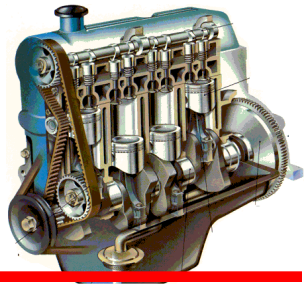

MDPG 126

Mechanics of Machines

Lecture 1

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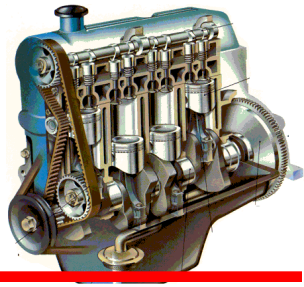
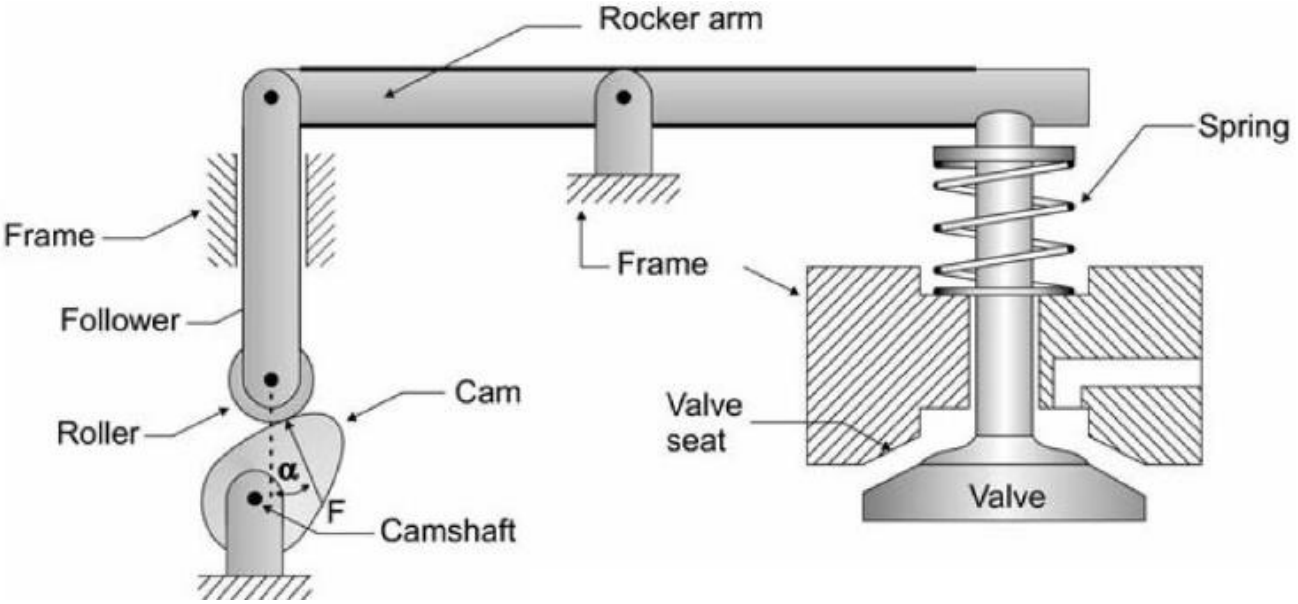
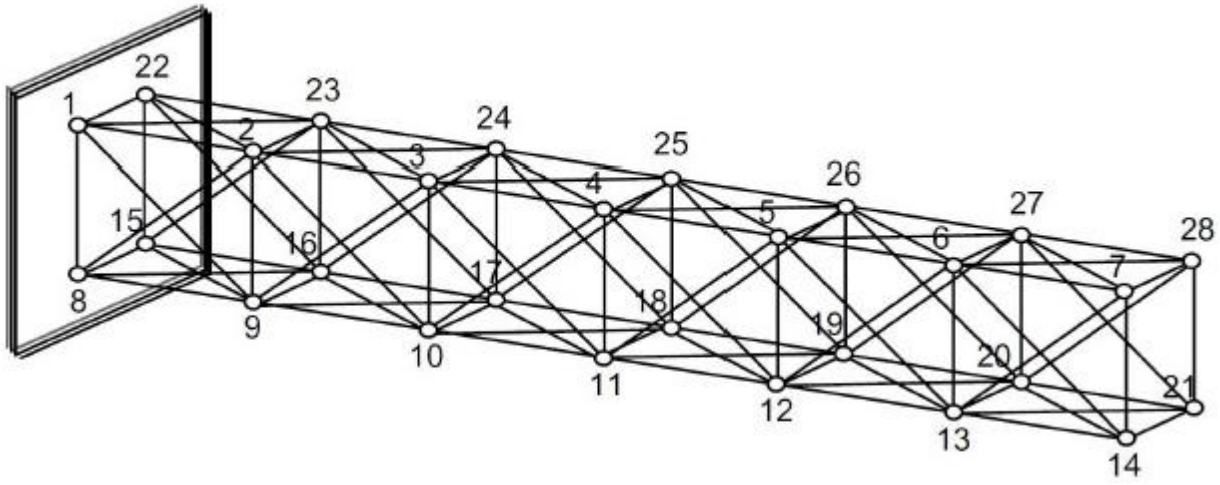
Basic Definitions



