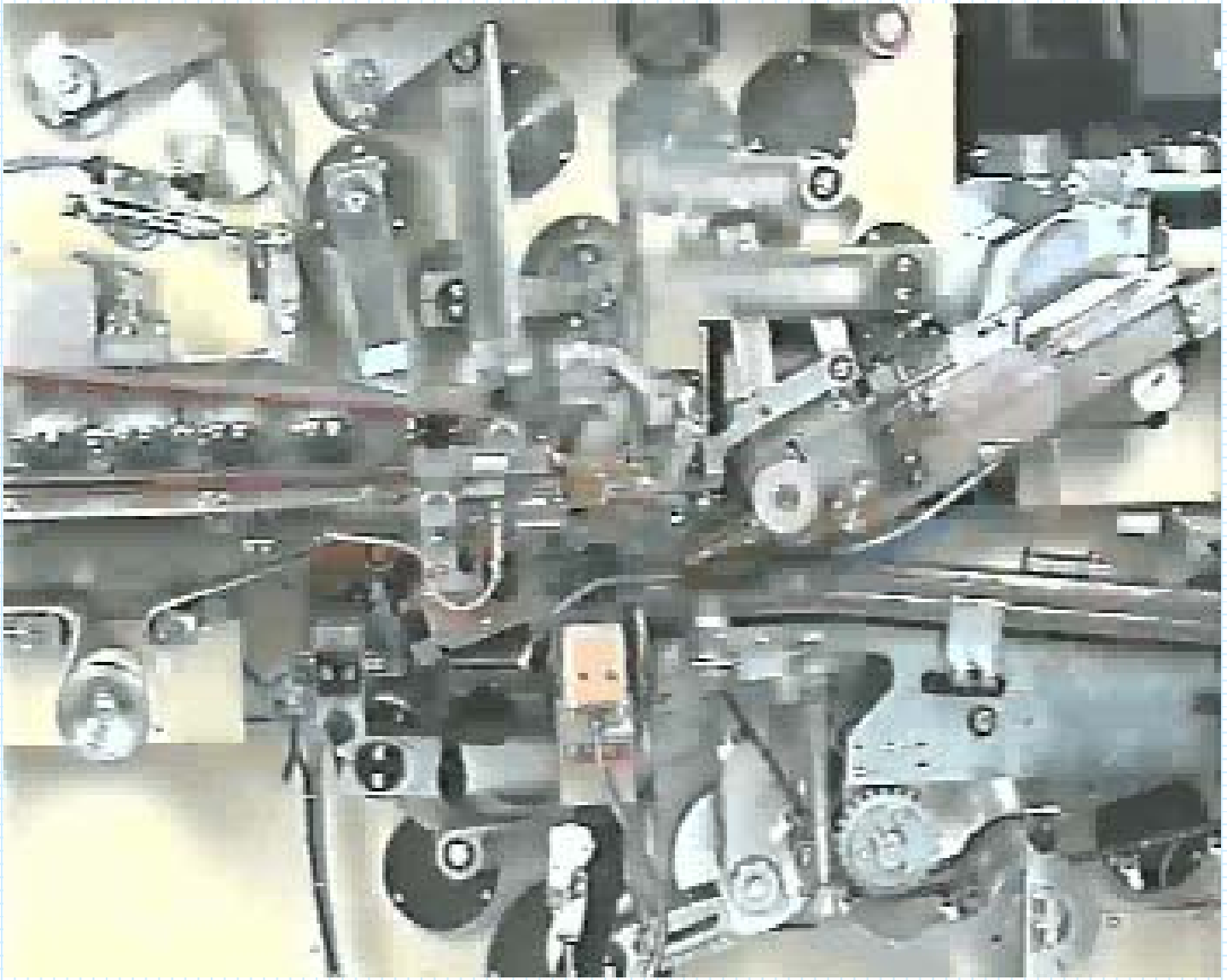
Mechanisms

Mechanisms



ME 301 Theory of Machines I (MECHANISMS)

Instructor: Prof. Dr. Eres Söylemez
Rm: C205 e-mail: eres@metu.edu.tr
Assistant: Mr. Gökhan Kiper.
Rm. C205 e-mail: kiper@metu.edu.tr

Group 05

Course Hours: Monday (15:40-17:30) in Rm B102
Wendesday(16:40-17:30)

Computer Hours will be announced later.

