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THEORY OF MACHINES

-: By

AMIT KAKKAR SIR

Amit Kakkar Speaks (Telegram Channel)

(YOUTUBE) Channel

- 3-Points [ways to making Easy Life]

1. Have some Patience
2. कुछ बर्दाश्त करना है।
3. बहुत कुछ नजरअंदाज करना है।

- Syllabus → TOM [Gate, Ese, ISRO, DRDO, BARC....]

Kinematics of machines

Kinetics (dynamics) of machine

Mechanical Vibrations

1. Simple Mechanism
2. Motion Analysis
   - ↳ Velocity Analysis
     - I-centre method
     - Relative velocity method
   - ↳ Acceleration Analysis
3. Gears
4. Gear Trains
5. Governors
6. Motion Analysis of Single-Slider Crank Mechanism
7. Flywheels
8. Balancing
9. Gyroscope

- Mechanical Vibrations
- CAM & FOLLOWERS

Mechanical Engineering

↓

Engg. of Mechanics

↓

Study of Motion (DYNAMICS)

(kinematics) ↓ ↓ (Kinetics)

Study of motion without considering the Basic case of motion i.e. Force

$\vec{V} = \frac{d\vec{s}}{dt}$

$\vec{a} = \frac{d\vec{V}}{dt}$

$\vec{j} = \frac{d\vec{a}}{dt}$

Study of motion with the Considering the basic cause of motion i.e. force.

Dynamics Viscosity (μ) → $\frac{N\text{-}S}{m^2}$

Kinematic viscosity (ν) = $\frac{\mu}{\rho}$

$= \frac{m^2}{s}$

- Text Book

→ S.S. Rattan

→ Prof V.P. Singh

- Reference Book (For Teachers)

→ Shigley

→ Norton

→ Thomas Beven

- **Weightage of TOM :→**

GATE → Min 8 marks from TOM

ESE

↳ Prelims : (22-30) Questions of TOM
(150 Total Questions)

↳ Mains : min. 125 marks of TOM
(300 marks of Paper-II)

After Learning Concepts

SIMPLE MECHANISM :→

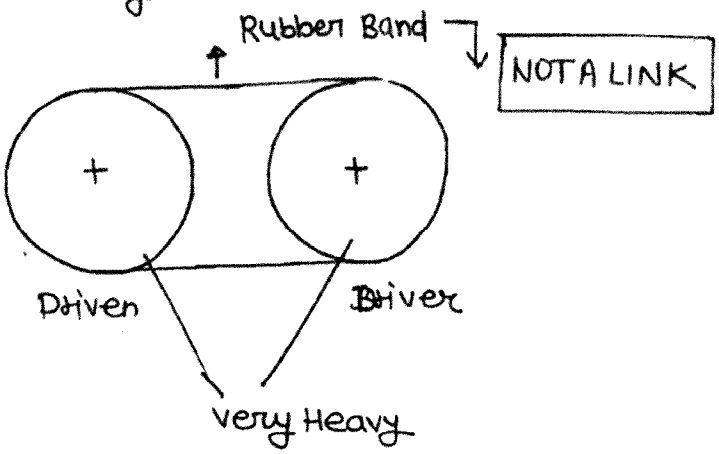
- Kinematic Link / Link / Element / Member :→

" Every Part of a machine which is having some relative motion wrt some other parts will be known as kinematic Link / Link / Element / member."

It is neccessary for the Link to be a Resistant Body so that it is capable of transmitting Power and motion from one element to the other element.

whether a Body is working like Resistant Body or Not, it depends upon
(i) Body itself
(ii) it's Surrounding

for eg

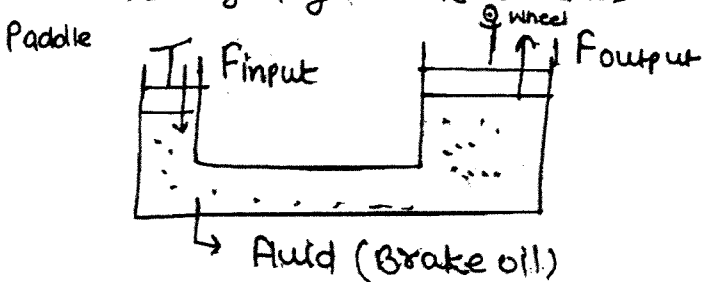


- Types of Links :→

1. Rigid Link → Deformation are Negligible as compared to the size of the Link.
   for eg: crank, connecting Rod, Piston, Cylinder etc.