- **Mechanism:** A combination of rigid and/or flexible bodies connected in such away to do work and there are definite constrained relative motions between them.
- **Structure:** The same definition of mechanism, but its purpose is not to do work and there is no relative motion between its parts.
- **Machine:** An arrangement of parts and/or mechanisms for doing work and there are constrained relative motions between its parts.
- **Kinematics:** Study of motion without reference to the forces causing the motion.
- **Kinetics:** Relates the action of forces on bodies to their resulting motions.
- **Statics:** The part of mechanics, which deals with the action of forces on bodies at rest.
- **Dynamics:** The part of mechanics, which deals with the action of forces on bodies in motion.
- **Mechanics:** Deals with the action of forces on bodies at rest and in motion.


Rocker arm
Spring
Frame
Frame
Follower
Cam
Roller
α
F
Camshaft
Valve
seat
Valve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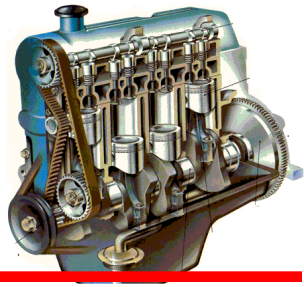
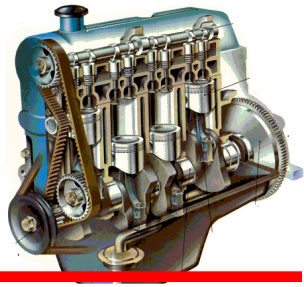
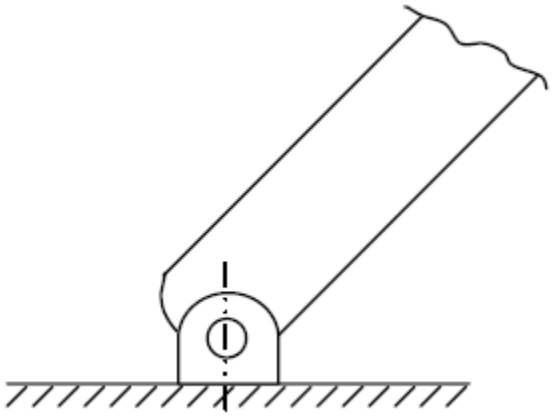


- A Mechanism is composed of three main elements: **links, pairing elements, and a drive or drives**.
- **links** are connected together with **kinematic pairs**, called joints, to permit their constraints relative motions.
- A mechanism is normally driven through a transmission system, which may include belts, ropes, chains, and/or gears, by a motor. Mechanism links may be **rigid, fluidics, or flexible.**
- For the sake of simplicity, links are assumed rigid and joints have perfect geometry with no clearance through out this text.

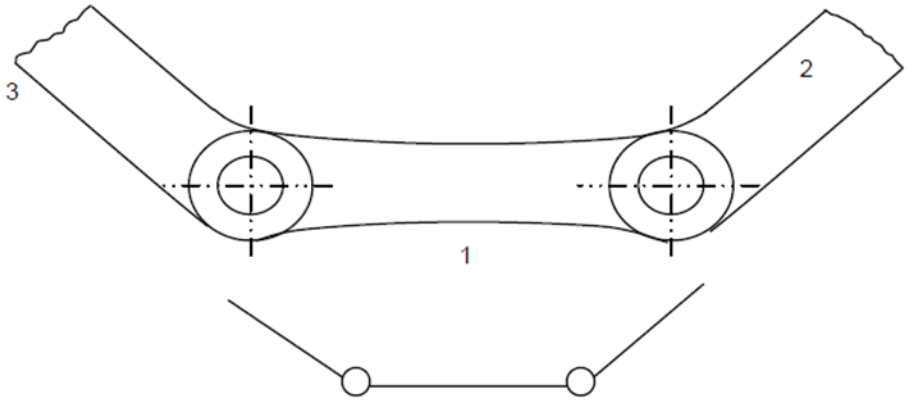
CLASSIFICATION OF LINKS



- **Link : A resistant body or group of resistant bodies with rigid connections preventing their relative movement .**
- **The links are classified depending on number of joints.**
- **Singular Link (A link which is connected to only one other link)**
- **Binary Link : A link which is connected to two other links**

