Kinematics Machines (NME-502)

KINEMATICS OF MECHINERY

- Unit I -Linkage and Mechanism,
  . -Velocity in Mechanism
- Unit – II – Accelerations in Mechanism
  - Mechanism of Lower Pairs
- Unit III- Friction
- Unit – IV – Cams
- Unit – V – Gears

Unit I

UNIT I

Introduction

Links-types, Kinematics pairs-classification, Constraints-types, Degrees of freedom of planar mechanism, Grubler's equation, linkage mechanisms, inversions of four bar chain, slider crank chain and double slider crank chain

Velocity in Mechanisms

Velocity of point in mechanism, relative velocity method, Velocities in four bar mechanism, slider crank mechanism and quick return motion mechanism, Rubbing velocity at a pin joint, Instantaneous center method, Types & location of instantaneous centers, Kennedy's theorem, Velocities in four bar mechanism & slider crank mechanism

Unit II

UNIT II

Acceleration in Mechanisms

Acceleration of a point on a link, Acceleration diagram, Coriolis component of acceleration, Crank and slotted lever mechanism, Klein's construction for Slider Crank mechanism and Four Bar mechanism, Analytical method for slider crank mechanism

Mechanisms with Lower Pairs

Pantograph, Exact straight line motion mechanisms-Peaucellier's, Hart and Scott Russell mechanisms, Approximate straight line motion mechanisms–Grass-Hopper, Watt and Tchebicheff mechanisms, Analysis of Hooke's joint, Davis and Ackermann steering gear mechanisms.

Unit III

UNIT III

FRICTION

Laws of friction, Friction on inclined plane, Efficiency on inclined plane, Friction in journal bearing-friction circle, Pivots and collar friction-uniform pressure and uniform wear, Belt and pulley drive, Length of open and cross belt drive, Ratio of driving tensions for flat belt drive, centrifugal tension, condition for maximum power transmission, V belt drive

Brakes & Dynamometers

Shoe brake, Band brake, Band and Block brake, Absorption and transmission type dynamometers

Unit IV

UNIT IV

CAMS

Cams and Followers - Classification & terminology, Cam profile by graphical methods with knife edge and radial roller follower for uniform velocity, simple harmonic and parabolic motion of followers, Analytical methods of cam design – tangent cam with roller follower and circular cams with flat faced follower

Unit V

UNIT V

Gears & Gear Trains

Classification & terminology, law of gearing, tooth forms & comparisons, Systems of gear teeth, Length of path of contact, contact ratio, interference & under cutting in involute gear teeth, minimum number of teeth on gear and pinion to avoid interference, simple, compound, reverted and planetary gear trains, Sun and planet gear.

Books and References:

Books

Theory of Machines(TMH Pub) : SS Rattan

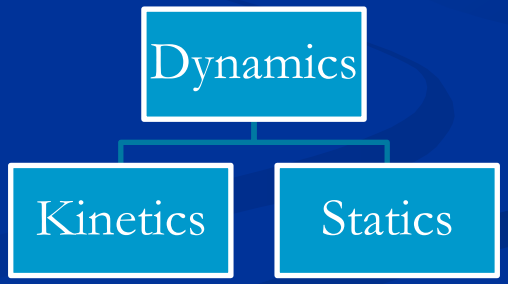
Theory of Machines(Khanna Pub) : R S Khurmi

Theory of Machines(TMH Pub) : Sadhu Singh

Theory of Machines(TMH Pub) : V P Singh

Unit – I-Linkage and Mechanism

- The world, and everything in it, moves.
- **Kinematics**: describes motion.
- **Dynamics**: deals with the cause of motion.



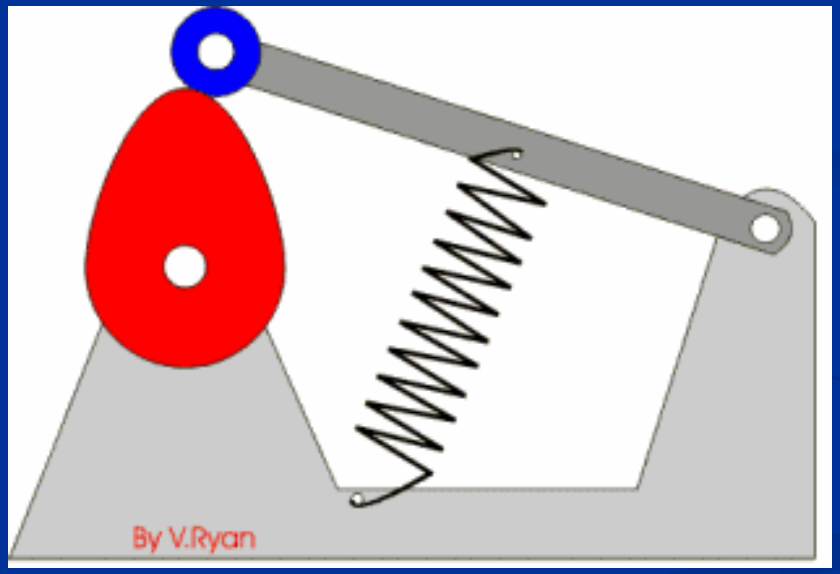
- Rigid and Resistant bodies

MECHANISM

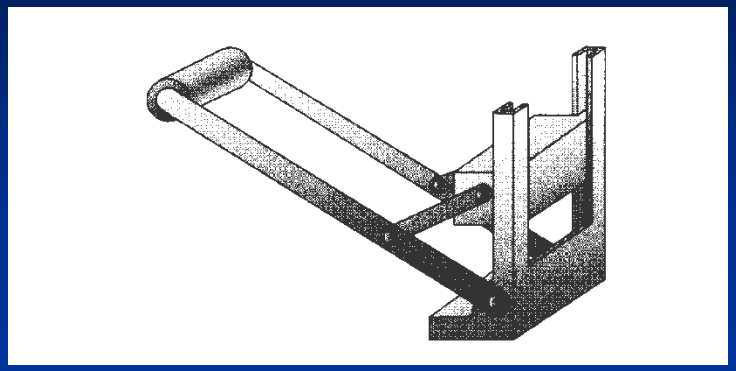
Mechanism – It is a number of bodies assembled in such a way that the motion of one causes constrained and predictable motion of others, it is known as machanism

