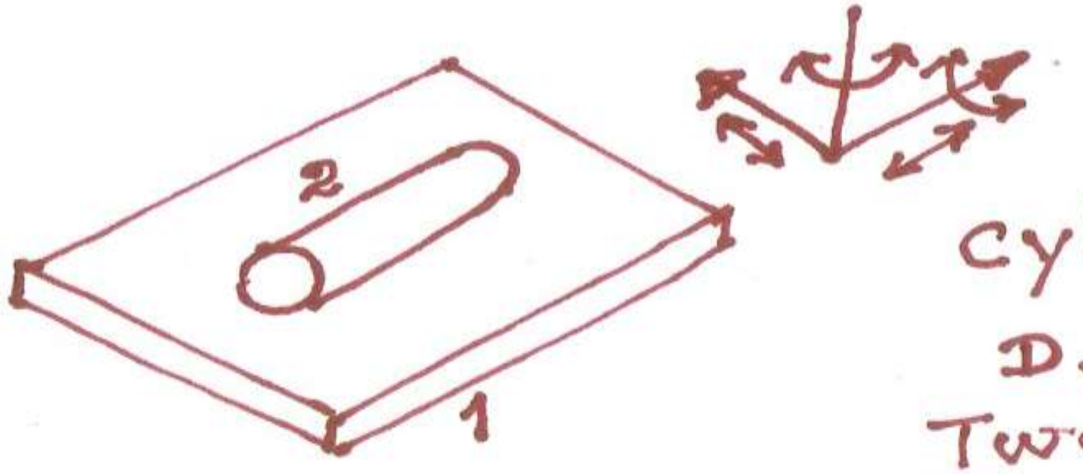
Cylinderical Pair 2-DOF



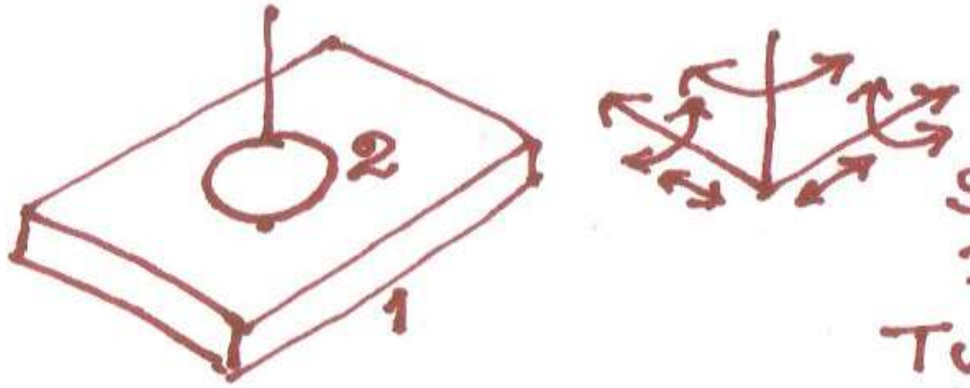
Spherical (Globular) Pair....3-DOF



Flat Pair 3-DOF



Cylindric Plane Pair
Cp
D.O.F - 4
Two Translations,
Two Rotations



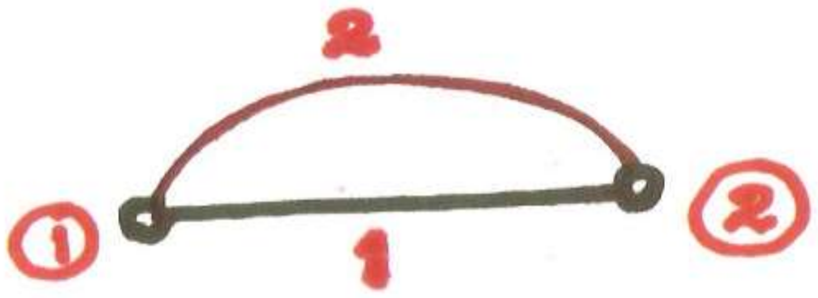
Spheric Plane Pair
D.O.F - 5
Two Translations
Three Rotations

V. SUNDARESWARAN

Mobility / D.O.F of Mechanism

- No. of inputs required to get a constrained mechanism (or) no. of position variables needed to sketch the mechanism with all link lengths known.

- KUTZBACH CRITERION FOR PLANAR MECHANISM
- $$F = 3(n-1)-2P_1-1P_2$$
- F – D.O.F n – No. of links
- P_1 – No. of kinematic pairs with 1 D.O.F.
- P_2 – No. of kinematic pairs with 2 D.O.F.



$n = 2$

$P_1 = 2$

$P_2 = 0$

$$F = 3(2-1) - 2\times 2 - 1\times 0$$
$$= 3 - 4 - 0$$
$$= -1$$

This is a Pre-loaded structure/ Super structure.