2. Flexible Link → Deformations are not Negligible as compared to the size of the ~~Link~~ Body (Link).
   for eg: Belt, Rope, chain drives.

3. Fluid Link → (Liquid, Gas) →
   For eg. Hydraulic Brakes



When Power is transmitted because of fluid Pressure.

Other eg:→

- Hydraulic Ram
- Hydraulic Lift
- Hydraulic Jack
- Hydraulic crane

- Different types of [Relative motion]:→

↓

System will be having Two Links

only those two Links will be the Part of system in b/w Relative motion is observed.

- Completely Constrained motion
- Successfully Constrained motion

] Constrained motion → (desired motion) → one & only one output

- Incompletely Constrained motion

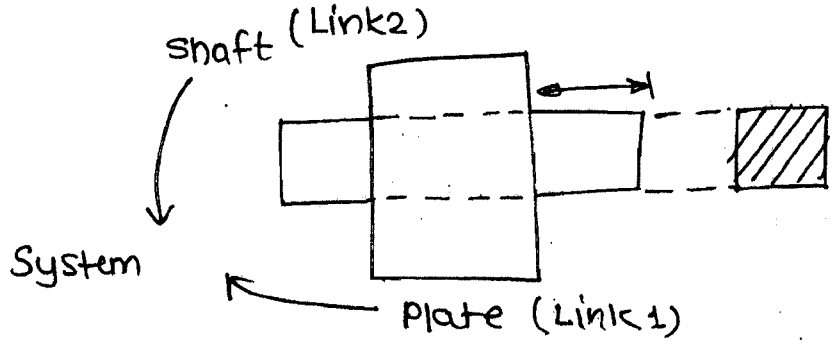
] Unconstrained motion → (Undesired ~~motion~~ output)

- Completely constrained motion:→

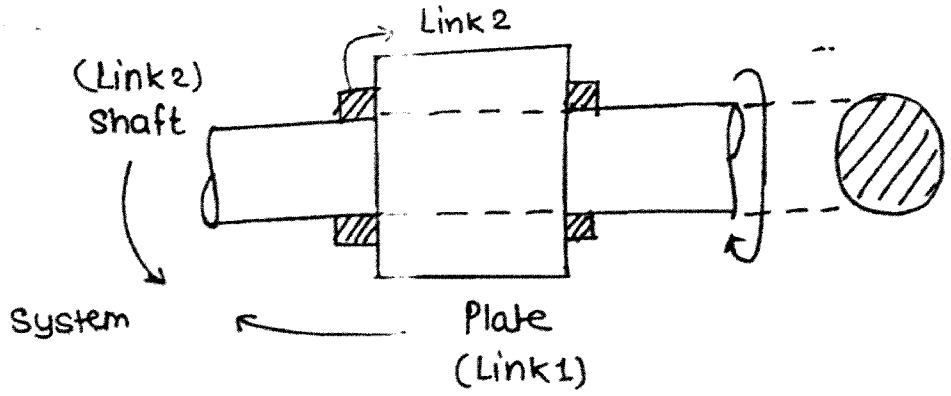
motion is getting constrained by its own Properties (By System)

For Eg

1. Square shaft in Square hole:→



2. circular shaft in circular hole with collars.

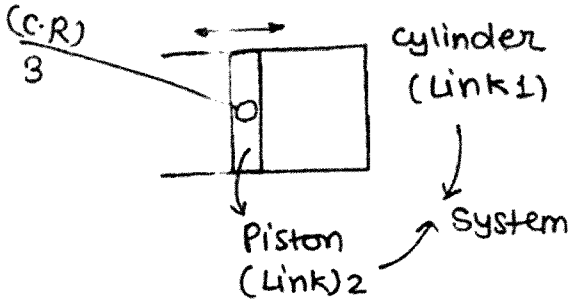


- Successfully constrained motion :→

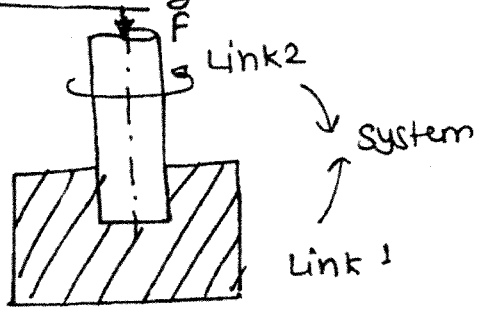
Motion is getting constrained with the help of surroundings

for eg.