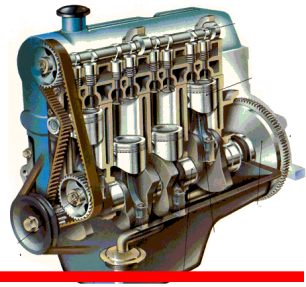


Singular Link

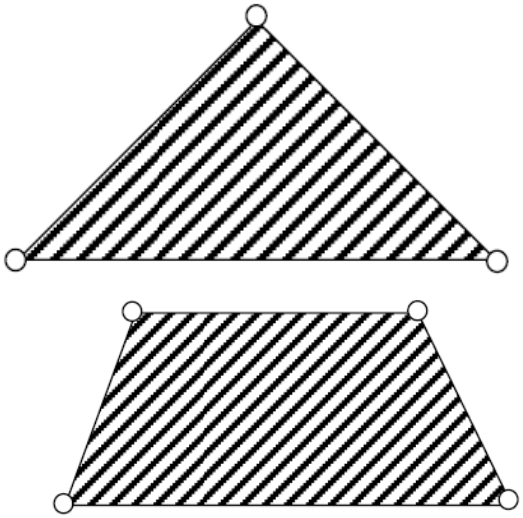


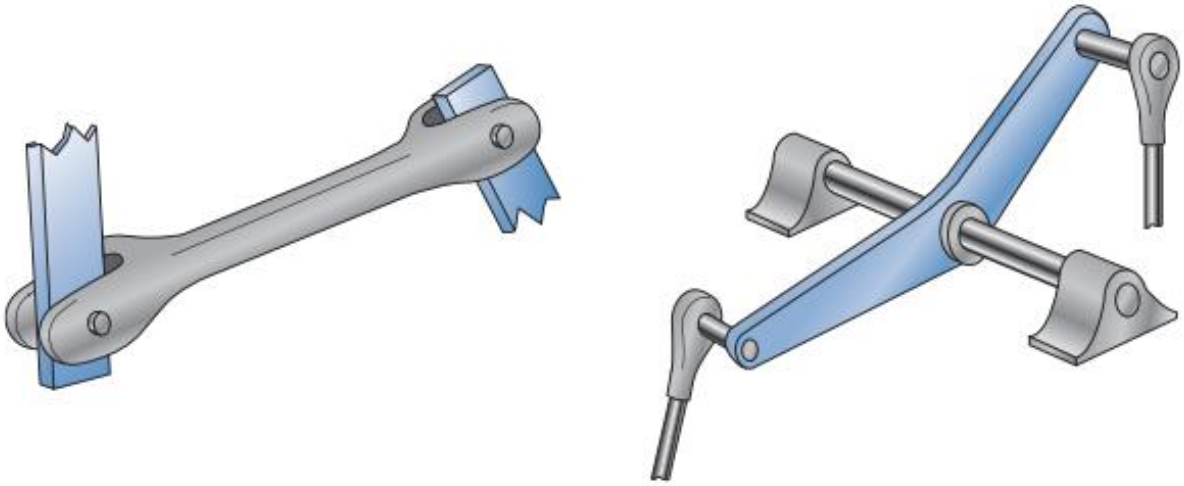
Binary Link

CLASSIFICATION OF LINKS



- **Ternary Link**
- A link which is connected to three other links
- **Quarternary Link**
- A link which is connected to four other links

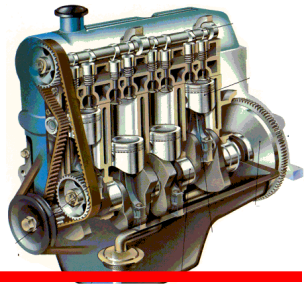




(a) Simple link (b) Complex link

FIGURE 1.6 Links: (a) Simple link and (b) Complex link.

kinematic pairs (Joints)

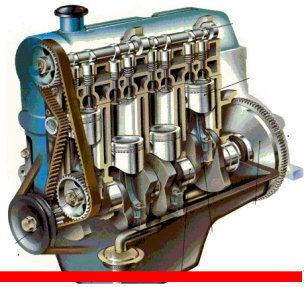


- **kinematic pair is** ***defined as a joint of two links having relative motion between them.***

- Broadly, kinematic pairs can be classified as :

1. **Lower pair** (have surface contact between mating elements)
2. **Higher pair**, (have line or point contact)
3. **Wrapping pair (**belts, chains and such other devices.)

