



Al-Mustaqbal University / College of Technical Engineering  
Department (Mechanical Power Technology)  
Class (Third)  
Subject (Theory of Machine)  
Lecturer (Prof. Dr. Salwan Khafaji)  
2<sup>nd</sup> term – 1- Intorduction



# Theory of Machines



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## 1.1 Introduction

**Mechanics:** It is that branch of scientific analysis which deals with motion, time and force.

**Kinematics** is the study of motion, without considering the forces which produce that motion. Kinematics of machines deals with the study of the relative motion of machine parts. It involves the study of position, displacement, velocity and acceleration of machine parts.

**Dynamics** of machines involves the study of forces acting on the machine parts and the motions resulting from these forces.

**Plane motion:** A body has plane motion, if all its points move in planes which are parallel to some reference plane. A body with plane motion will have only three degrees of freedom. I.e., linear along two axes parallel to the reference plane and rotational/angular about the axis perpendicular to the reference plane. (eg. linear along X and Z and rotational about Y.)The reference plane is called plane of motion. Plane motion can be of three types. 1) Translation 2) rotation and 3) combination of translation and rotation.

### Kinematic link (or) element

A machine part or a component of a mechanism is called a kinematic link or simply a link. A link is assumed to be completely rigid, or under the action of forces it does not suffer any deformation, signifying that the distance between any two points on it remains constant. Although all real machine parts are flexible to some degree, it is common practice to assume that deflections are negligible and parts are rigid when analyzing a machine's kinematic performance.

### Types of link

#### (a) Based on number of elements of link:

**Binary link:** Link which is connected to other links at two points. (Fig.1.3 a)

**Ternary link:** Link which is connected to other links at three points. (Fig.1.3 b)

**Quaternary link:** Link which is connected to other links at four points. (Fig.1.3 c)

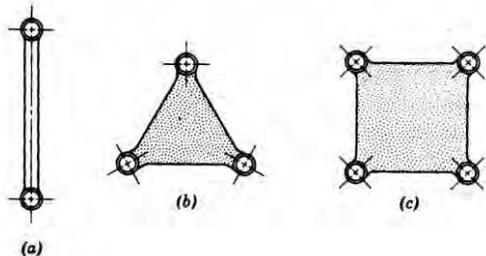


Fig.1.3



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Sometimes, a machine member may possess one-way rigidity and is capable of transmitting the force in one direction with negligible deformation. Examples are (a) chains, belts and ropes which are resistant to tensile forces, and (b) fluids which are resistant to compressive forces and are used as links in hydraulic presses, brakes and jacks. In order to transmit motion, the driver and the follower may be connected by the following three types of links:

1. **Rigid link.** A rigid link is one which does not undergo any deformation while transmitting motion. Strictly speaking, rigid links do not exist. However, as the deformation of a connecting rod, crank etc. of a reciprocating steam engine is not appreciable, they can be considered as rigid links.
2. **Flexible link.** A flexible link is one which is partly deformed in a manner not to affect the transmission of motion. For example, belts, ropes, chains and wires are flexible links and transmit tensile forces only.
3. **Fluid link.** A fluid link is one which is formed by having a fluid in a receptacle and the motion is transmitted through the fluid by pressure or compression only, as in the case of hydraulic presses, jacks and brakes.

#### 1.4 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.

**Machine:** A machine is a mechanism or collection of mechanisms, which transmit force from the source of power to the resistance to be overcome. Though all machines are mechanisms, all mechanisms are not machines. Many instruments are mechanisms but are not machines, because they do no useful work nor do they transform energy.

#### Difference between structure & machine

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 transmits forces only.



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M		
1. Ther motion between the parts of a mechanism	between parts of a machine.	motion between the members of a structure. It is rigid as a whole.
2. A mechanism modifies and transmits motion.	A machine consists of one or more mechanisms and hence transforms motion	A structure does not transform motion.
3. A mechanism does not transmit forces and does not do work	A machine modifies energy or do some work	A structure does not do work. It only transmits forces.
4. Mechanisms are dealt with in kinematics.	Machines are dealt with in kinetics.	Structures are dealt with in statics.