Example for Mechanism

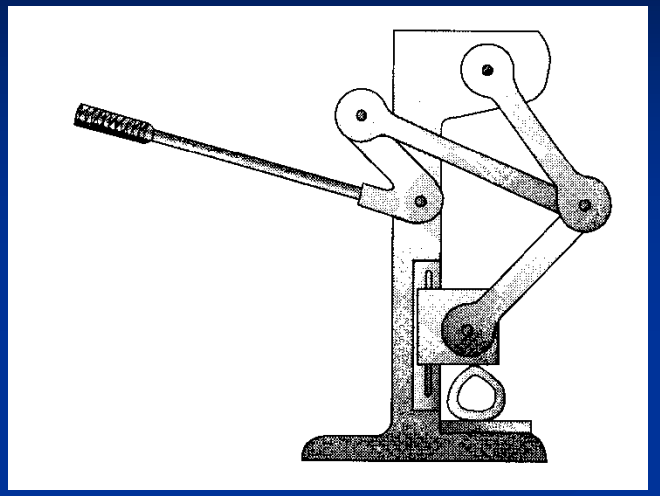
Example for Mechanism



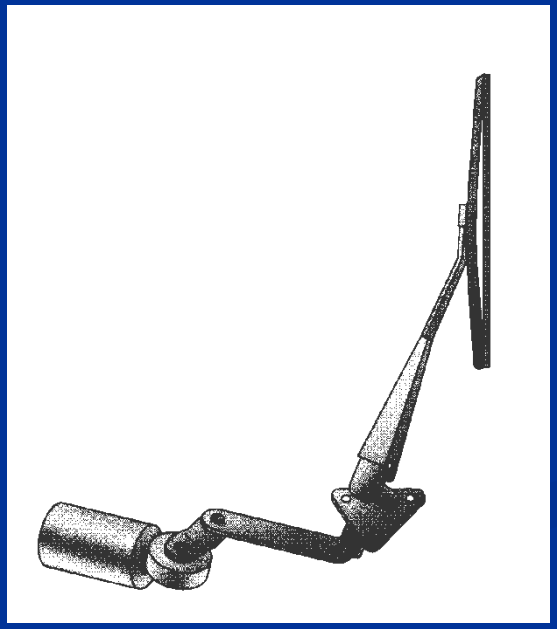
Example of Mechanism



Can crusher

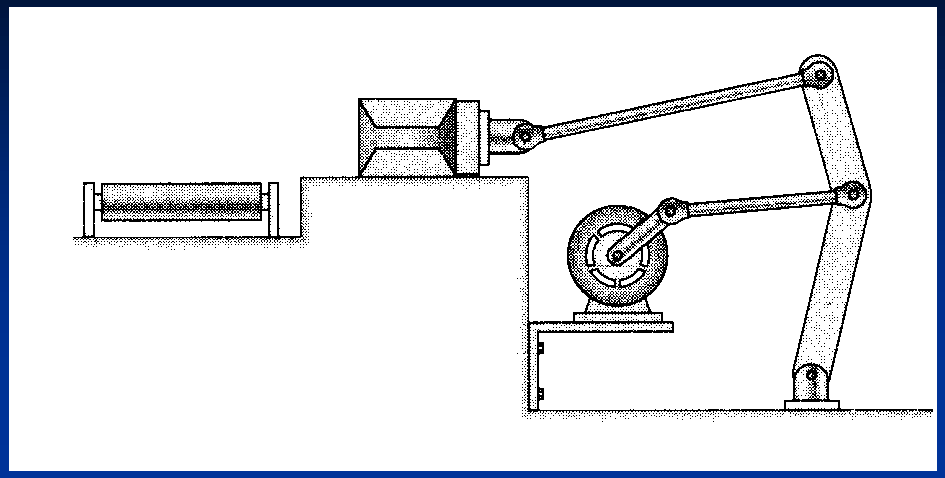


Simple press

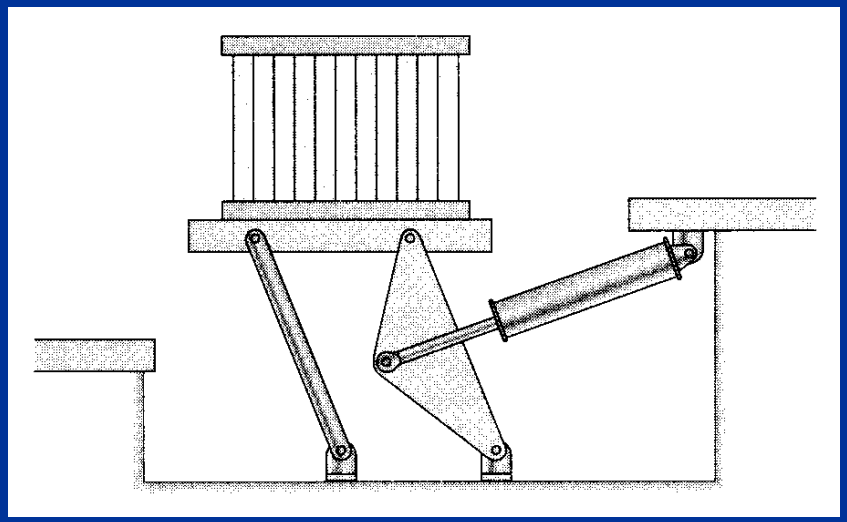


Rear-window wiper

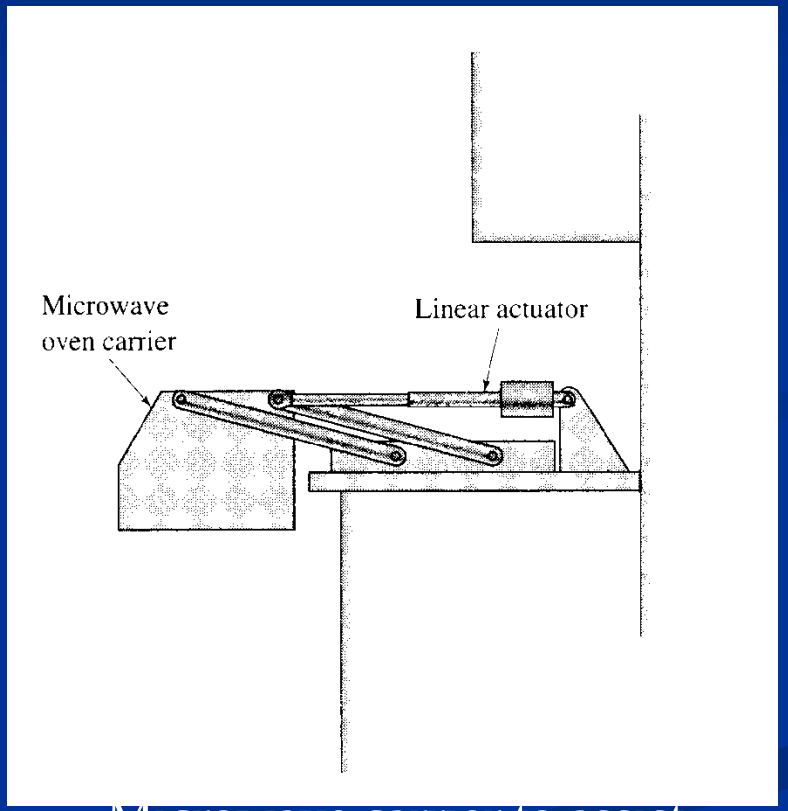
Example of Mechanisms



Moves packages from an assembly bench to a conveyor

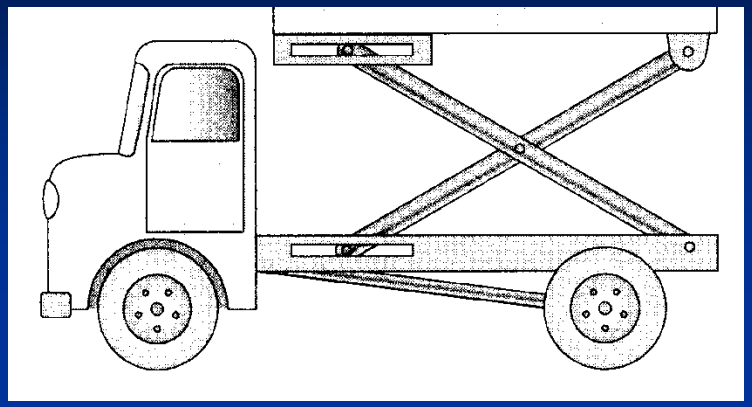


Lift platform

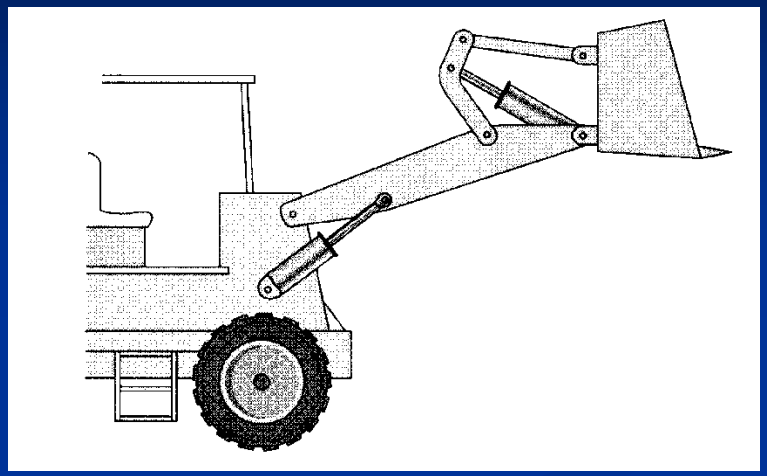


Microwave carrier to assist people on wheelchair

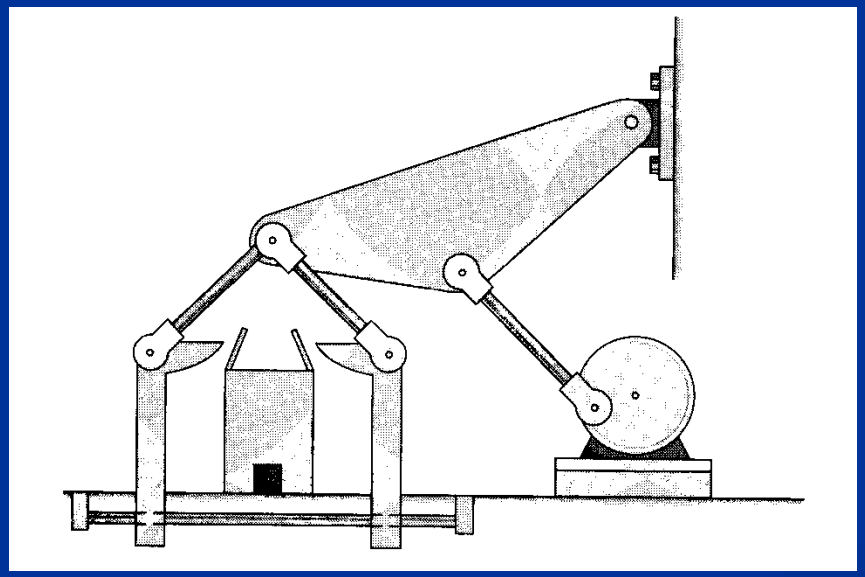
Example of Mechanisms



Lift platform