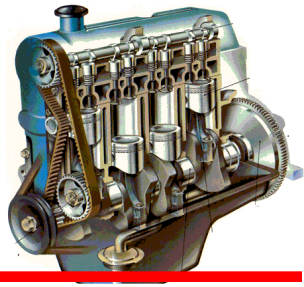
Types of Lower Pairs



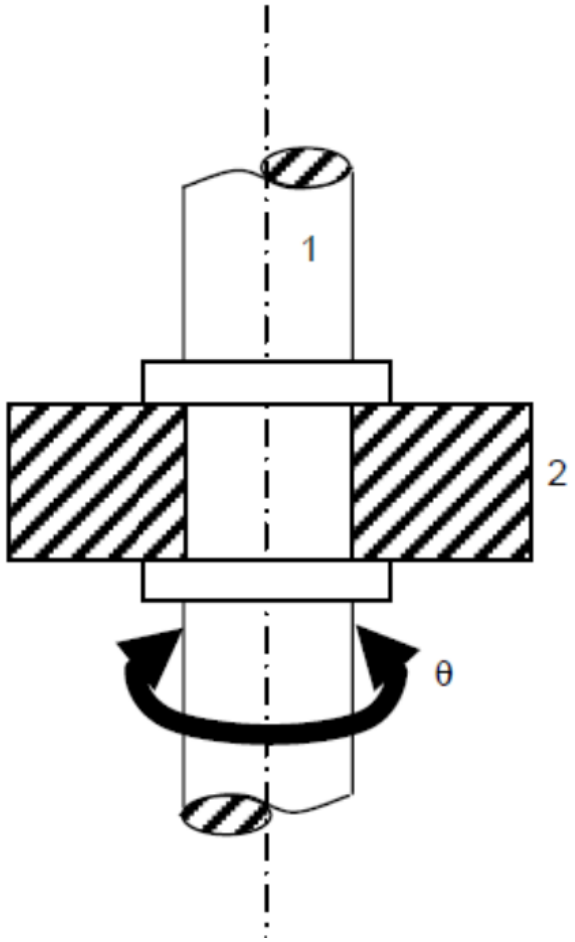
- There are six types of lower pairs as given below :

1. **Revolute or Turning Pair (Pin or Hinged Joint)**
2. **Prismatic of Sliding Pair (*piston* Joint)**
3. **Screw Pair**
4. **Cylindrical Pair**
5. **Spherical Pair**
6. **Planar Pair**

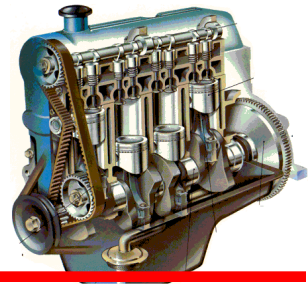
1-Revolute or Turning Pair



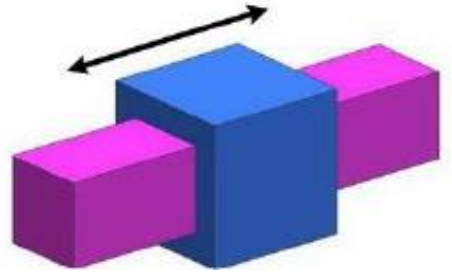
- **Revolute or Turning Pair (Hinged Joint)**
- **A revolute pair is shown in Figure. It is seen that this pair *allows only one relative rotation between elements 1 and 2*, which can be expressed by a single coordinate 'Θ'. Thus, a revolute pair has a single degree of freedom.**

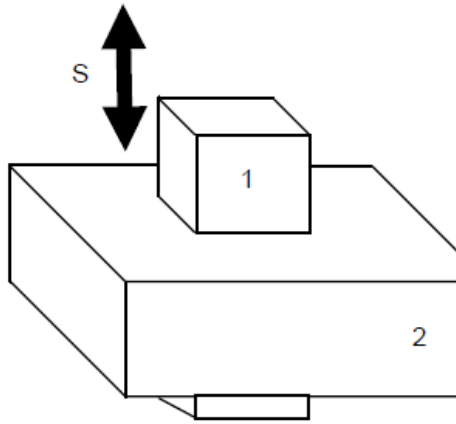


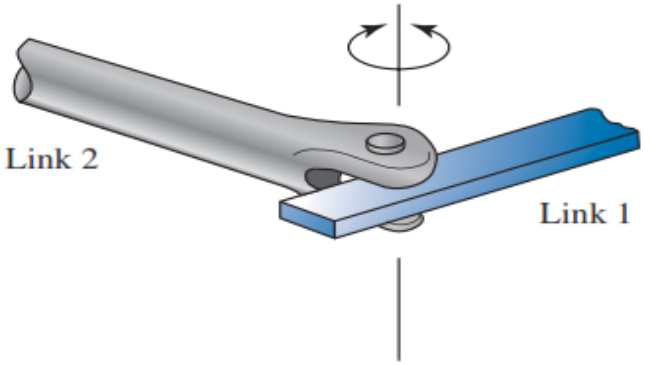
2-Prismatic or Sliding Pair



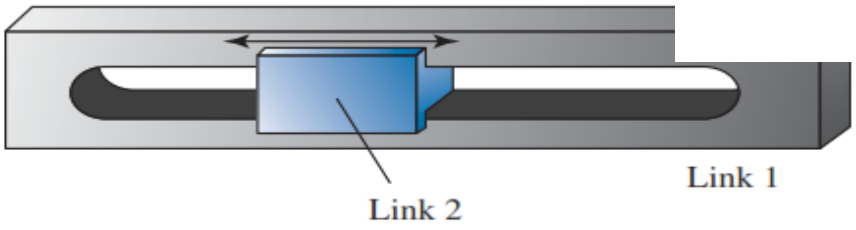
- **Prismatic or Sliding Pair**
- As shown in Figure , a prismatic pair ***allows only a relative translation between elements 1 and 2***, which can be expressed by a single coordinate '*s*', and it has one degree of freedom.