### 1.6 Kinematic pair

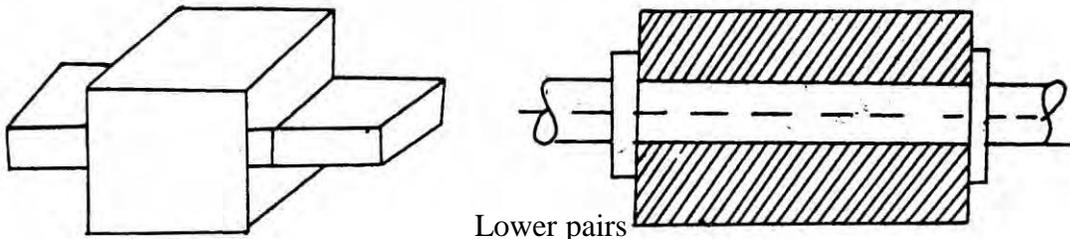
The two links or elements of a machine, when in contact with each other, are said to form a pair. If the relative motion between them is completely or successfully constrained (i.e. in a definite direction), the pair is known as **kinematic pair**.

#### Classification of kinematic pair

The kinematic pairs may be classified according to the following considerations :

##### (i) Based on nature of contact between elements:

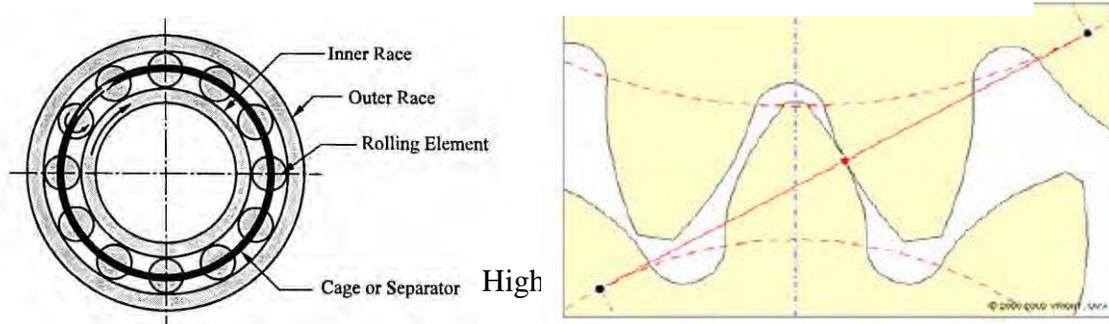
- (a) **Lower pair.** If the joint by which two members are connected has surface contact, the pair is known as lower pair. Eg. pin joints, shaft rotating in bush, slider in slider



- (b) **Higher pair.** If the contact between the pairing elements takes place at a point or along a line, such as in a ball bearing or between two gear teeth in contact, it is known as a higher pair.

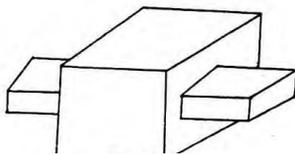


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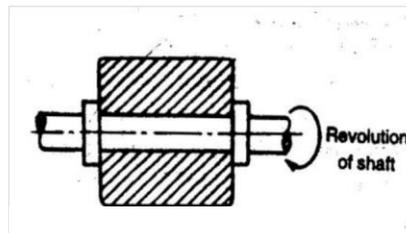


(ii) Based on relative motion between pairing elements:

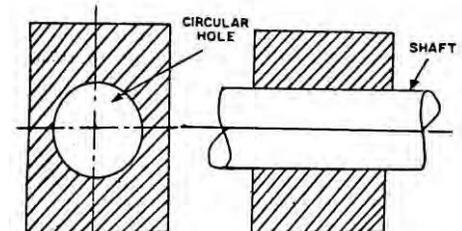
- (a) **Sliding pair.** Sliding pair is constituted by two elements so connected that one is constrained to have a sliding motion relative to the other.  $DOF = 1$
- (b) **Turning pair (revolute pair).** When connections of the two elements are such that only a constrained motion of rotation of one element with respect to the other is possible, the pair constitutes a turning pair.  $DOF = 1$
- (c) **Cylindrical pair.** If the relative motion between the pairing elements is the combination of turning and sliding, then it is called as cylindrical pair.  $DOF = 2$



Sliding pair



Turning pair



Cylindrical pair

- (d) **Rolling pair.** When the pairing elements have rolling contact, the pair formed is called rolling pair. Eg. Bearings, Belt and pulley.  $DOF = 1$