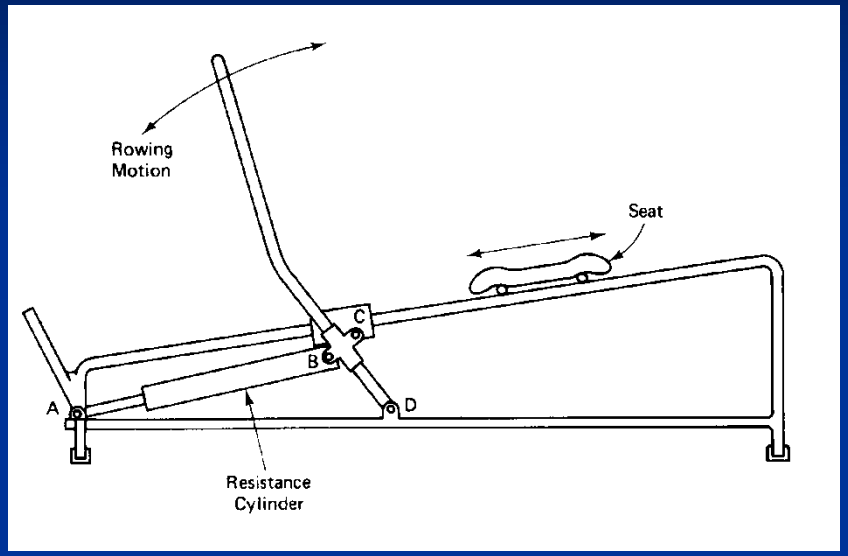


Front loader

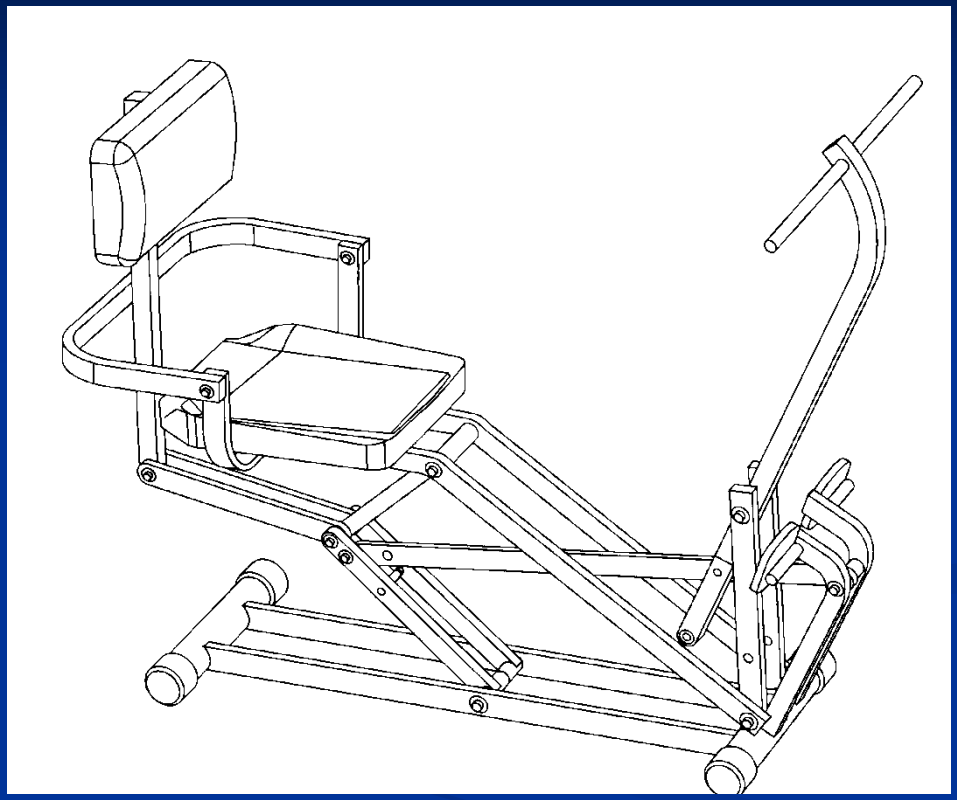


Device to close the top flap of boxes

Example of Mechanisms



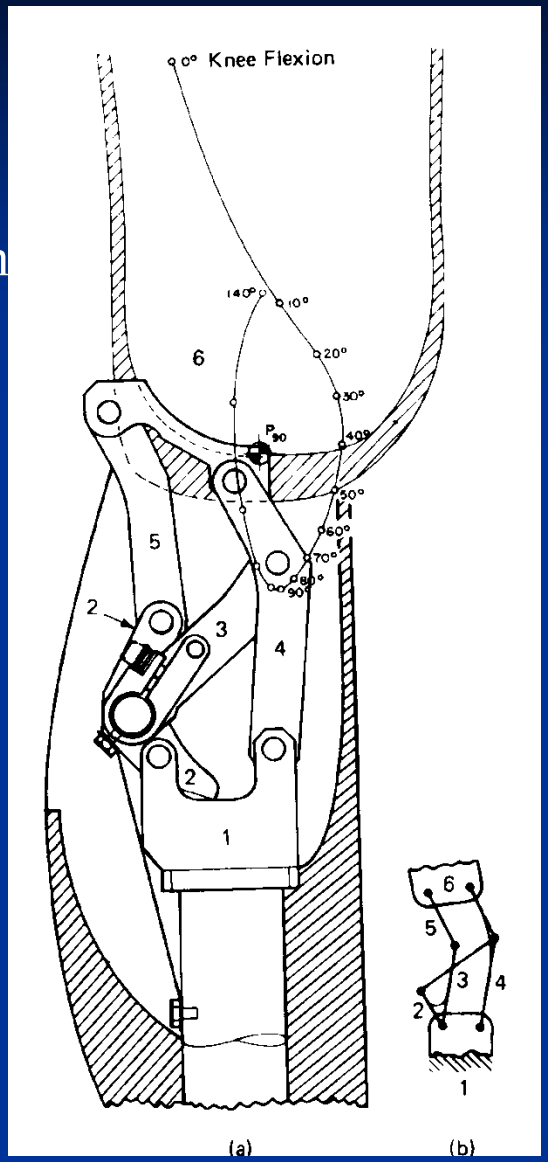
Rowing type exercise machine

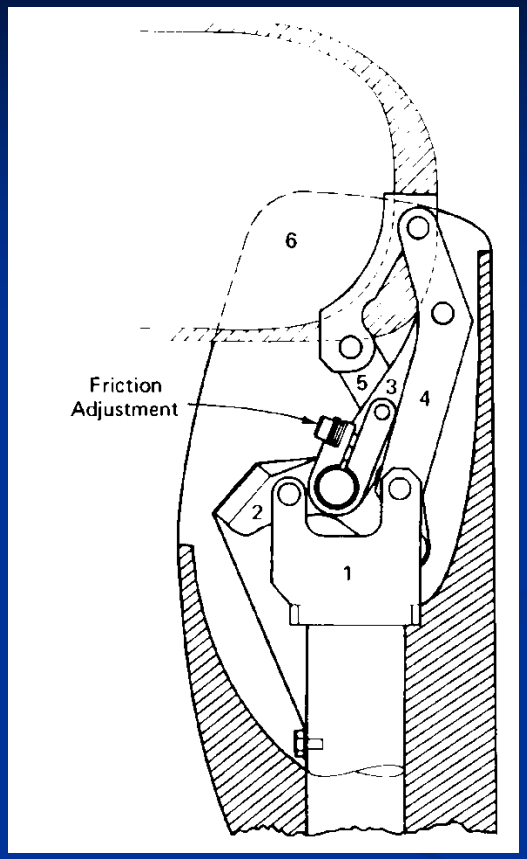


Conceptual design for an exercise machine

Example of Mechanisms

Extension position

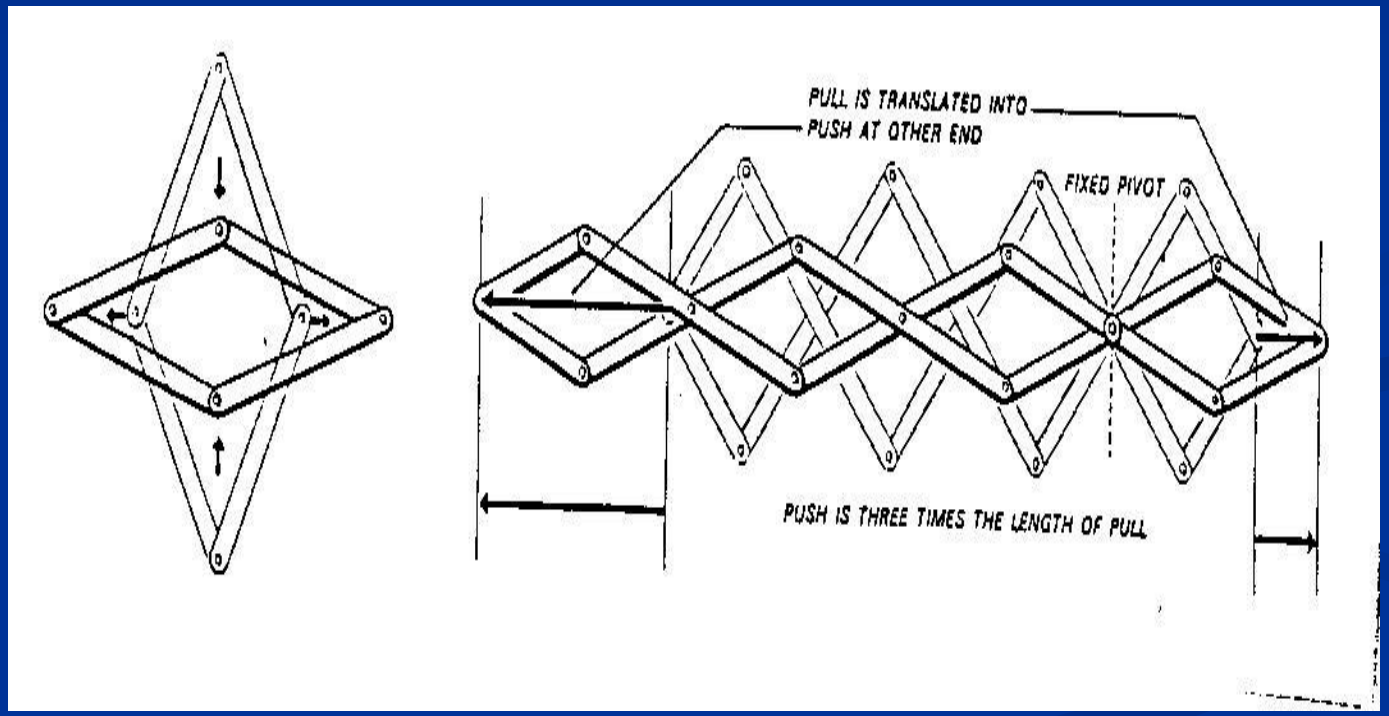




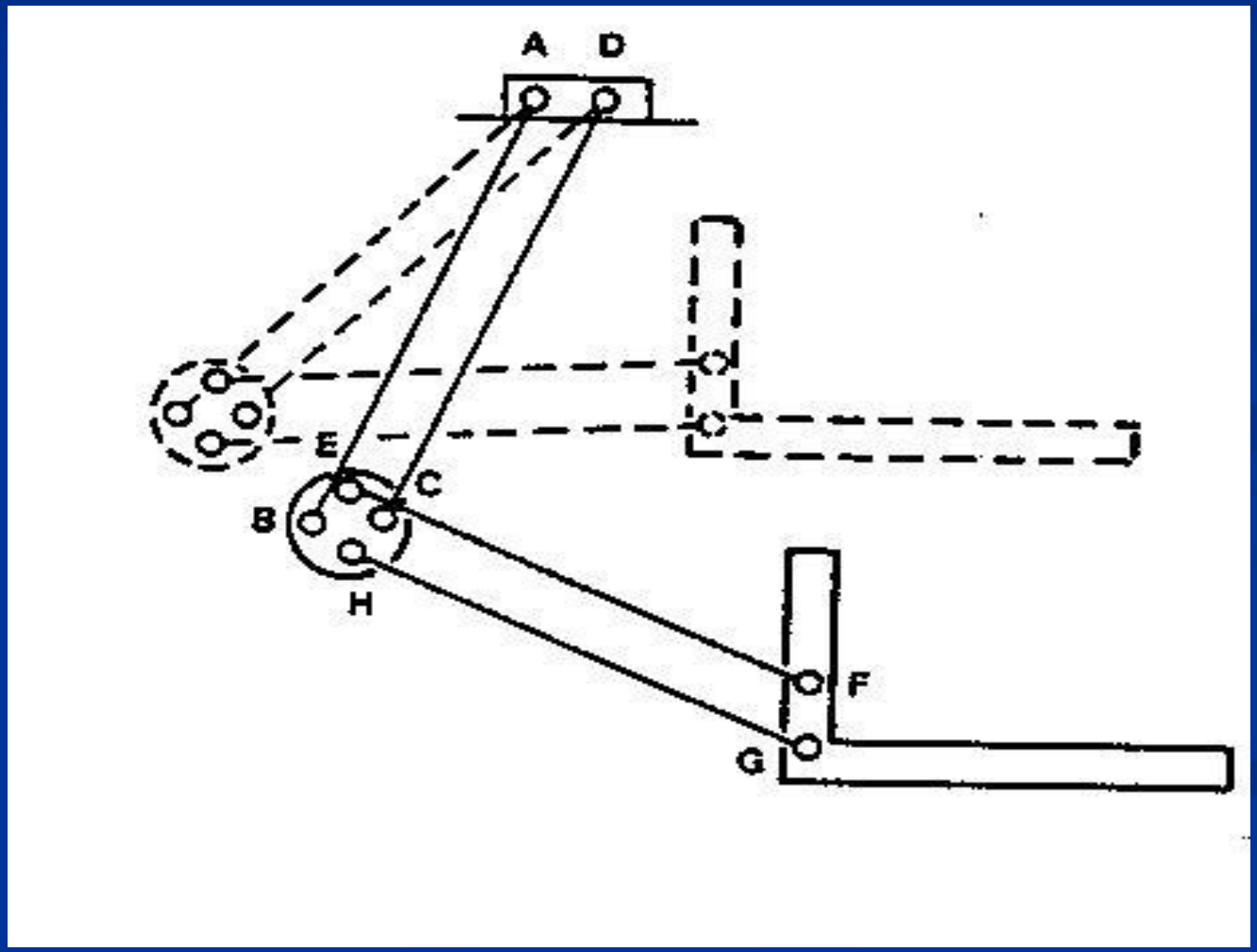
Flexed position

Six-bar linkage prosthetic knee mechanism

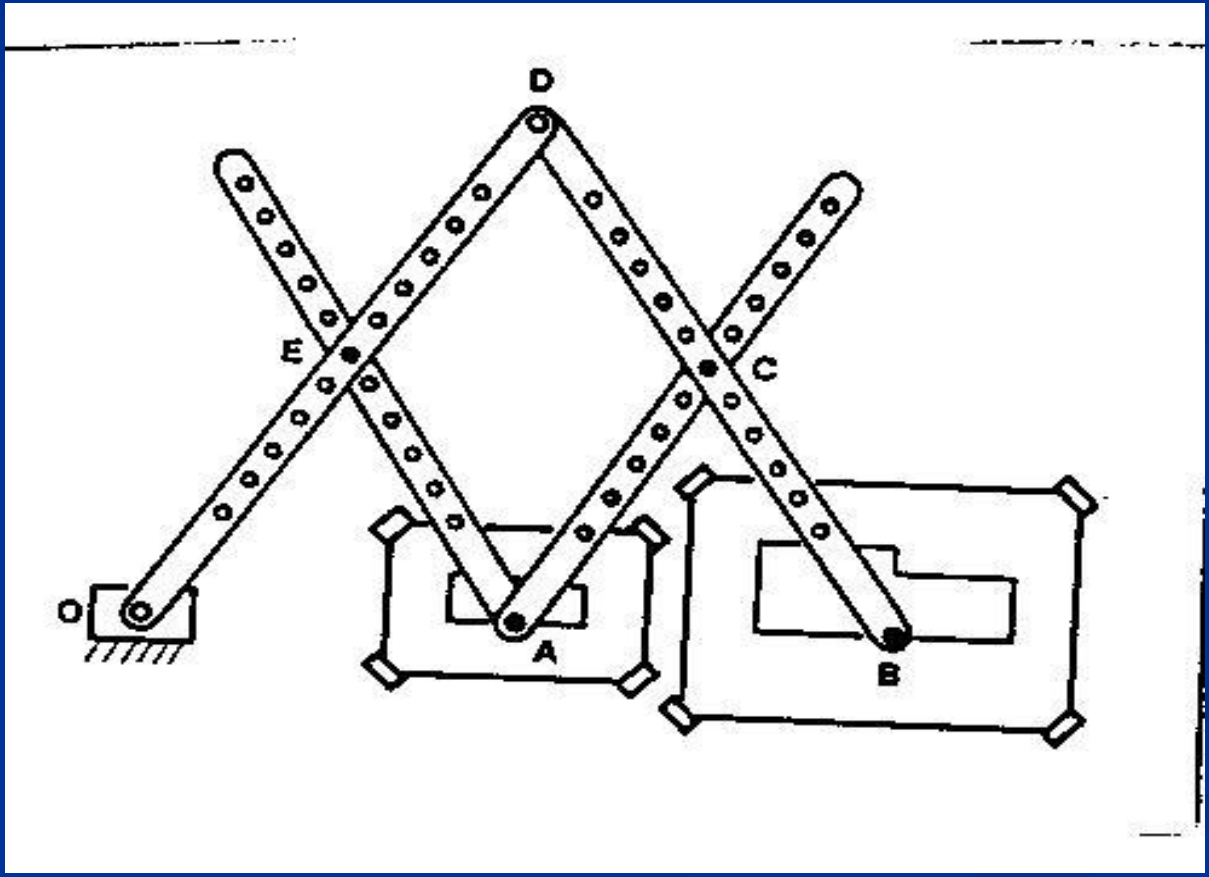
Tongs


PULL IS TRANSLATED INTO
PUSH AT OTHER END
FIXED PIVOT
PUSH IS THREE TIMES THE LENGTH OF PULL

Drafting Mechanism