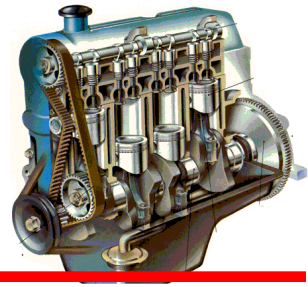


(a) Pin



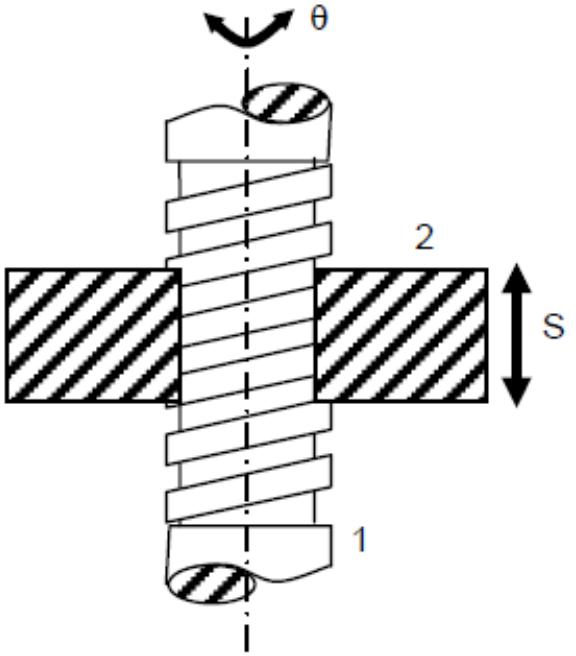
(b) Sliding

3-Screw Pair



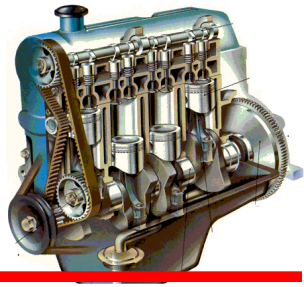
- a screw pair ***allows rotation as well as translation but these two movements are related to each other***. Therefore, screw pair has one degree of freedom because the relative movement between 1 and 2 can be expressed by a single coordinate '**Θ**' or '*s*'. These two coordinates are related by the following relation :

$$\frac{\Delta\theta}{2\pi} = \frac{\Delta s}{L}$$

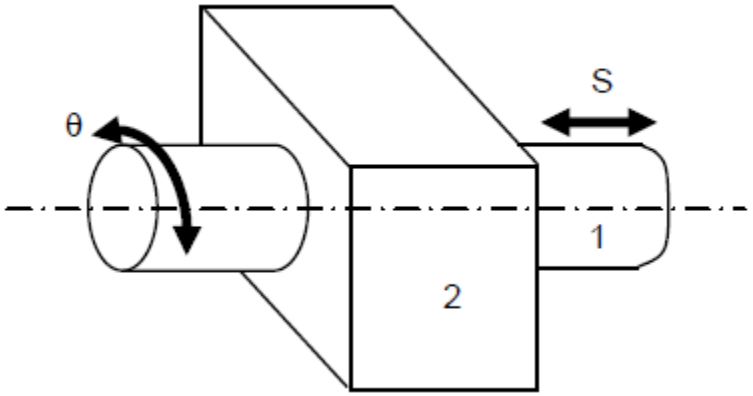


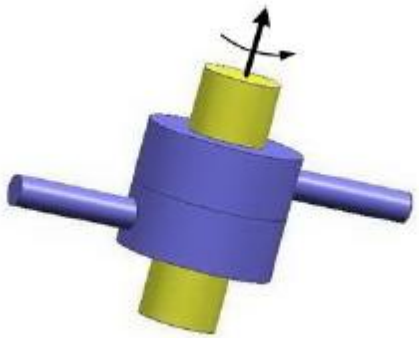
where, *L* is lead of the screw.

4-Cylindrical Pair

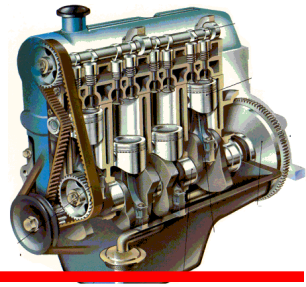


- a cylindrical pair ***allows both rotation and translation parallel to the axis of rotation between elements 1 and 2.*** These relative movements can be expressed by two independent coordinates ‘Θ’ or ‘*s*’ because they are not related with each other.
  Degrees of freedom in this case are equal to two.