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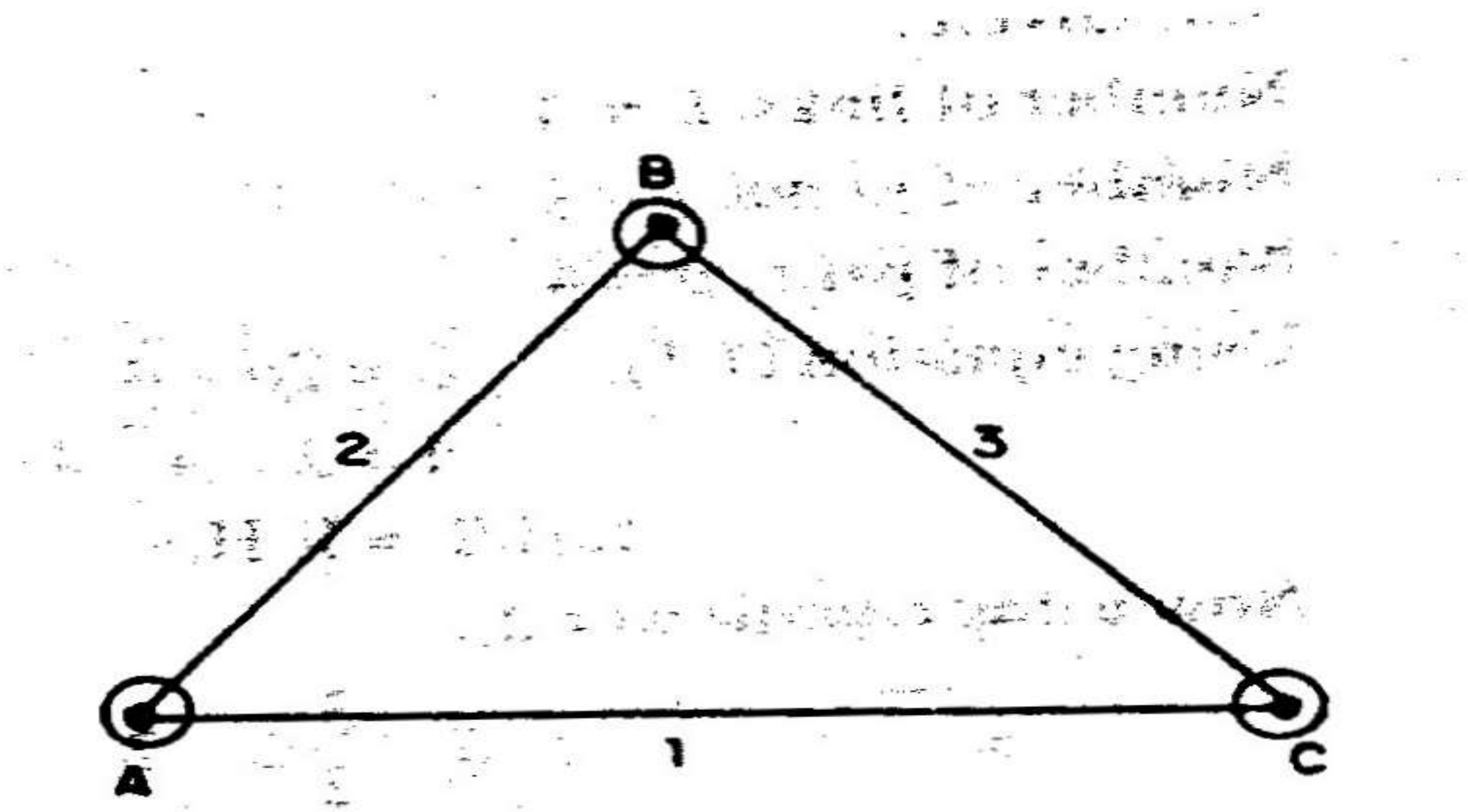
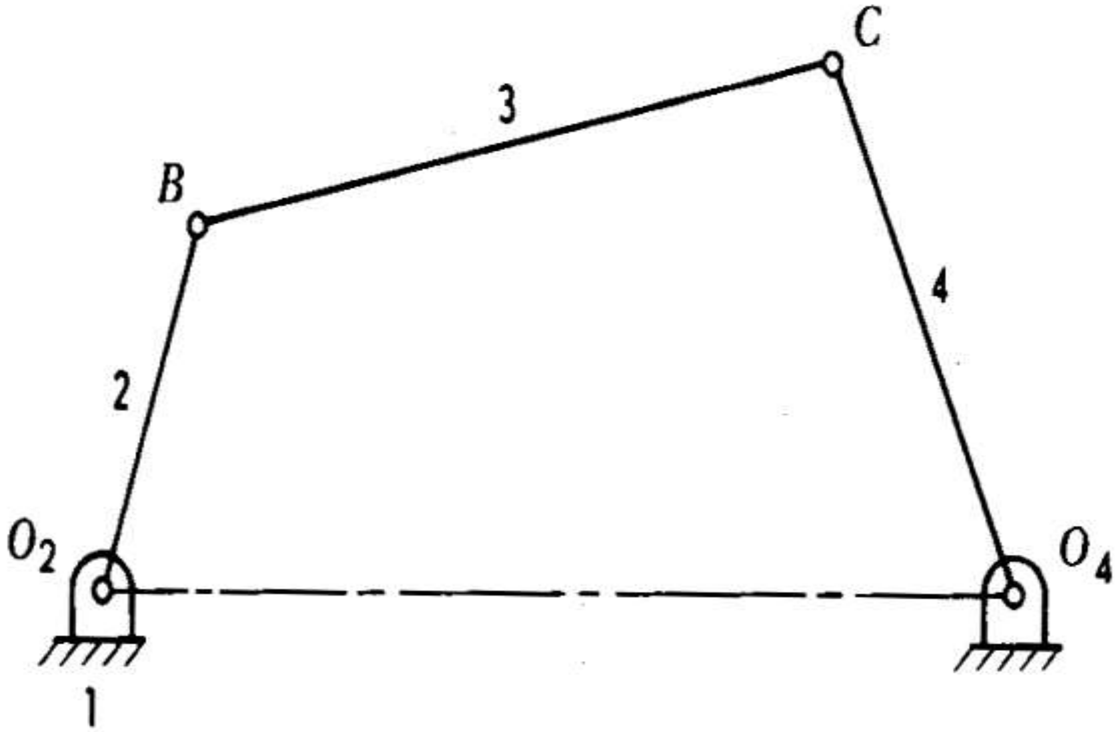