Pantograph



PLANAR MECHANISMS

When all the links of a mechanism have plane motion, it is called as a planar mechanism. All the links in a planar mechanism move in planes parallel to the reference plane.

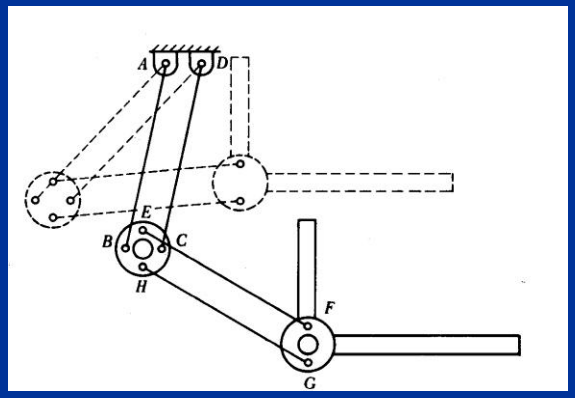
MACHINE

A machine is a mechanism or collection of mechanisms, which apart from imparting motion of the parts also transmits and modifies the available mechanical energy into some kind of useful work.

The *difference* between *machine* and *mechanism* is that machines transform energy to do work, while mechanisms do not necessarily perform this function.

All machines are mechanisms. But all mechanisms are not machines.

Though all machines are mechanisms, all mechanisms are not machines



Structure

- It is an assemblage of a number of resistant bodies (known as members) having no relative motion between them and meant for carrying loads having straining action. A railway bridge, a roof truss, machine frames etc., are the examples of a structure.

Difference Between a Machine and a Structure

The following differences between a machine and a structure are important from the subject point of view :

1. The parts of a machine move relative to one another, whereas the members of a structure do not move relative to one another.