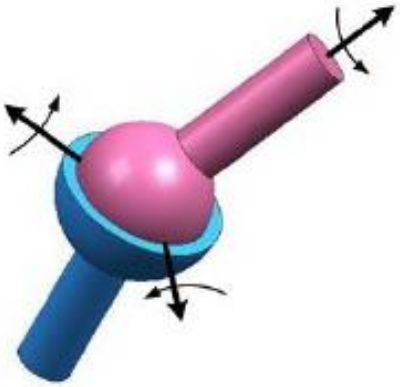


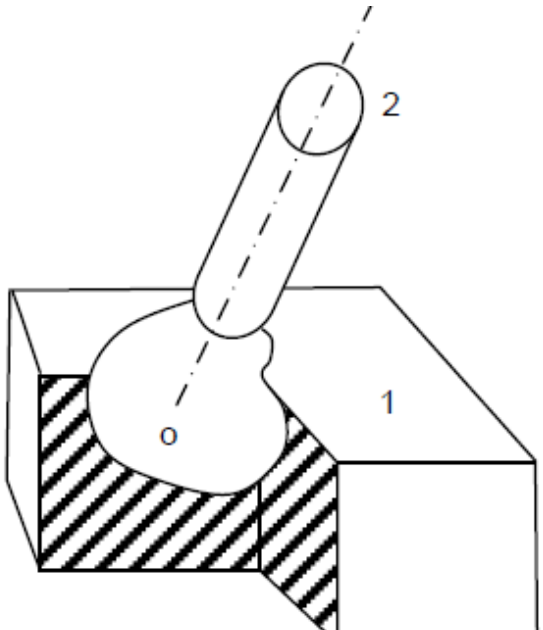


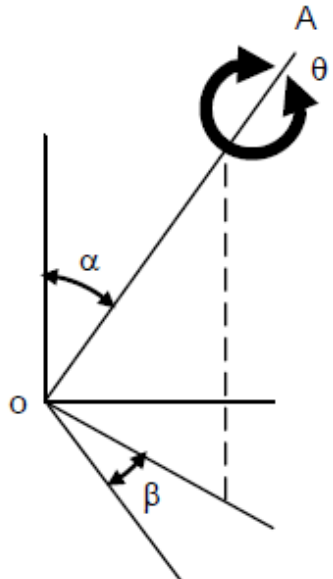
5-Spherical Pair



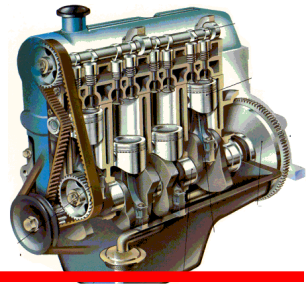
- A ball and socket joint forms a spherical pair. Any rotation of element 2 relative to 1 can be resolved in the three components. Therefore, the complete description of motion requires three independent coordinates. Two of these coordinates ‘β’ and ‘α’ are required to specify the position of axis *OA* and the third coordinate ‘Θ’ describes the rotation about the axis of *OA*. This pair has three degrees of freedom.