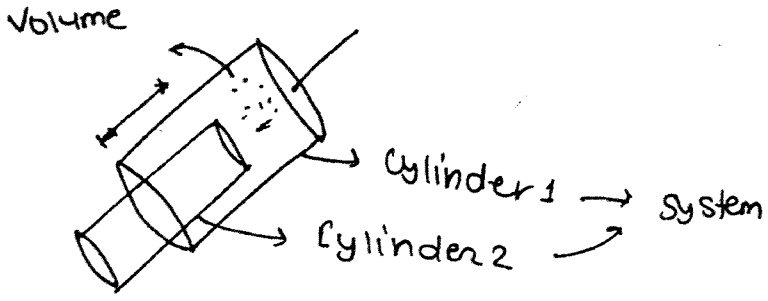
1. Piston inside the cylinder of IC Engine



2. Shaft in foot-step Bearing



3. Syringe →



- **Incompletely constrained motion**

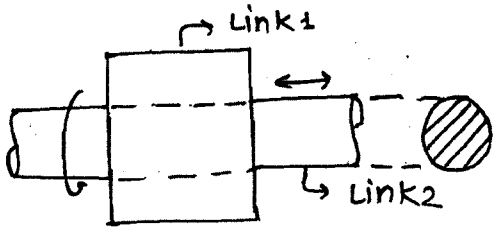
  (unconstrained motion)

  Motion is Not Constrained.

  (More than one Independent output)

foreg

Circular shaft in Circular hole



• Kinematic Pair / Pair / Joint :→

"Any connection b/w the two Links is a kinematic Pair or Pair or a Joint."

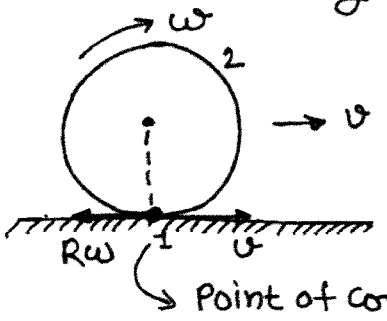
This Pair may be a constrained Pair if the relative motion b/w the Links is constrained or may be a unconstrained Pair if relative motion b/w the Links is unconstrained.

• classification of kinematic Pairs
• According to the type of Relative motion

1. Turning Pair (Revolute Pair) (Pin-Joint) →
   → Relative motion is Pure Turning
   → constrained Pair
   for eg: crank Pin

2. Sliding Pair (Prizmatic Pair) →
   → Relative motion is Pure Sliding
   → Constrained Pair
   for eg: • Piston - cylinder in IC Engine
   • Key - Keyway

3. Rolling Pair →
   → Relative motion is Rolling



• if $\boxed{V = R\omega}$ → Rolling without Slipping (Pure Rolling)
   → Independent motion → only Rotation
   (Constrained Pair)

• if $\boxed{V \neq R\omega}$ → Rolling with Slipping Pair

→ Independent motion ⇉ 02 ⇒ Translation & Rolling
Unconstrained Pair

(4) Screw Pair :→

Relative motion is over the threads.

For eg:

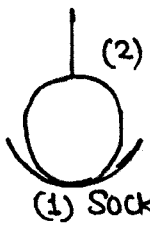
→ Nut - Bolt

→ Bottle - Bottle Cap.

Independent motion → 01 (Rotation)
(Constrained Pair)

(5) Spherical Pair (Ball in Socket joint) →

Relative motion is 3-D Rotation (spherical motion)
(Constrained Pair)



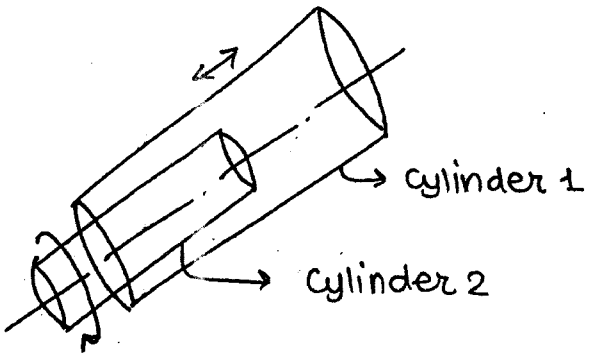
eg. Pen-Stand, Bike mirror, Hip-Joint.