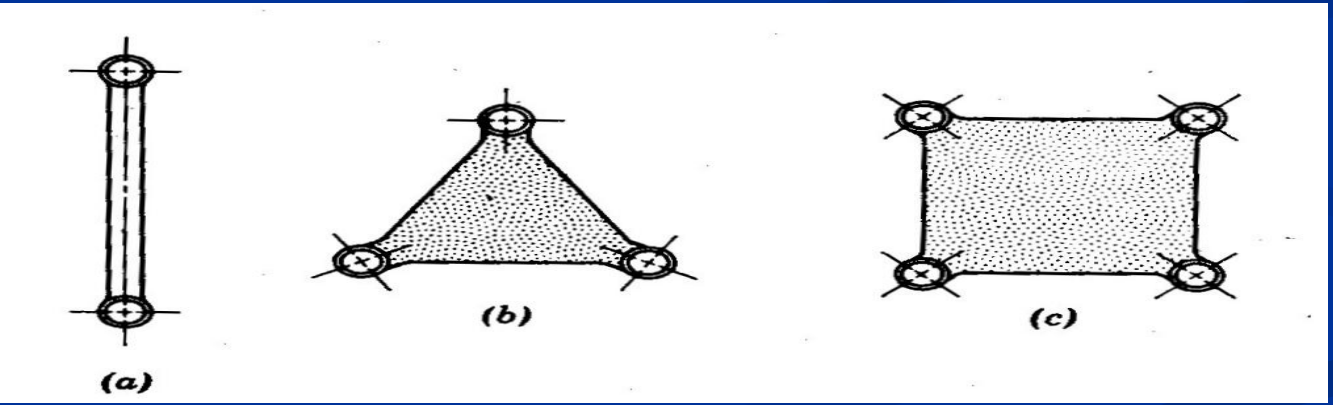
2. A machine transforms the available energy into some useful work, whereas in a structure no energy is transformed into useful work.

3. The links of a machine may transmit both power and motion, while the members of a structure transmit forces only.

Kinematic Link(Resistant Body)

Binary link: Link which is connected to other links at two points. (Fig.a)

Ternary link: Link which is connected to other links at three points. (Fig.b)
Quaternary link: Link which is connected to other links at four points. (Fig. c)

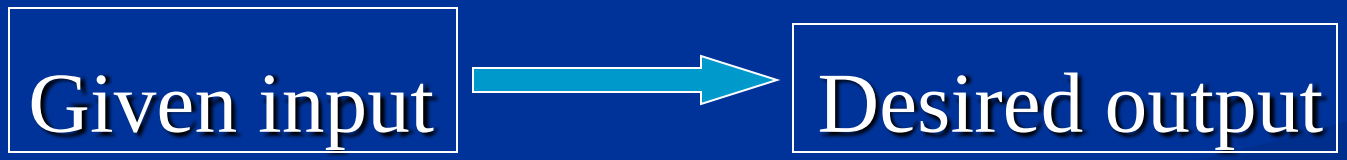


RELEVANCE OF KINEMATIC STUDY

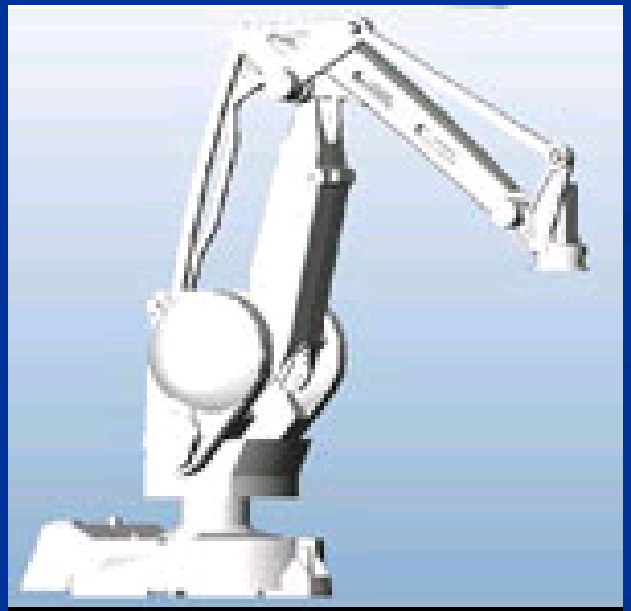
- Motion requirements
- Design requirements

MOTION STUDY

Study of position, displacement, velocity and acceleration of different elements of mechanism