Text Book: "Mechanisms" Eres Söylemez,2009 (4th Edition) METU Publ. No:64 (will be available in the bookstore by the end of the week)

Web Page:
http://www.me.metu.edu.tr/people/eres/ME301/Index.html

References:

J.E. Shigley and J.J. Uicker, "**Theory of Machines and Mechanisms**", 2nd Edition, McGraw-Hill, 1995.

R.L. Norton "**Design of Machinery**", 2nd Edition, McGraw-Hill, 1999

K.J. Waldron, G. L. Kinzel **"Kinematics, Dynamics and Design of Machinery"**, John Wiley, 2004

Course Policy

- Attendance is compulsory and will be checked.
- Weekly reading assignments will be given and you will be kept responsible.
- Homeworks will be given regularly (almost every week)
- 2 Midterms (20%) + 1 Final (40%) +Homeworks,Lab Work, Attendance (20%)
- Cheating will be severely punished

ME 301

Catalogue Description:

Introduction to mechanisms;basic concepts, mobility, basic types of mechanisms. Position, velocity and acceleration analysis of linkages. Cam Mechanisms, gear trains, static and dynamic force analysis of mechanisms.

Course Objectives

- What is a mechanism? The basic concepts about mechanisms (at the end of this course you must be able to identify a mechanism and determine its degree-of freedom)
- Kinematic analysis of mechanisms (at the end of this course you must be able to perform motion, velocity and acceleration analysis of planar mechanisms including the gear trains.)
- Static and dynamic force analysis of mechanisms (at the end of this course you must be able to perform static and dynamic force analysis of planar mechanisms.)

Prerequisites of the course

- ME 208 Dynamics is prerequisite for this course
- I expect that you have a good knowledge on:
  - Newton's Laws of Motion
  - Basic Geometry and Trigonometry
  - Basic Calculus
  - Basic Computer Skills
  - Ability and will to study regularly

Tools

- Today computer use is essential.
- There are several well developed package programs available (Adams ®, Visual Nastran ®, Working Model ®, etc).You may use these programs later as an engineer. These programs will not be thought or used in this course.
- In this course:
  - You will be asked to write small programs in any computer language you are familiar with;
  - You will be asked to use Excell® extensively and you have to write small macros in Excell ®;
  - You will be asked to use the mathematical package “MathCad” ® and MatLAB ®.

Course Material

- Textbook is essential. You have a large amount of reading material and examples in the textbook. Reading assignments and homework problems will be given from the textbook.
- Internet will be used. There will be a large amount of material (as examples and additional information and some other related web sites) available for you on the web site. And on METU-OnLine. Some of the homeworks will be given and collected through the internet.The web adress is:

http://www.me.metu.edu.tr/people/eres/ME301/Index.html

Please also look at:

http://mekanizma.me.metu.edu.tr

- Lectures will be given using powerpoint and computer. Some examples will be solved in class using the computer.These examples will be different than the ones in the textbook.

Course behavior

- Late comers to class are not accepted.
- Please come to class prepared. Do your reading assignments!!
- Please feel free to ask questions in class.
- Please feel free to ask questions outside class by using e-mail or come to my office at any time (from 9:00 to 19:00 Hour normally).
- Please don't talk in class.

I. Introduction to Mechanisms

Objectives:

- To understand the terms used in mechanisms study,
- To understand and be able to use the degree of freedom of space, and the degree of freedom of a joint concept,
- To understand and be able to use the degree of freedom of a mechanism concept
- To be able to identify the mechanisms in patent documents.

Reading Assignment:

Ch 1 (By October 12, Monday)

Machine

Machine: Combination of resistant bodies so arranged that by their means the mechanical forces of nature can be compelled to do work accompanied by certain determinate motion.

Note:

- In the above definition we are only concerned with the mechanical machines. The definition does not include electrical or heat machines (eg. a computer or a heat pump is not included as a machine with the above definition).
- The main characteristics of a mechanical machine is that there is force (or torque) accompanied with motion, Some exceptions to this characteristics are mechanical calculating machines, mechanical watches, indicating instruments, etc. In these types there is no actual work output. The work input is dissipated as heat due to friction within the system.