(6) Cylindric Pair →

Relative motion b/w two Co-axial Cylinder in Contact.
(Unconstrained Pair)

Independent ~~Pair~~ motion → 02 (Translation & Rotation)

for eg: Door - Bolt



7. Flat Pair →

Relative motion b/w two flat Surfaces in contact

Independent motions → 03 (2 Translation + 1 Rotation)

For eg: mouse - mouse Pad

[B] According to the type of Contact:

1. Lower Pair (LP)

Surface contact → Area contact

for eg:

- Turning Pair , • Sliding Pair , • Screw Pair , • Spherical Pair
- Cylindrical Pair , • Flat Pair

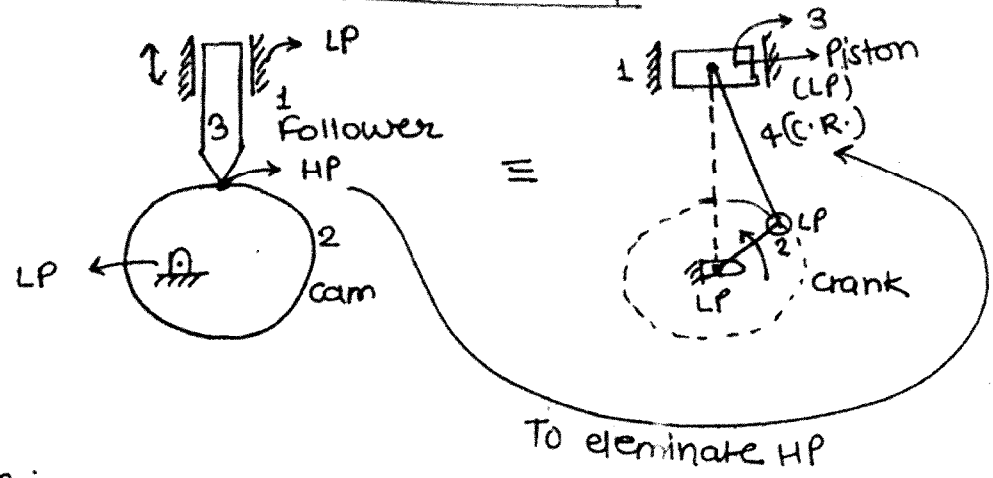
2. Higher Pair (HP)

Point or Line contact → zero Area contact

for eg:

- Rolling Pair
- Pair b/w cam & follower.

1 Higher Pair ≡ 2 Lower Pair



3. Wrapping Pair

- When one Link is wrapped over other Link

for wrapping Pair

↳ one of the Link must be flexible

for eg

Belt - Pulley
Rope - Pulley
chain - Sprocket

multiple Point Contact exists

↓

This Pair is Very close to Higher Pair

[C] According to the type of closure:

1. Self closed Pair (closed Pair)
   ↳ Permanent connection

   No external force is required to maintain the connection.

   for eg:
   - Turning Pair
   - Sliding Pair
   - Rolling Pair

2. Force closed Pair (open Pair):-
   ↳ Forceful connection

   continous force is required to maintain the connection.

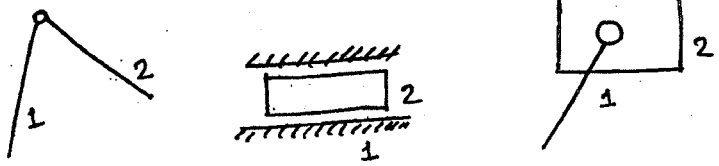
   for eg:
   - Pair b/w cam & follower
   - Door closer
   - Automatic clutch operating system.

- Different types of Joints / Pairs :→

  [ONLY FOR LOWER PAIRS]

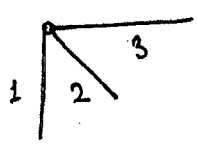
1. Binary joint :→

   Where two Links are Connected.



2. Ternary Joint :→

   Where three Links are Connected

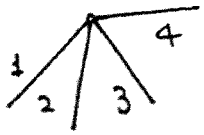


* (1,2) → B
* (2,3) → B
  (3,1) → B

1 Ternary joint ≡ 2 Binary joint *

3. Quaternary joint :→

where four Links are connected.



(1,2) (1,3) (1,4)
(2,3) (2,4)
(3,4)

1 Quaternary Joint ≡ 3 Binary Joints

NOTE:→

In our further more studies, all the lower Pair will be Counted as the effective no of binary joints (J)

- Kinematic chain :→ (Constrained chain)

" If all the Links are connected in such a way such that first Link is connected to the Last Link in order to have close chain and if all the relative motions in this close chain are Constrained then such a chain is known as kinematic chain "