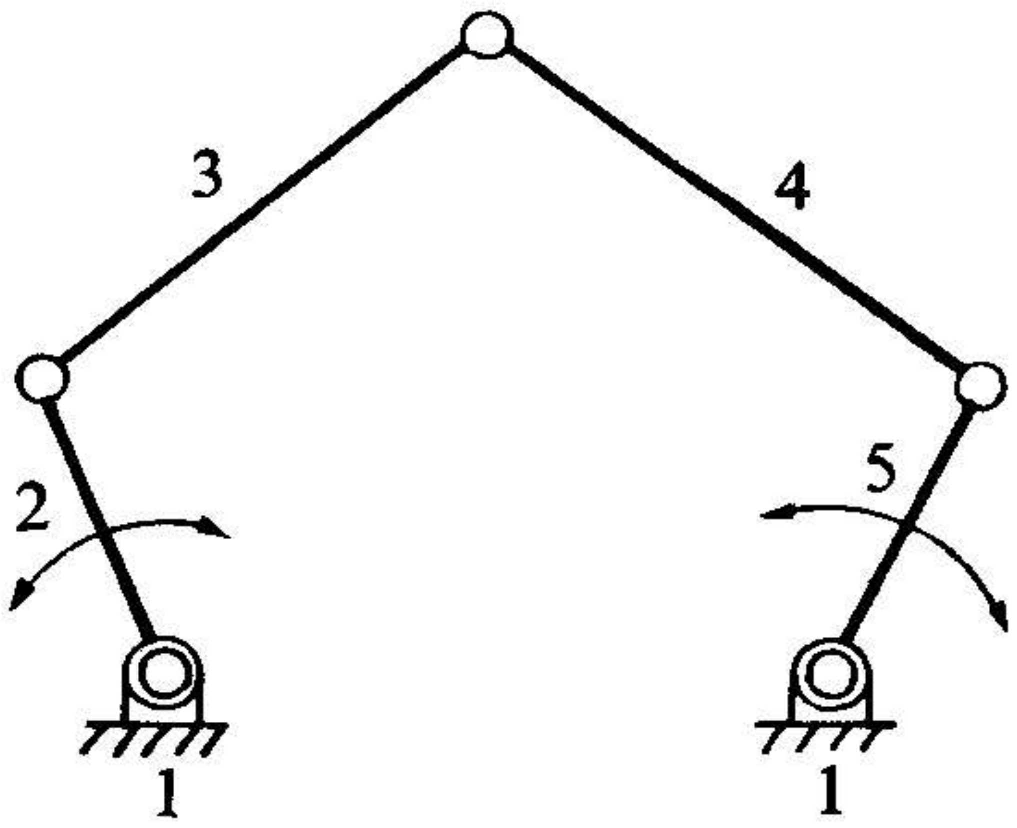
1

2



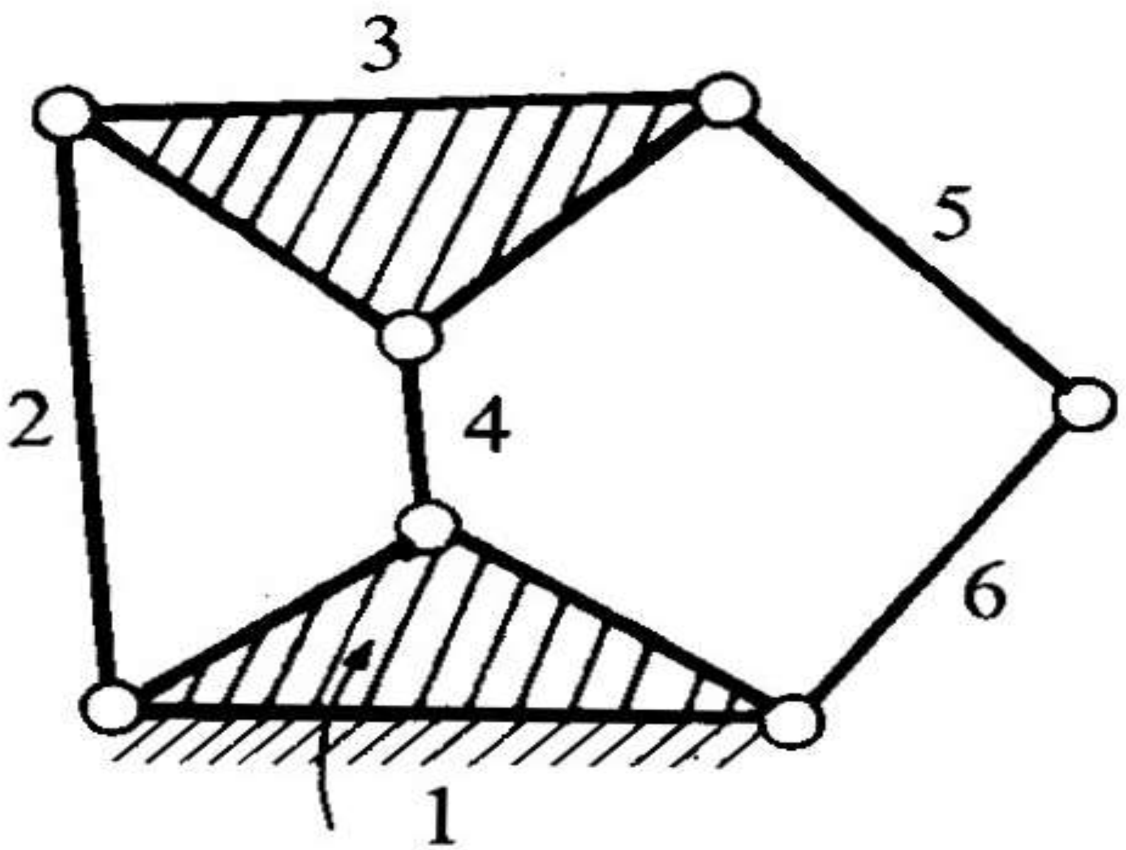
1

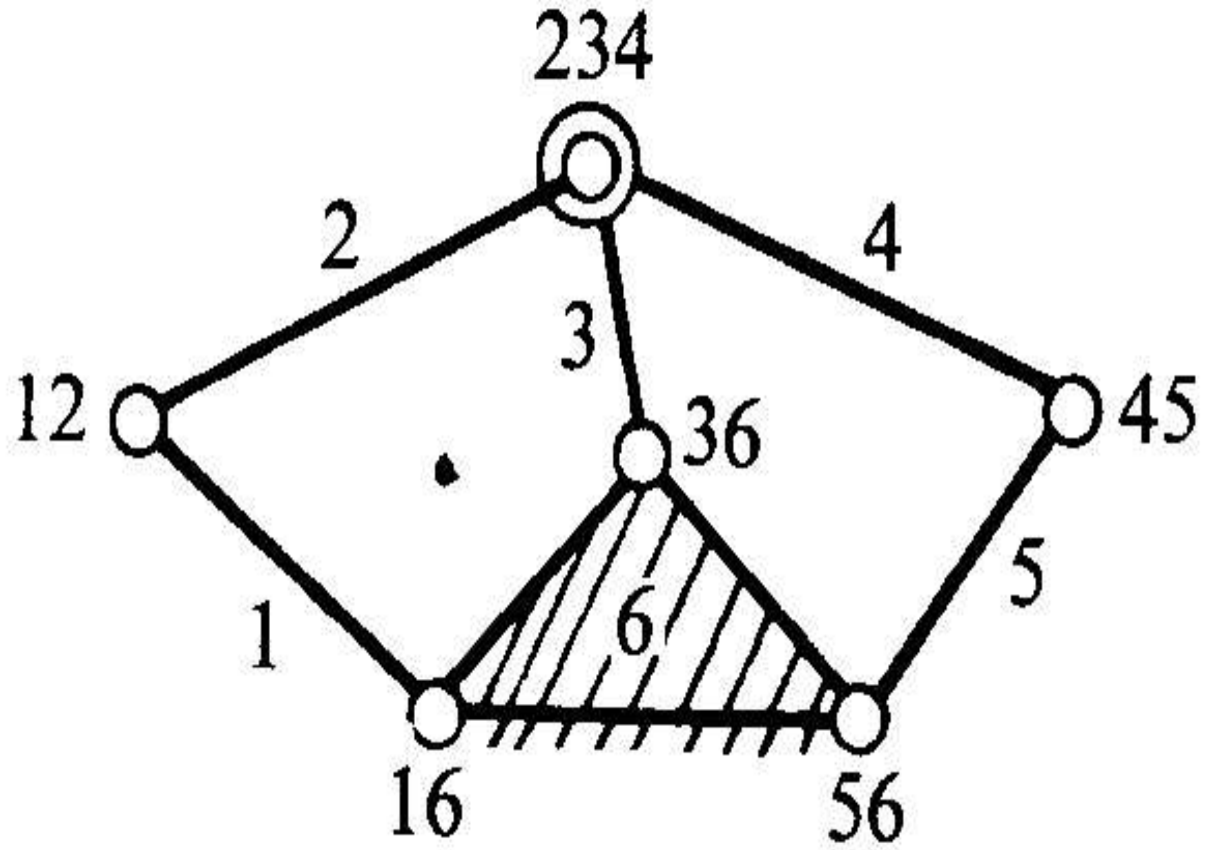
2



1

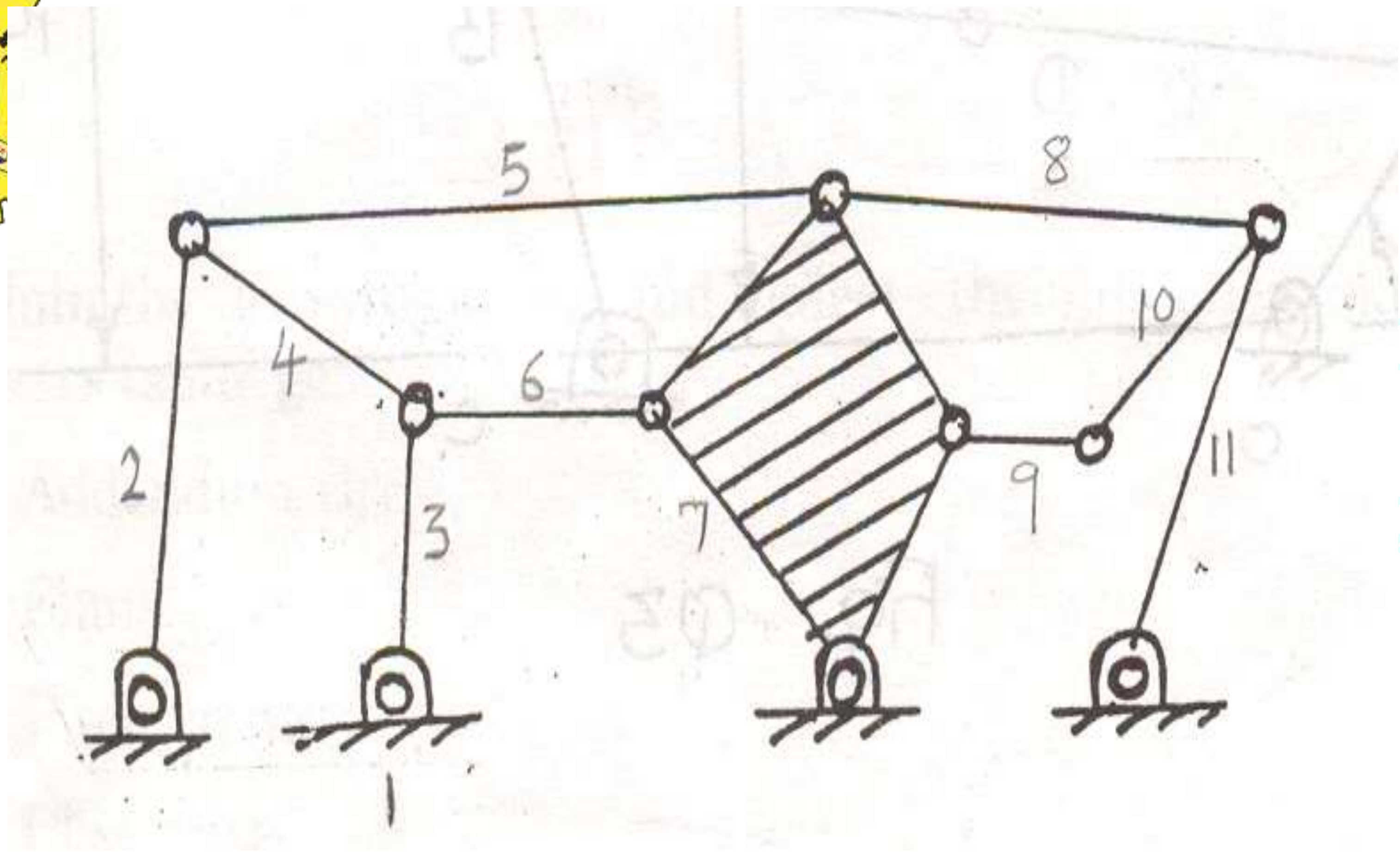
2


3
5
2
4
6
1

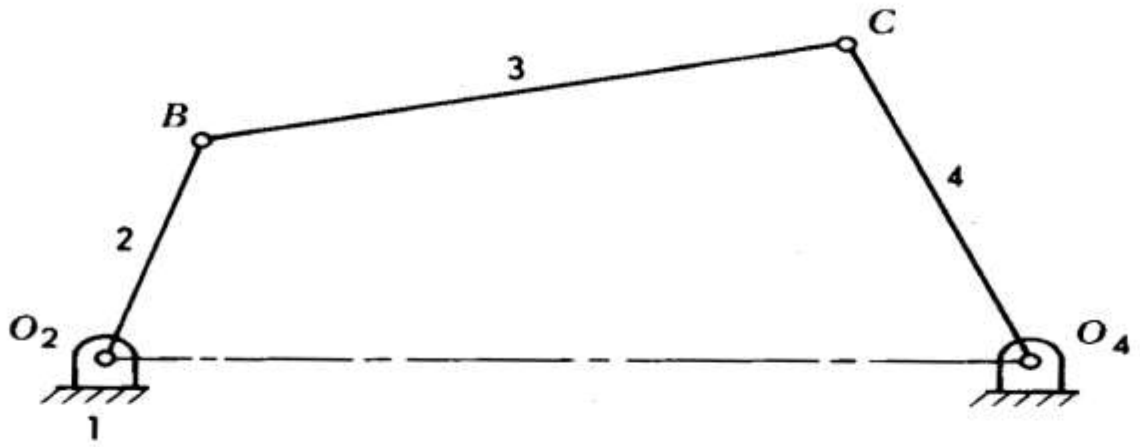


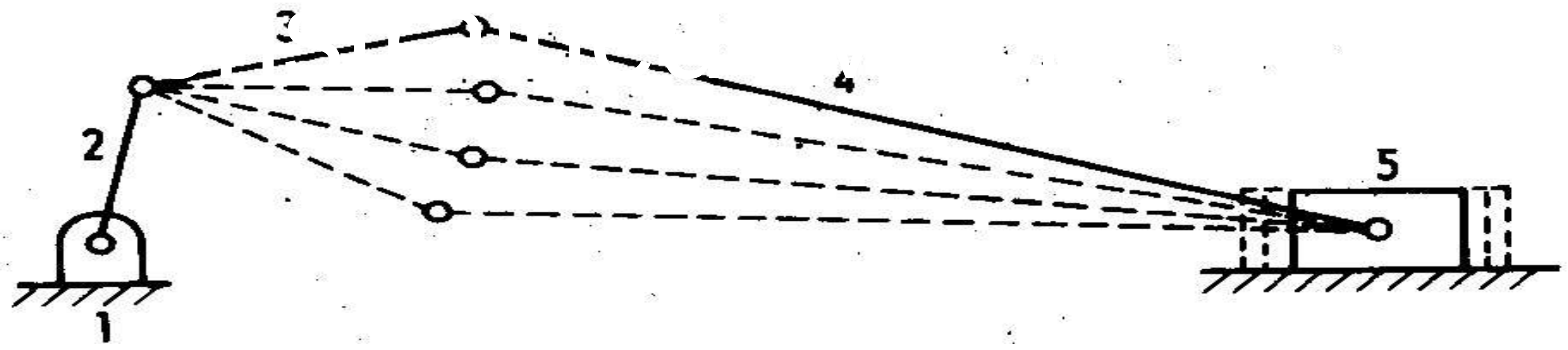
1

2


5
8
4
6
10
2
3
7
9
11
1

Gruebler’s Criterion


C
3
B
4
2
O_2
O_4
1


4
2
5
1

2 − 3
Slip-Rolling Pair
(Higher Pair)

1 − 2 R
3 − 1 P

$n = 3$
$P_1 = 2$
$P_2 = 1$

$$F = 3(3-1) - 2\times 2 - 1\times 1$$
$$= 6 - 4 - 1$$
$$= 1$$

This is a constrained mechanism.