Mechanism

A group of rigid bodies connected to each other by rigid kinematic pairs (joints) to transmit force and motion

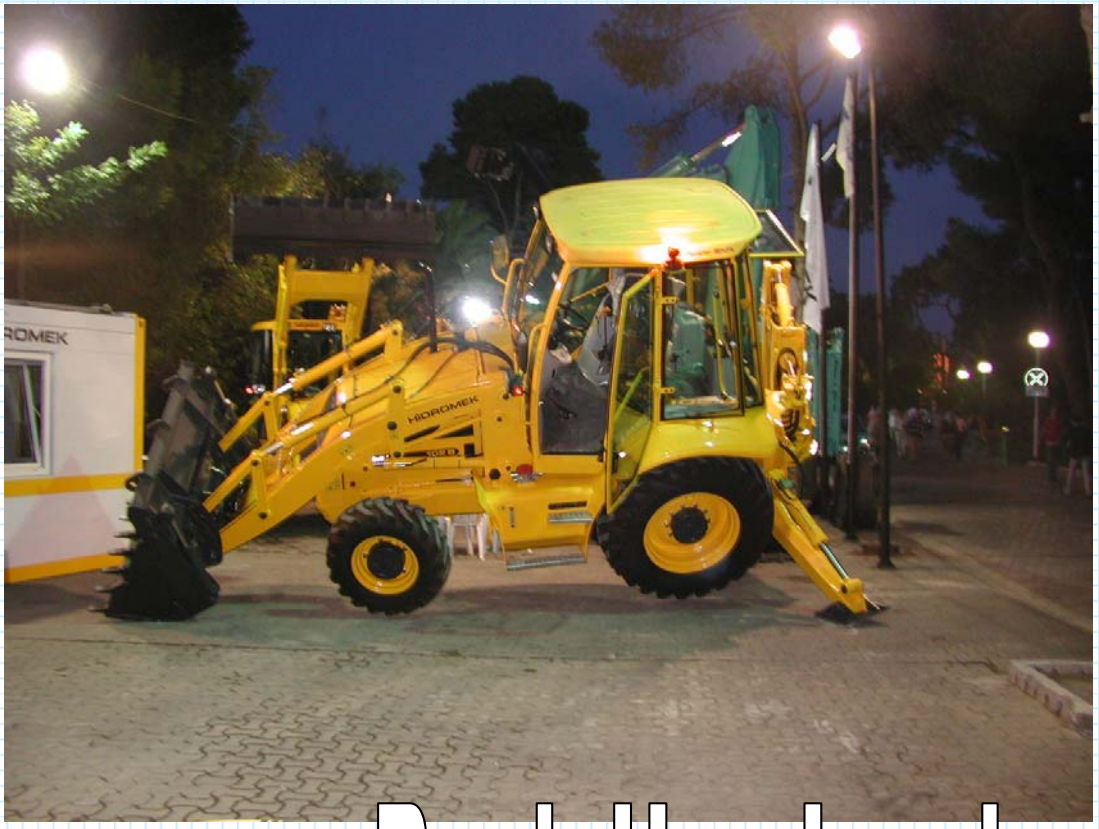
Machine or Device

A machine is designed and constructed for a particular task

Collapsible Bed

Reclining Chair

Mechanical Press



Back-Hoe Loader

Cement Pump

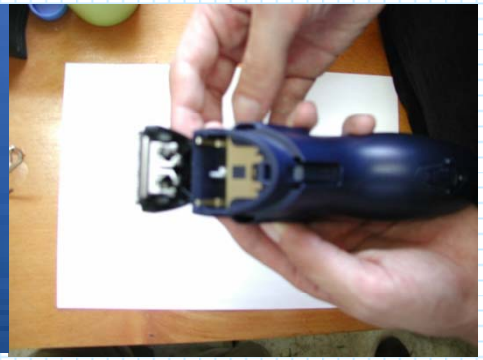
Harvester

Wheel Suspension

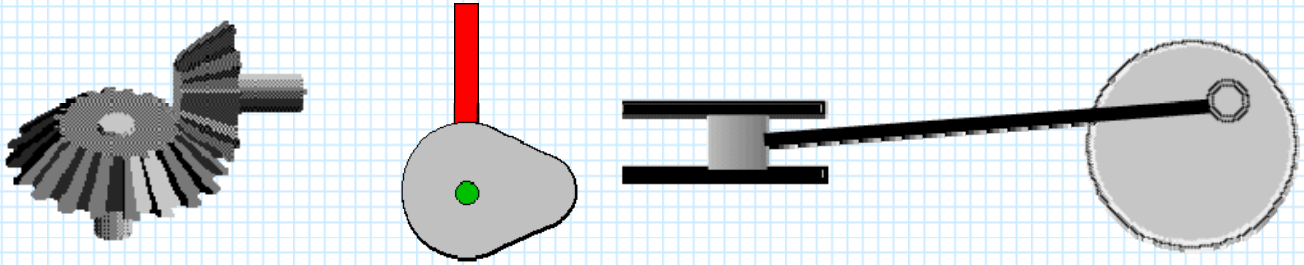
Mechanisms

- A machine structure is constructed to perform a particular task, such as a sewing machine, a mixer, a hair cutter, a lath, a packaging machine, etc.