Motion requirement



The 4 Axis Packing Robot

DESIGN REQUIREMENTS

Design: determination of shape and size

1. Requires knowledge of material
2. Requires knowledge of stress

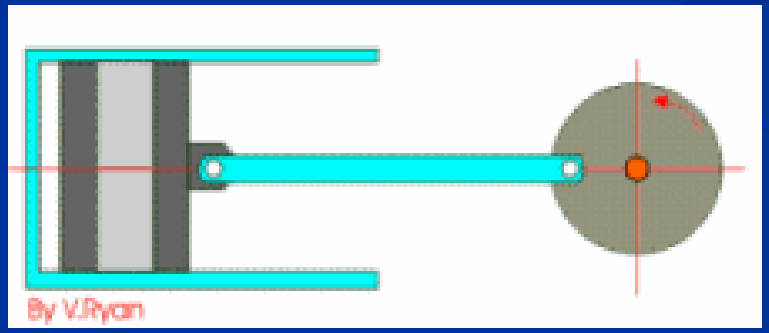
Requires knowledge of load acting

(i) static load

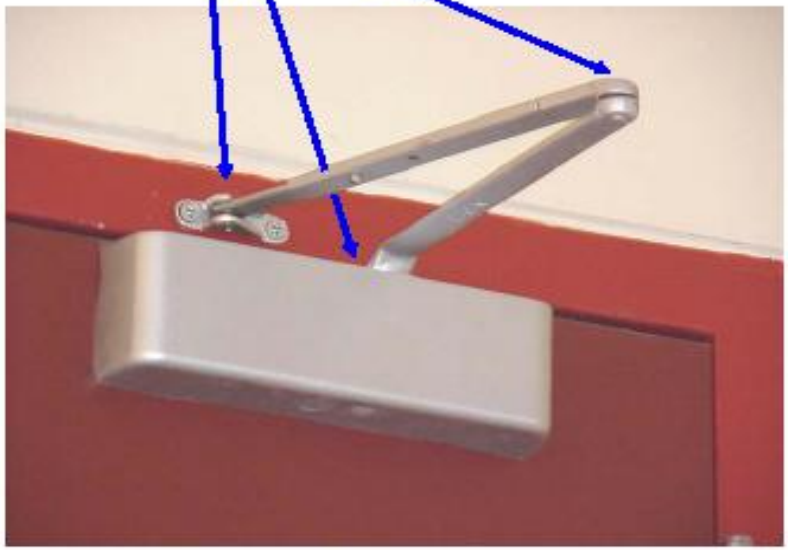
(ii) dynamic/inertia load

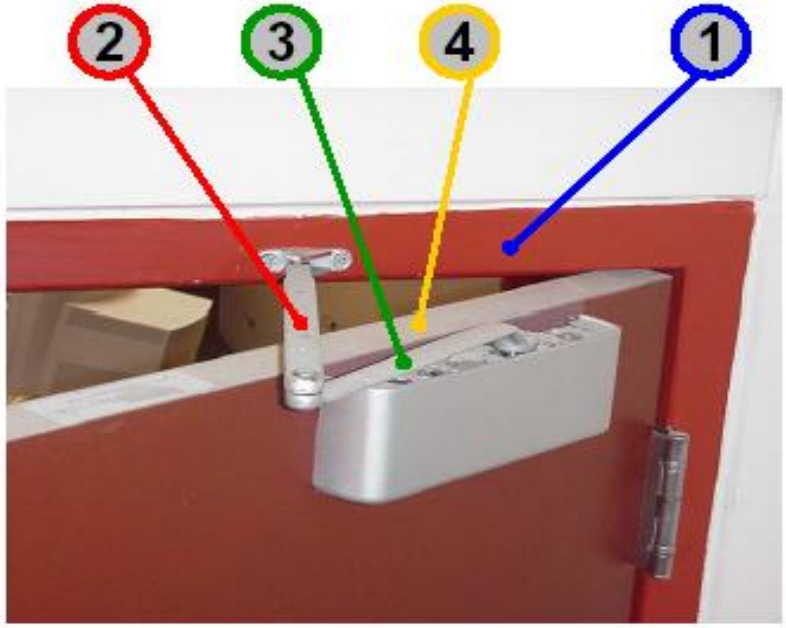
DYNAMIC/INERTIA LOAD

Inertia load require acceleration



Example: 4 bar door damper linkage



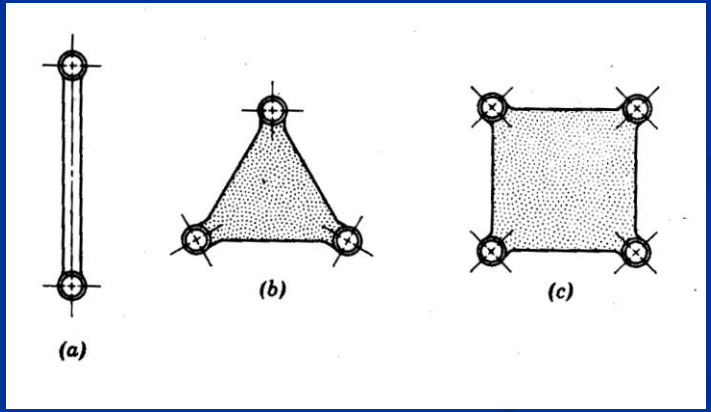


1	= Wall	or	Link 1	This is the grounded (held still)
2	= Bar 2	or	Link 2	
3	= Bar 3	or	Link 3	
4	= Door	or	Link 4	

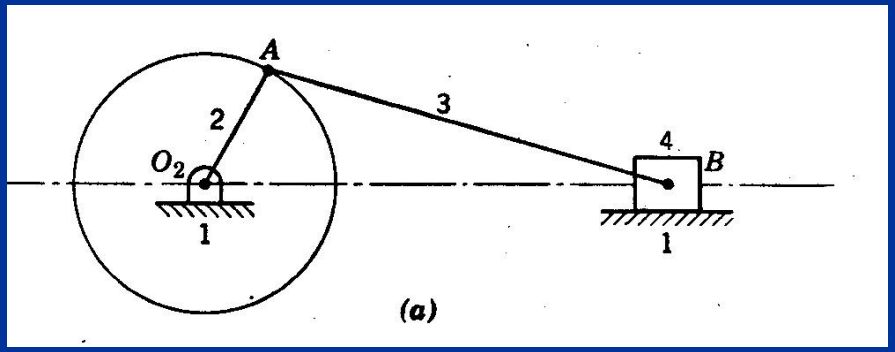
LINK OR ELEMENT

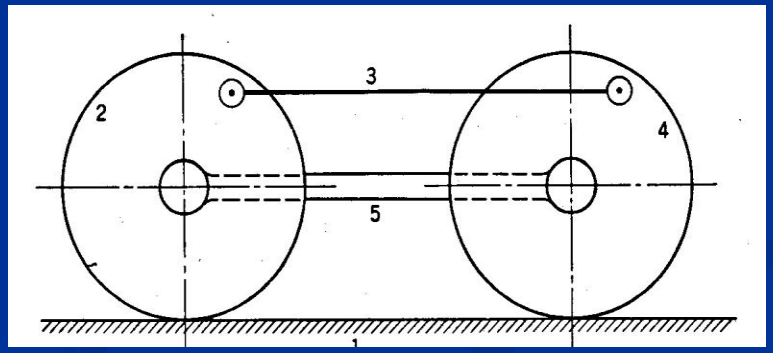
Any body (normally rigid) which has motion relative to another

- **Binary link**
- **Ternary link**
- **Quaternary link**



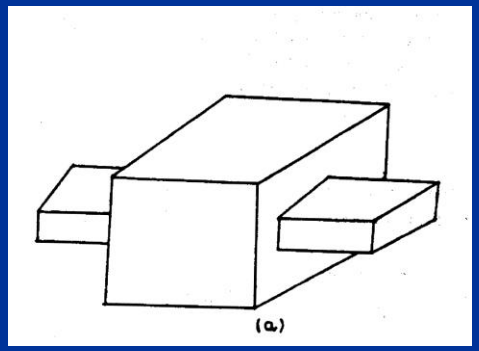
Examples of rigid links

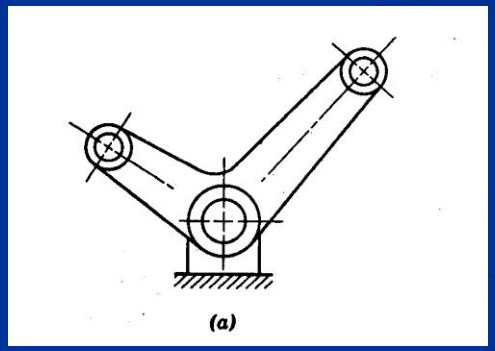




PAIRING ELEMENTS

Pairing elements: the geometrical forms by which two members of a mechanism are joined together, so that the relative motion between these two is consistent. Such a pair of links is called **Kinematic Pair**.





KINEMATIC PAIRS

- A mechanism has been defined as a combination so connected that each moves with respect to each other. A clue to the behavior lies in in the nature of connections, known as kinetic pairs. The degree of freedom of a kinetic pair is given by the number independent coordinates required to completely specify the relative movement.

TYPES OF KINEMATIC PAIRS

Based on nature of contact between elements

- (i) **Lower pair** : Surface or Area contact. Its 6 types are

Revolute(Or)TurningPair

Prismatic(Or)SlidingPair

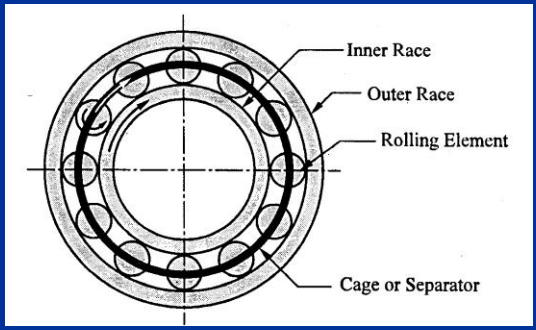
Screw(Or)HelicalPair

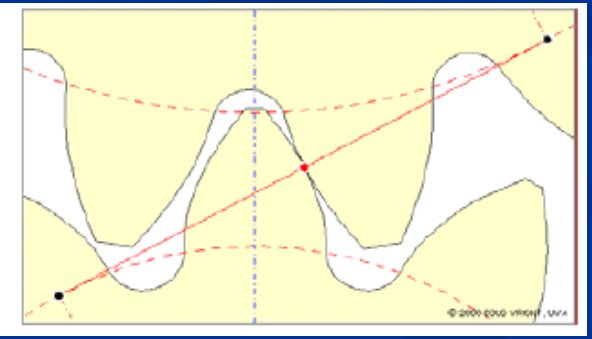
CylindricalPair

Spherical(Or)GlobularPair

Flat(or)PlanarPair

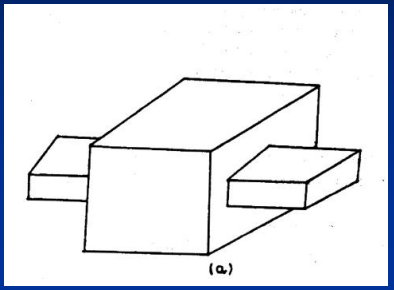
(ii) Higher pair: The contact between the pairing elements takes place at a point or along a line.