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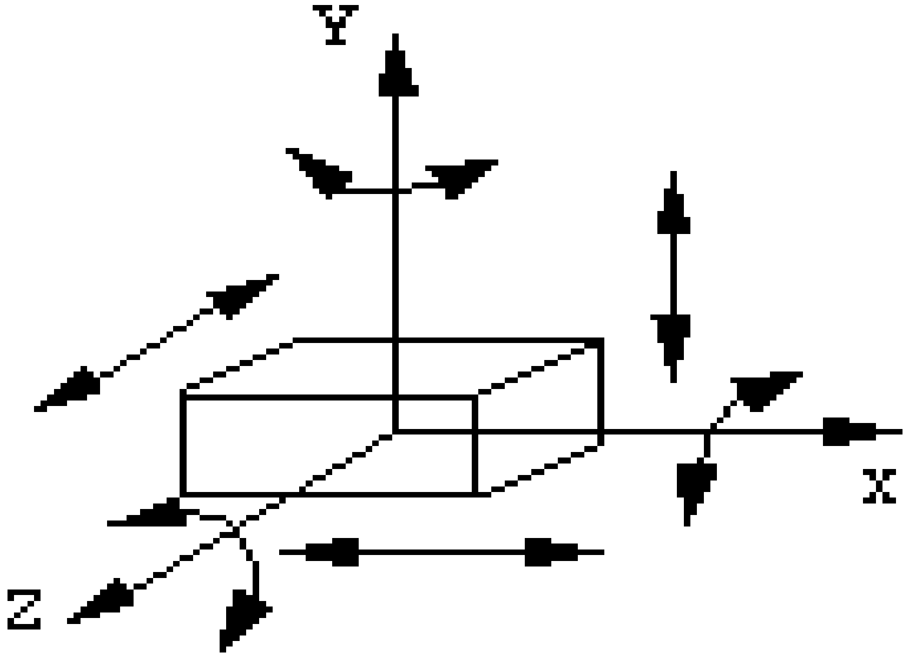
LINK / ELEMENT