- A mechanism is considered to be more general. It is an isolated group of rigid bodies through the study of which we can understand the basic structure of any machine and can design machines that are not in existence.

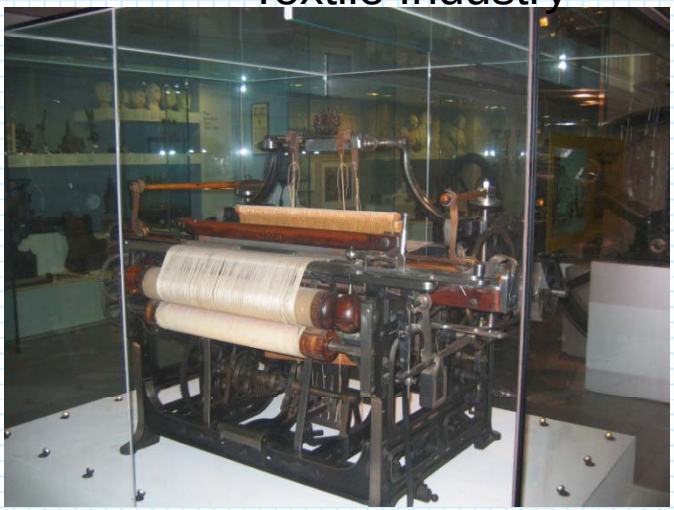



- A machine may also involve a number of mechanisms and certain elements that are not rigid (although resistant). Such as hydraulic drives, springs, dashpots, flexible elements, etc. which are not considered as bodies that can be included in a mechanism

Mechanisms are used in all kinds of industry

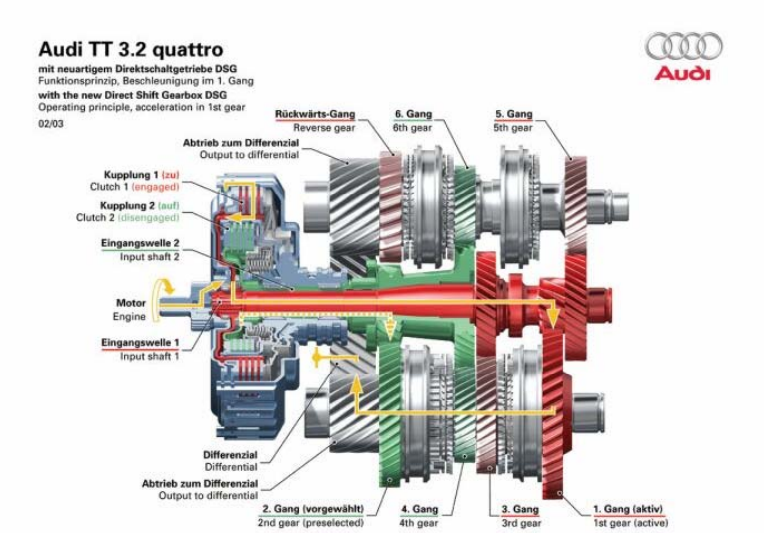
Whenever there is a need for motion accompanied with force, there is a mechanism