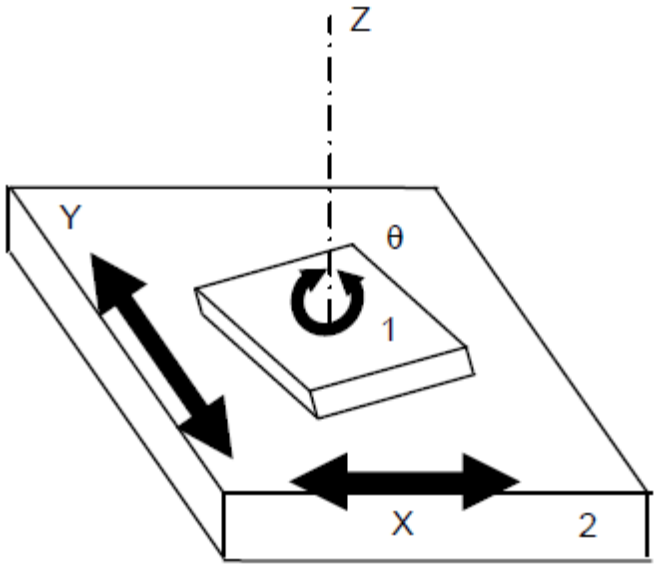




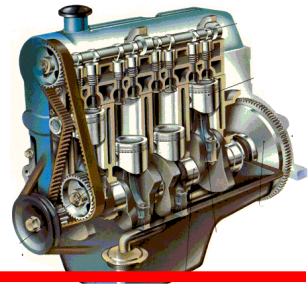
6-Planar Pair



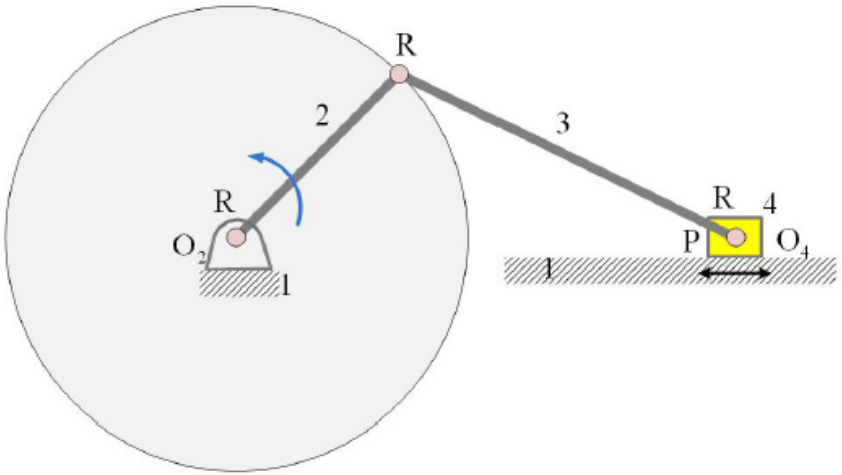
- The relative motion between 1 and 2 can be described by *x* and *y* coordinates in *x*-*y* plane. The *x* and *y* coordinates describe relative translation and Θ describes relative rotation about *z*-axis. This pair ha- three degrees of freedom.

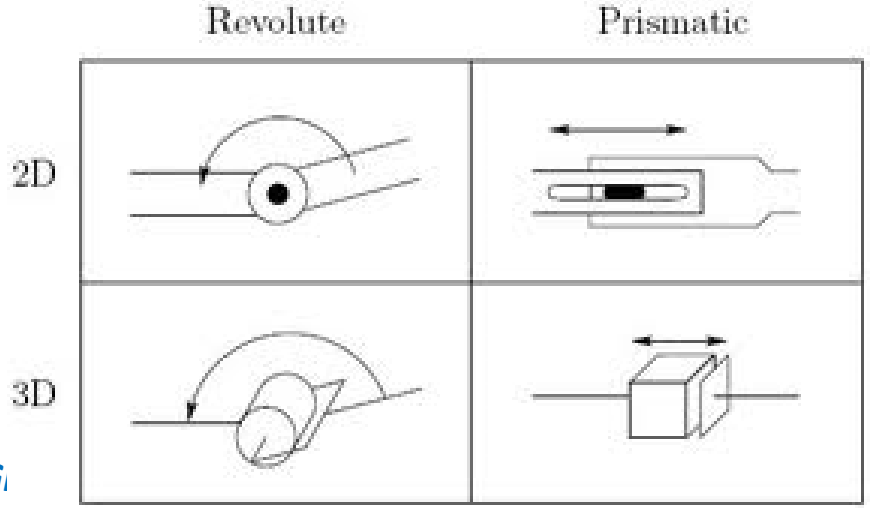


Summary

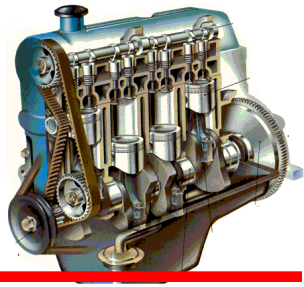


Kinematic Pair	Symbol	Joint DOF	Rotational	Translational
Revolute	*R*	1	1	0
Prismatic	*P*	1	0	1
Cylindric	*C*	2	1	1
Helical	*H*	1	1	coupled
Spherical	*S*	3	3	0
Plane	*E*	3	1	2

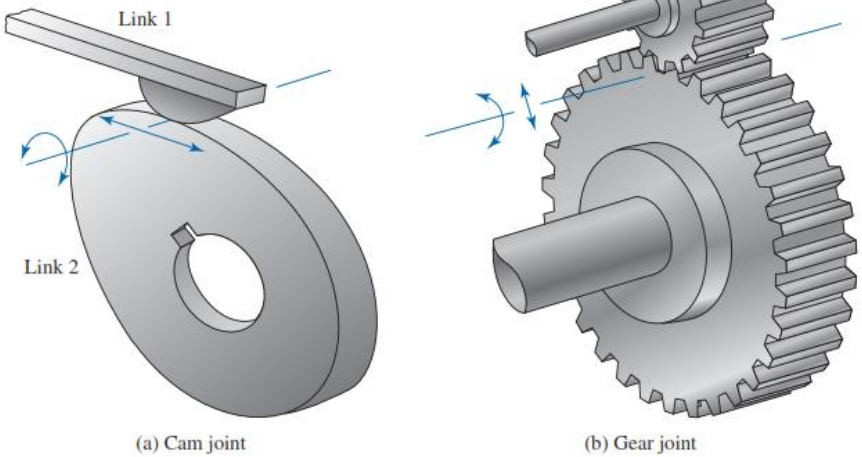




Higher Pair or *higher-order joint* (*half joint*)