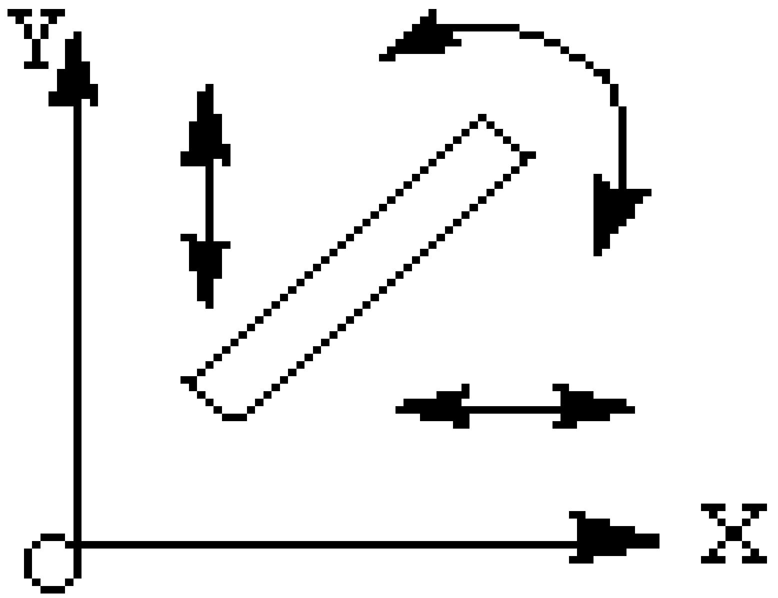
KINEMATIC PAIR / JOINT

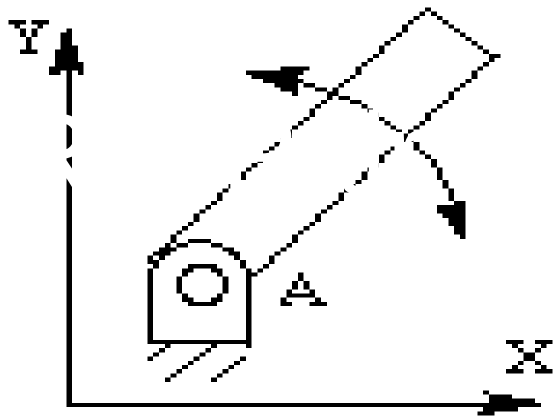
KINEMATIC CHAIN

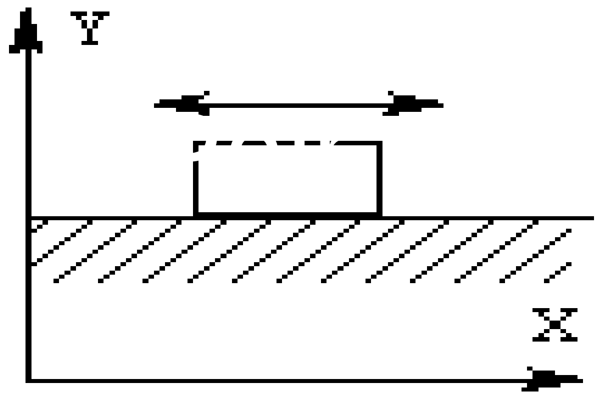
MECHANISM

MACHINE


Y
X
Z


Y
X


Y
A
X

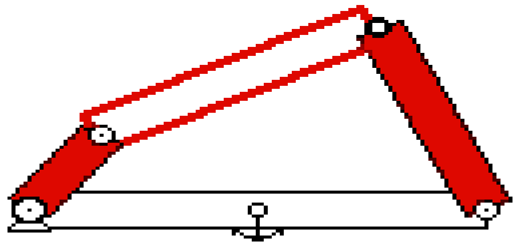

Y
X

KINEMATIC CHAIN

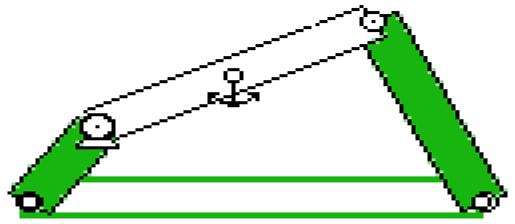
On

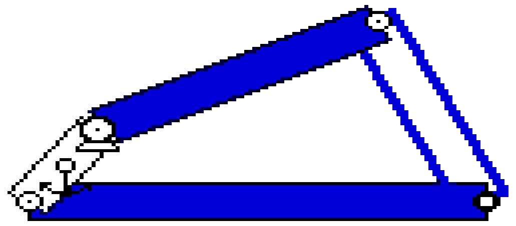
MECHANISM

All inversions of the Grashof fourbar linkage

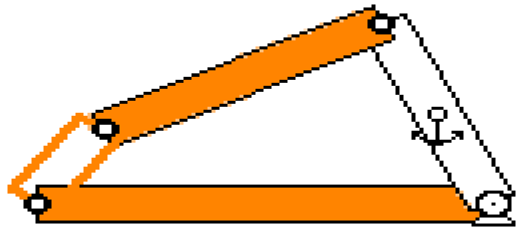


Two non-distinct
crank-rocker inversions



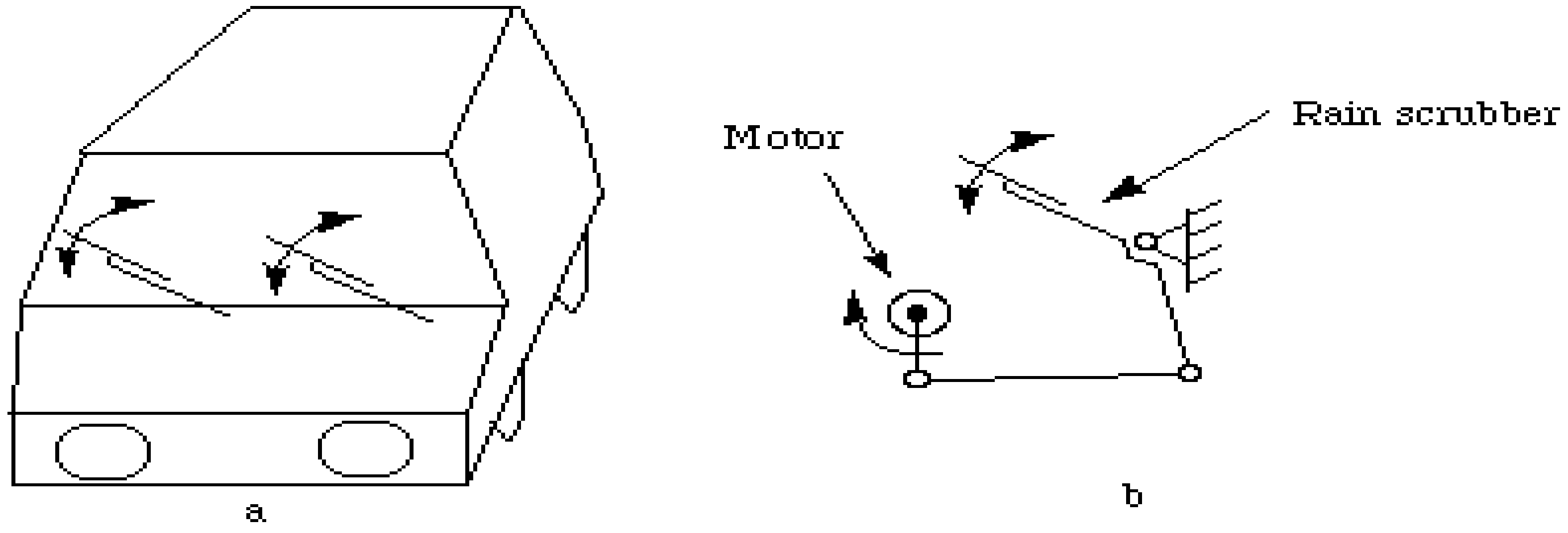


Double-crank inversion
(drag link)



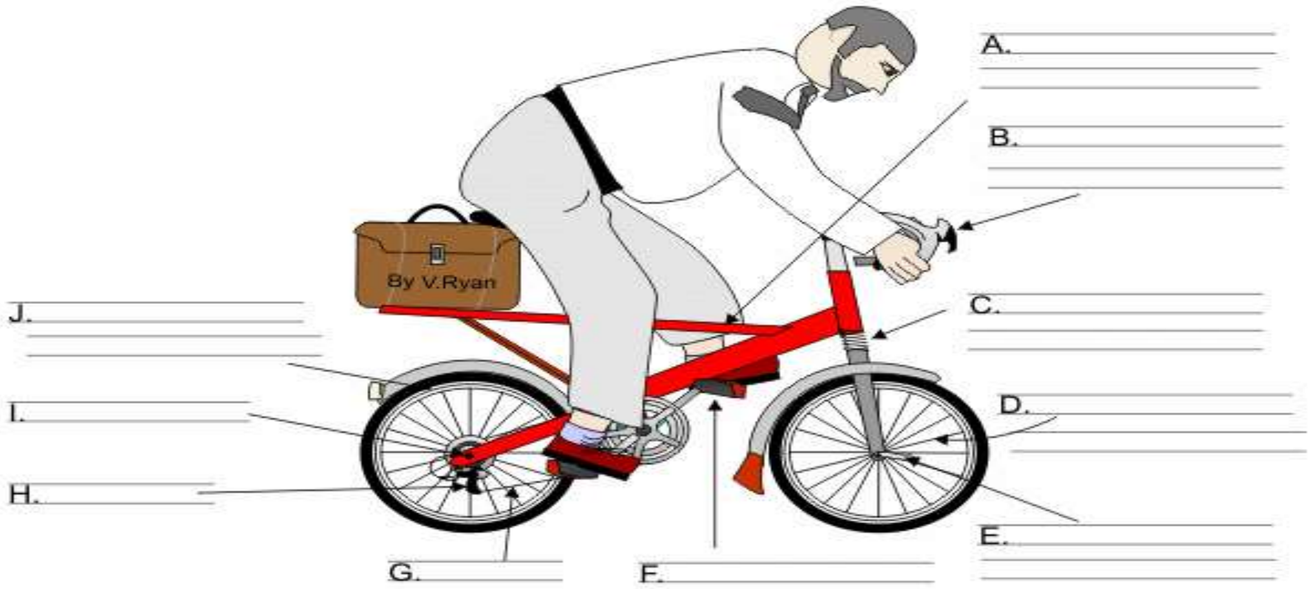
Double-rocker inversion
(coupler rotates)