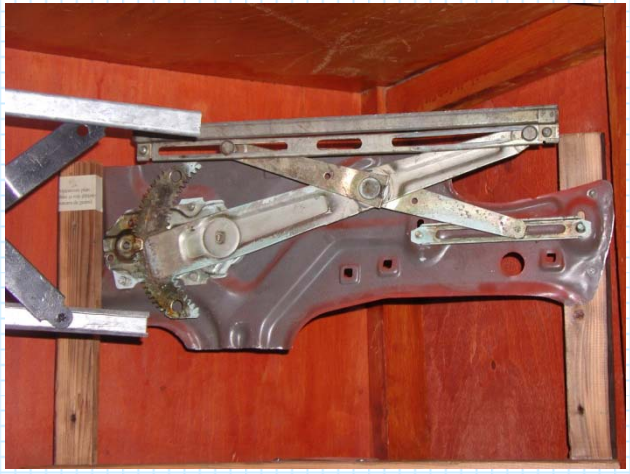
Textile Industry

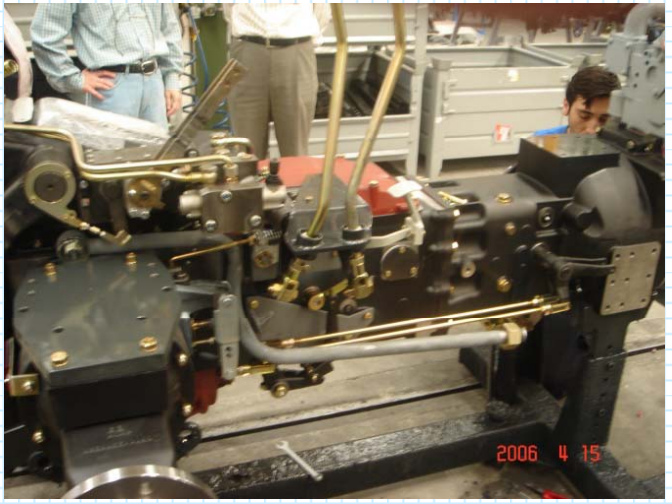


Furniture

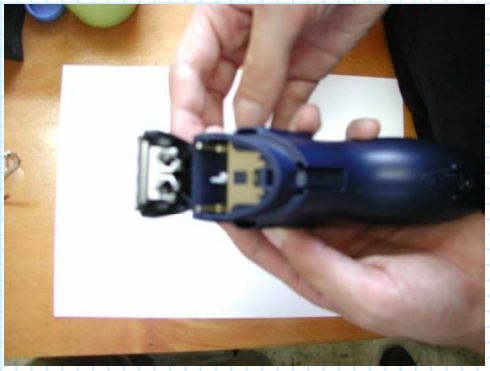
Automotive Industry







Healthcare and fitness industry



Aerospace Industries

Construction and Handling Machinery

Mechanism

A group of rigid bodies connected to each other by rigid kinematic pairs (joints) to transmit force and motion

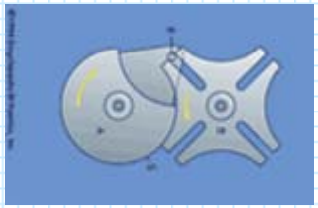
Gives the basic characteristics

Kinematic Element: is that part of a rigid body which is used to connect it to another rigid body such that the relative motion between the two rigid bodies can occur

Kinematic pair is the joining of two kinematic elements. The types of kinematic pairs and their distribution within the mechanism determine the main characteristics of a mechanism.