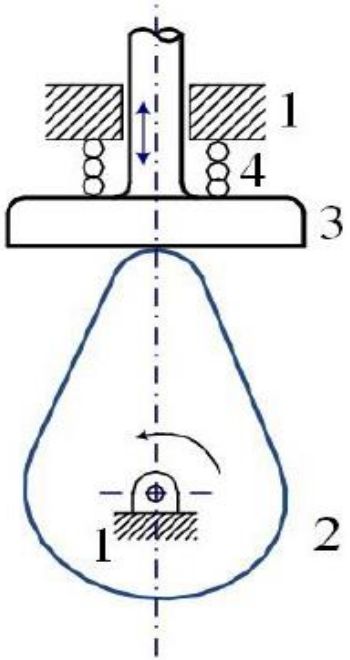


- **A higher pair is a kinematic pair in which connection between two elements is only a point or line contact. The cam and follower arrangement is an example of this pair. Other examples are ball bearings, roller bearings, gears, etc. A cylinder rolling on a flat surface has a line contact while a spherical ball moving on a flat surface has a point contact.**



(a) Cam joint

(b) Gear joint



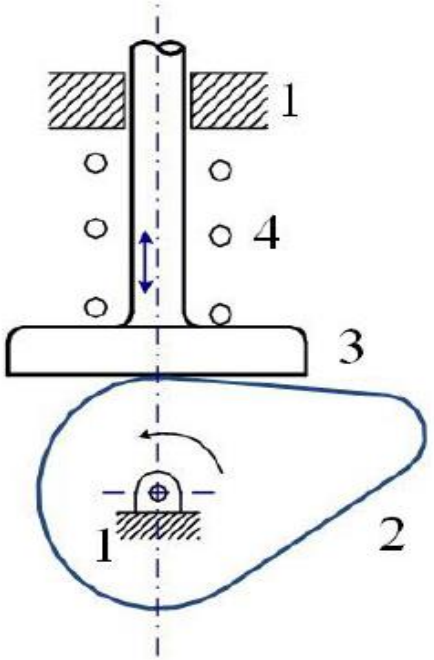
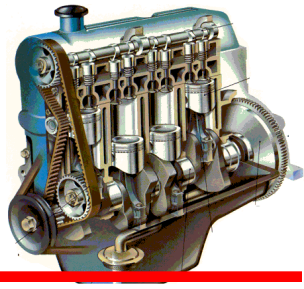
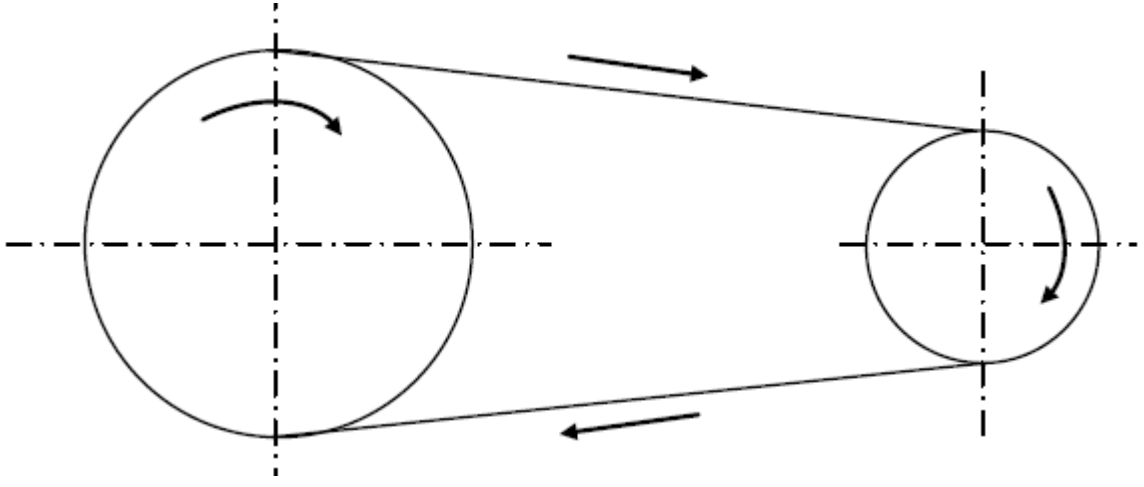


FIGURE 1.5 Higher-order joints: (a) Cam joint and (b) Gear joint.

Wrapping Pair



- **Wrapping pairs comprise belts, chains and such other devices. Belt comes from one side of the pulley and moves over to other side through another pulley as shown in Figure**



Questions?