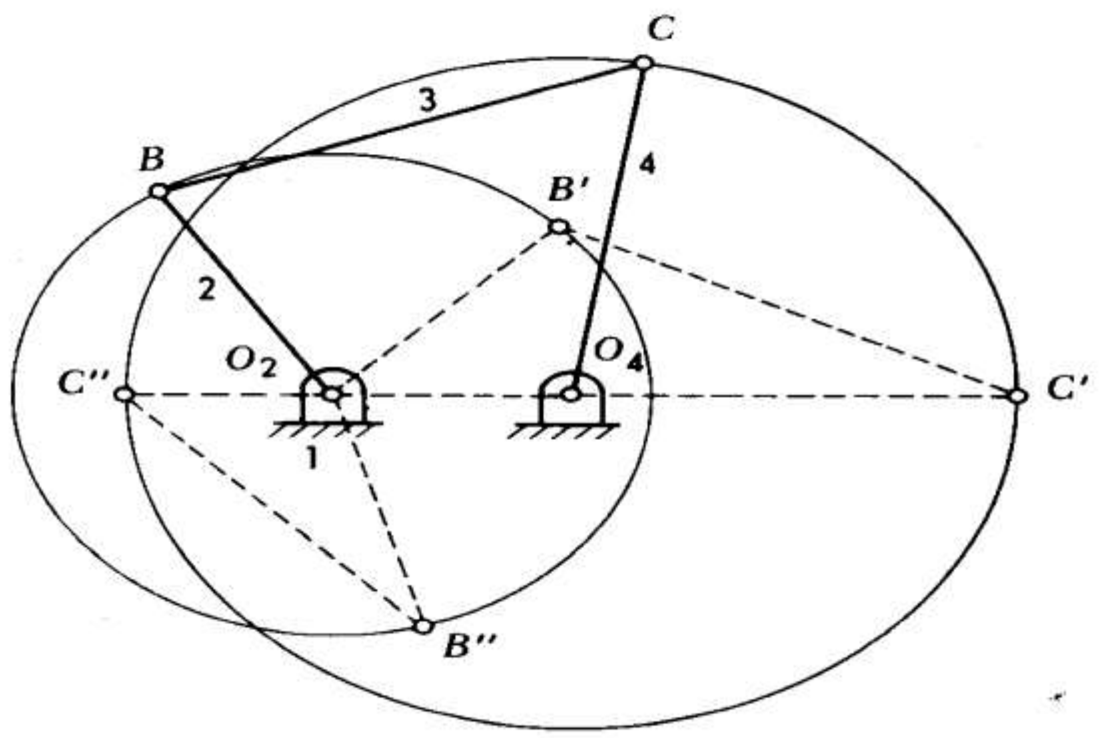
grashof_inversion

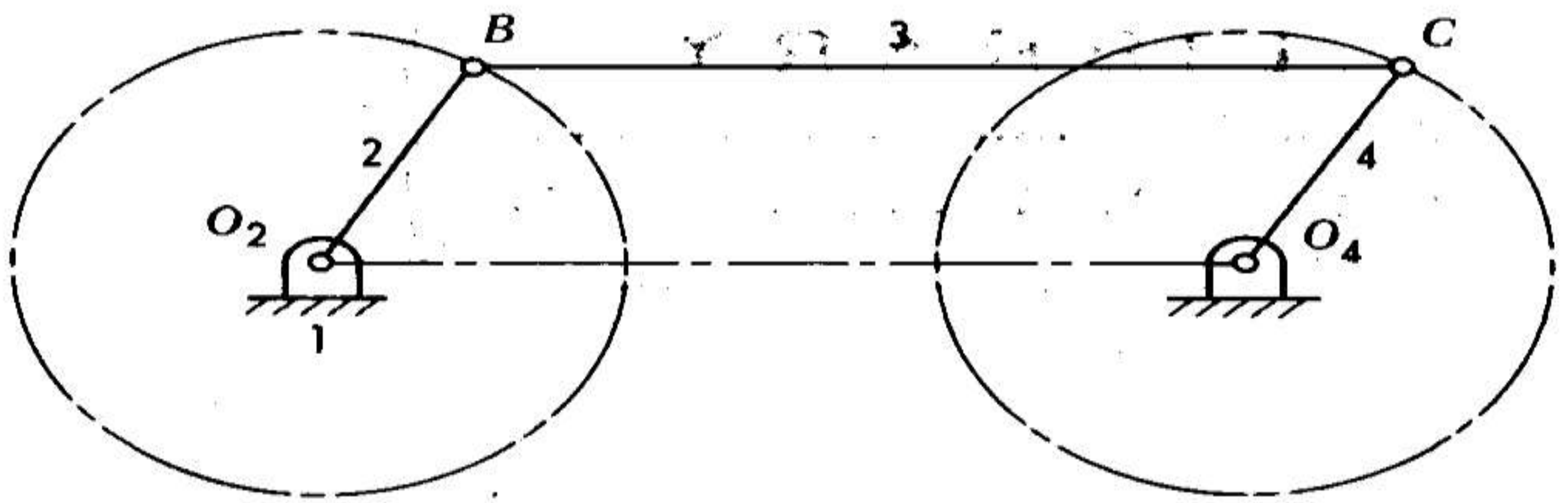

Motor
Rain scrubber
a
b

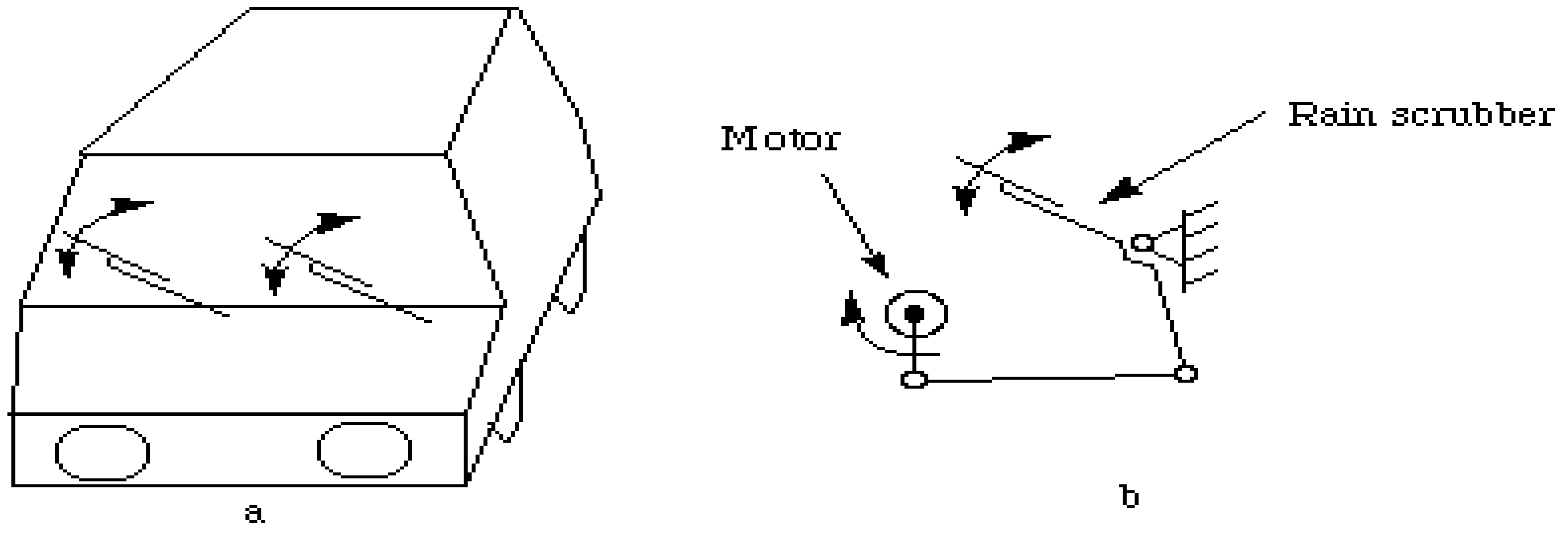

SINGER

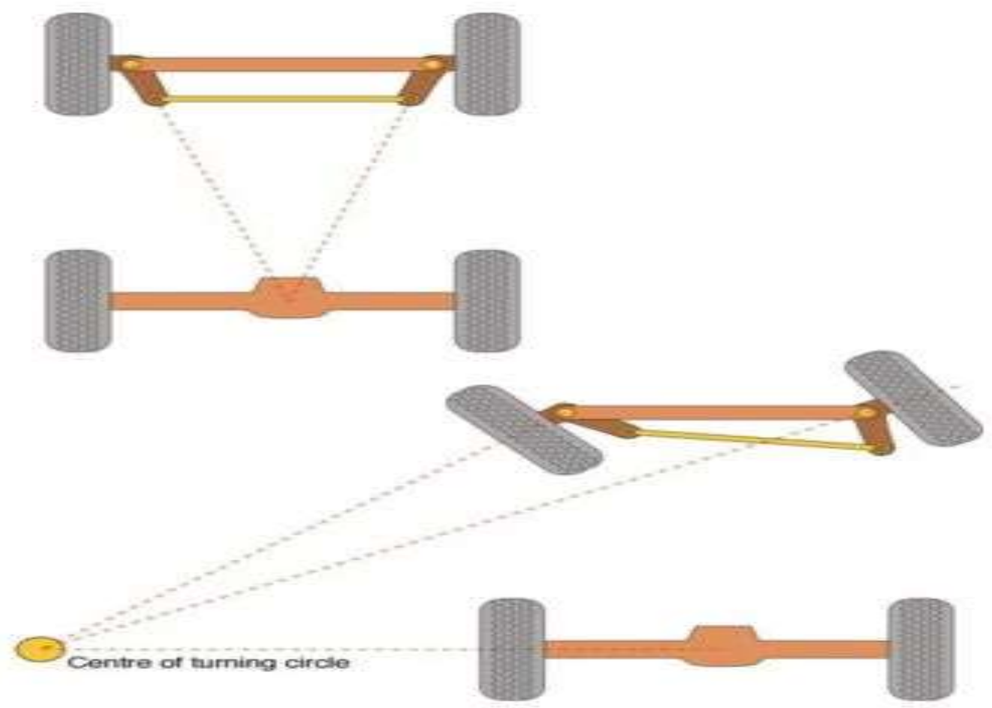

SINGER

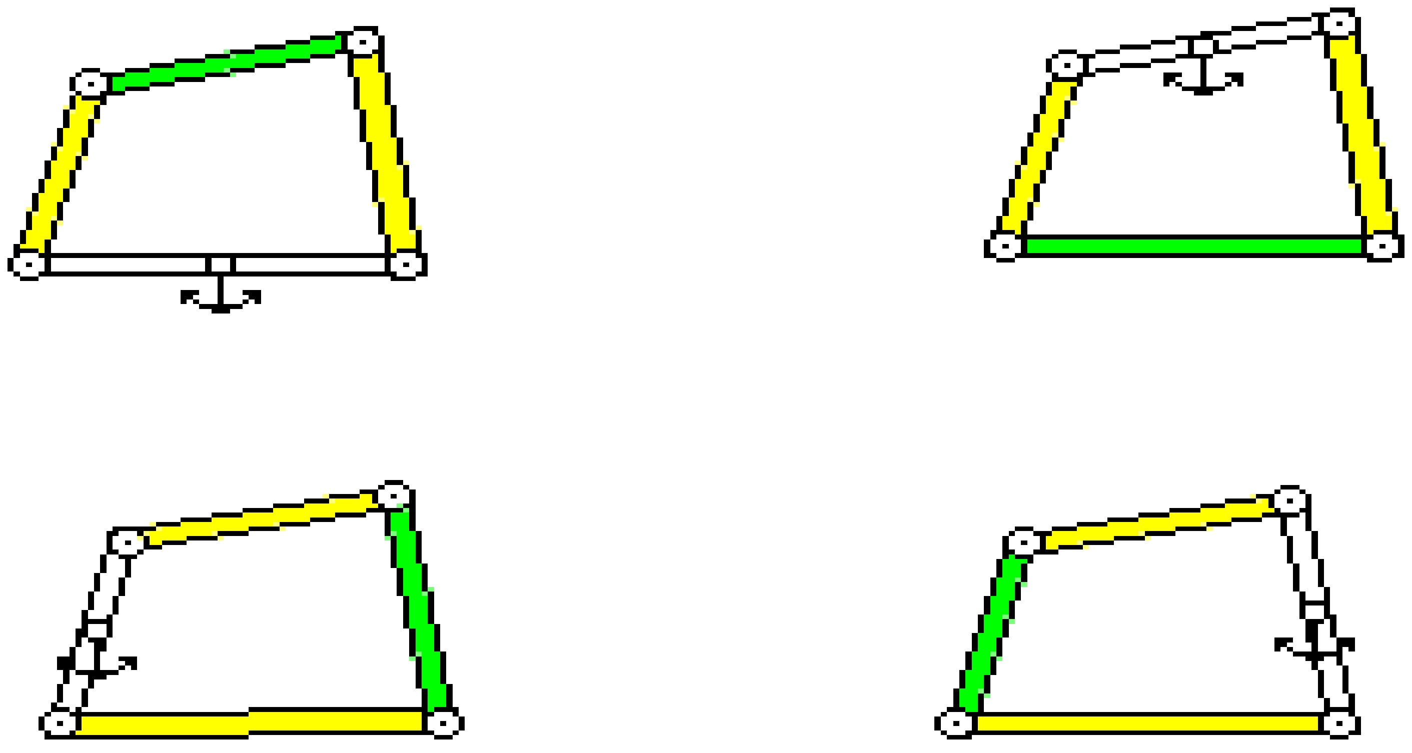

A.
B.
C.
D.
E.
F.
G.
H.
I.
J.
By V.Ryan


C
3
B
B'
4
2
O2
O4
C''
C'
1
B''


B
3
C
2
4
O2
O4
1


Motor
Rain scrubber
a
b


Centre of turning circle



Created for "Design of Machinery, 3rd ed." by R. L. Norton and "The Multimedia Handbook of Mechanical Devices" by S. Wang

inversions_non-grashof

Thank You