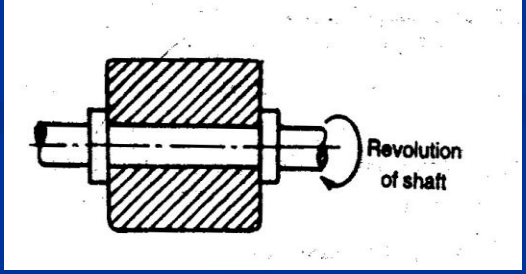


Based on relative motion between pairing elements

(a) Siding pair [DOF = 1]



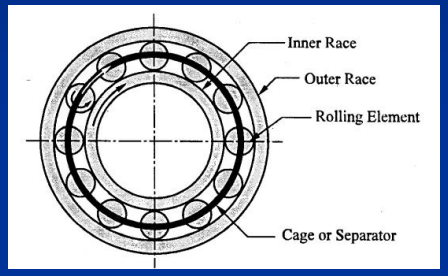
(b) Turning pair (revolute pair) [DOF = 1]

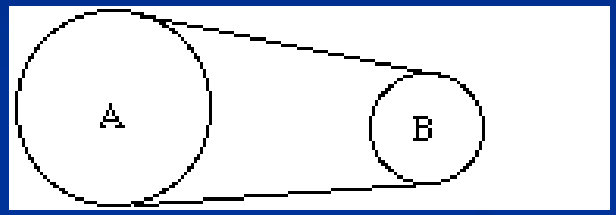


Based on relative motion between pairing elements

(c) Rolling pair

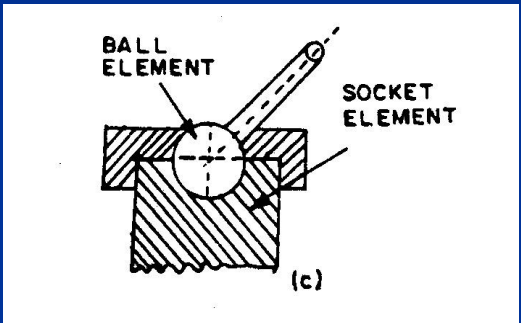
[DOF = 1]



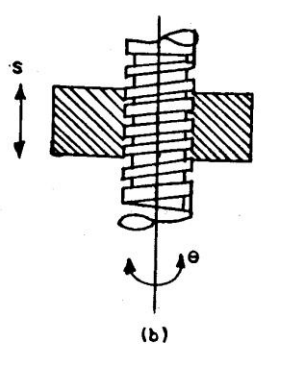


Based on relative motion between pairing elements

(d) Spherical pair [DOF = 3]

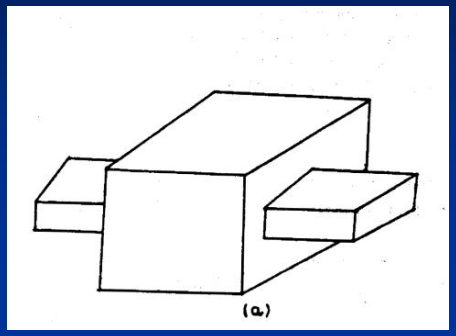


(e) Helical pair or screw pair [DOF = 1]

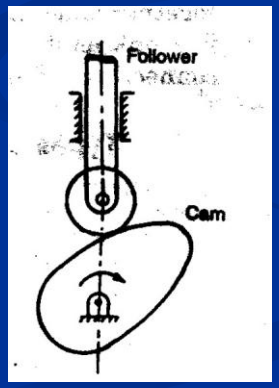


Based on the nature of mechanical constraint

(a) Closed pair



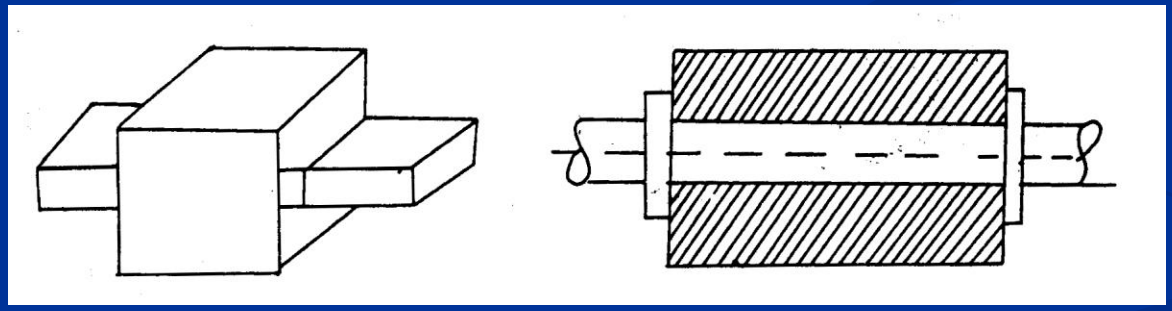
(b) Unclosed or force closed pair



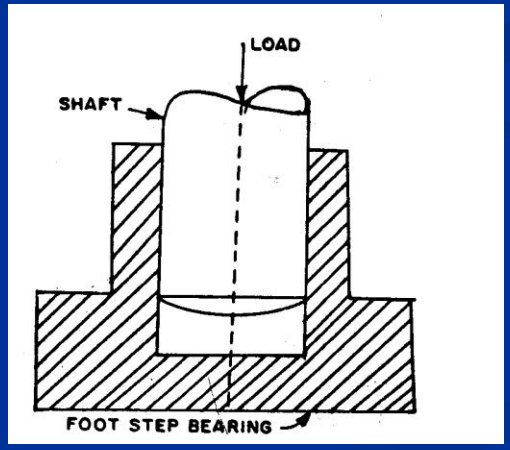
CONSTRAINED MOTION

one element has got only one definite motion relative to the other

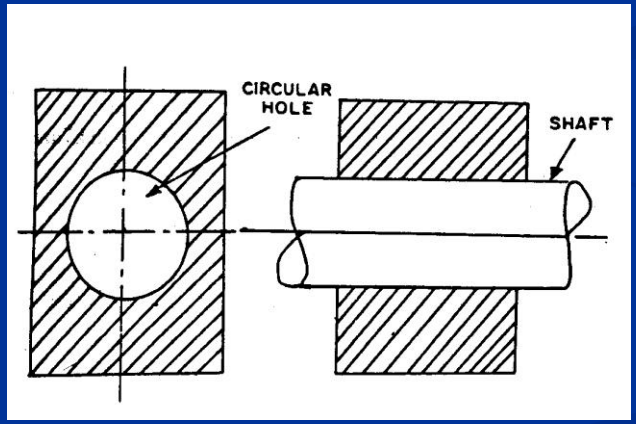
(a) Completely constrained motion



(b) Successfully constrained motion



(c) Incompletely constrained motion



KINEMATIC CHAIN

Group of of links connected in closed loop such that the first link is attached to last link and each link moves relative to another link in a constrained manner

Kinematic Chain

Relation between Links and Joints

$J=(3/2)\,n-2$

L => No of Links
n => No of Joints

L.H.S > R.H.S => Locked chain(Structure)
L.H.S = R.H.S => Kinematic Chain
L.H.S < R.H.S => Redundant Chain