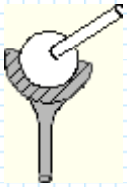
Classification Of Kinematic Pairs

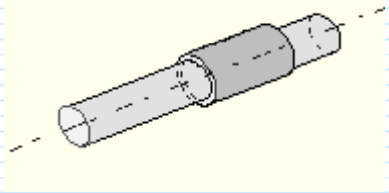
- OpenKinematic pairs



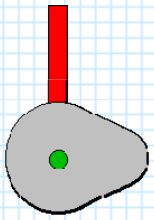
- Closed Kinematic Pairs

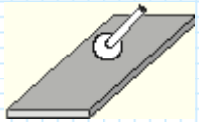
- Form Closed Kinematic Pairs



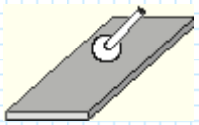


- Force Closed Kinematic Pairs

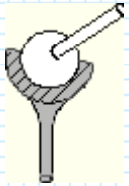


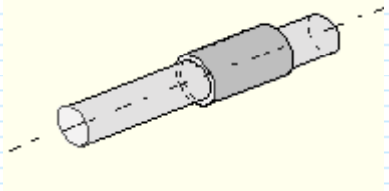


- **Higher Kinematic Pairs**
  Contact along a surface



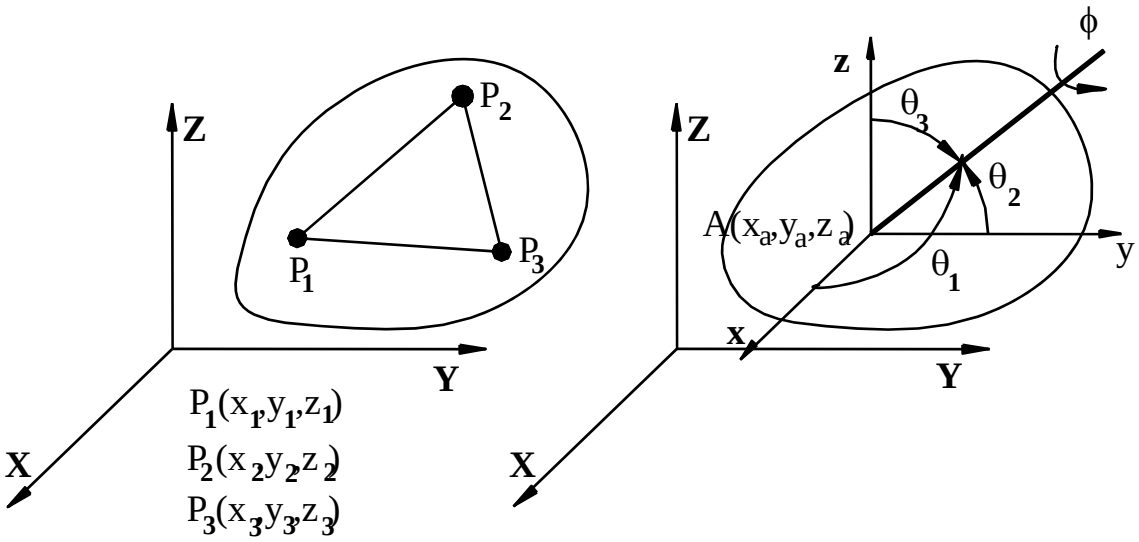
- **Lower kinematic Pairs**
  Contact at a point or on a line





Degree of Freedom

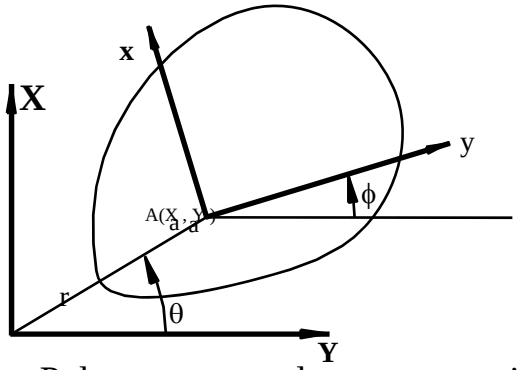
- ***Degree of Freedom of Space***
- **Spatial Space:**
  the number of independent parameters required to define the



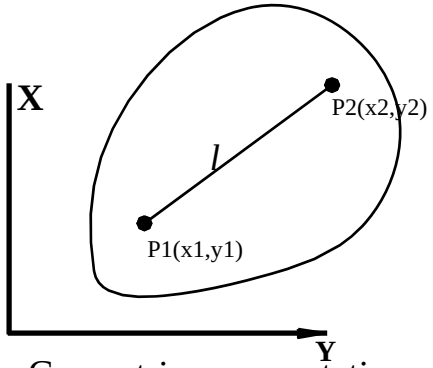
DoF=6 or $\lambda = 6$

Degree of freedom of planar space:

DoF=3 or $\lambda = 3$



Polar or rectangular representation



Geometric representation

Degree-of-freedom of a kinematic pair:

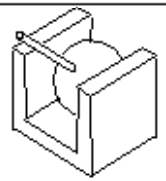
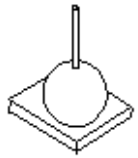
the number of independent parameters that is required to determine the relative position of one rigid body with respect to the other connected by the kinematic pair.

Mechanisms

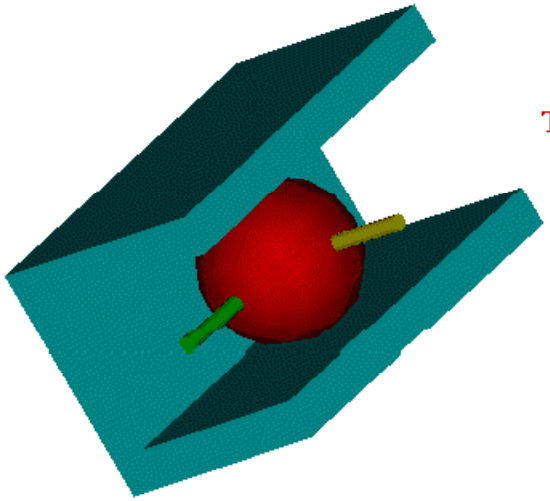
Degree-of-freedom of a kinematic pair:

TABLE I

KINEMATIC PAIRS WITH INDEPENDENT ROTATIONAL AND TRANSLATIONAL MOTION

DEGREE OF FREEDOM	ROTATIONAL FREEDOM	TRANSLATIONAL FREEDOM	NAME	FORM CLOSED	FORCE CLOSED
5	3	2	Sphere between parallel planes		

SPHERE BETWEEN PARALLEL PLANES

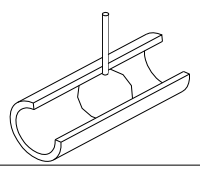
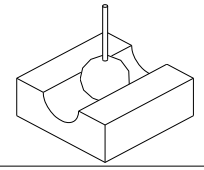
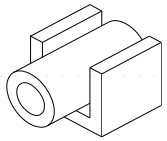
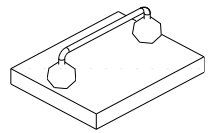


Translation-I

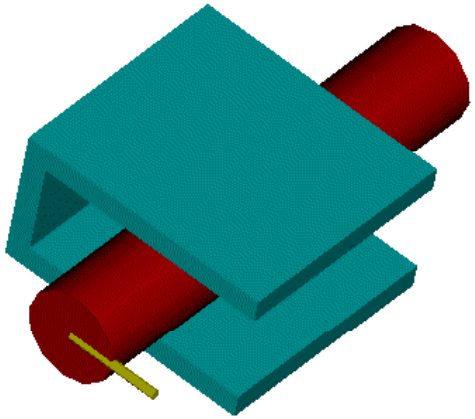
Mechanisms

TABLE I

KINEMATIC PAIRS WITH INDEPENDENT ROTATIONAL AND TRANSLATIONAL MOTION

DEGREE OF FREEDOM	ROTATIONAL FREEDOM	TRANSLATIONAL FREEDOM	NAME	FORM CLOSED	FORCE CLOSED
4	3	1	Sphere in a cylinder		
	2	2	Cylinder between parallel planes		

CYLINDER BETWEEN PARALLEL PLANES

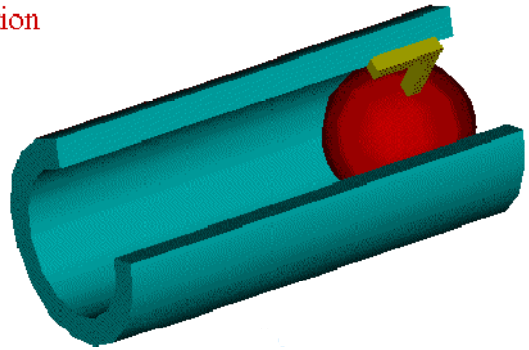


Translatio

©es

SPHERE in a CYLINDER

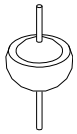
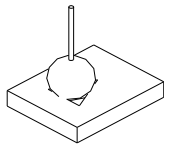
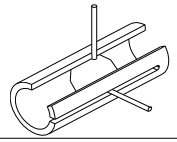
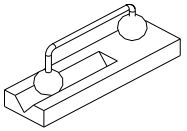
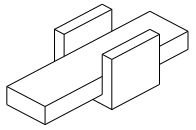
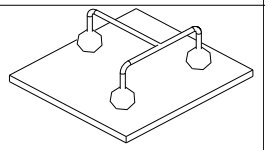
Translation



Mechanisms

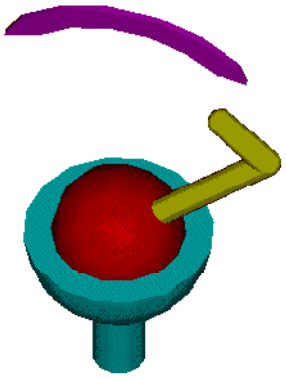
TABLE I

KINEMATIC PAIRS WITH INDEPENDENT ROTATIONAL AND TRANSLATIONAL MOTION

DEGREE OF FREEDOM	ROTATIONAL FREEDOM	TRANSLATIONAL FREEDOM	NAME	FORM CLOSED	FORCE CLOSED
3	3	0	Spherical pair (Ball joint)		
	2	1	Slotted sphere in a cylinder		
	1	2	Plane joint		

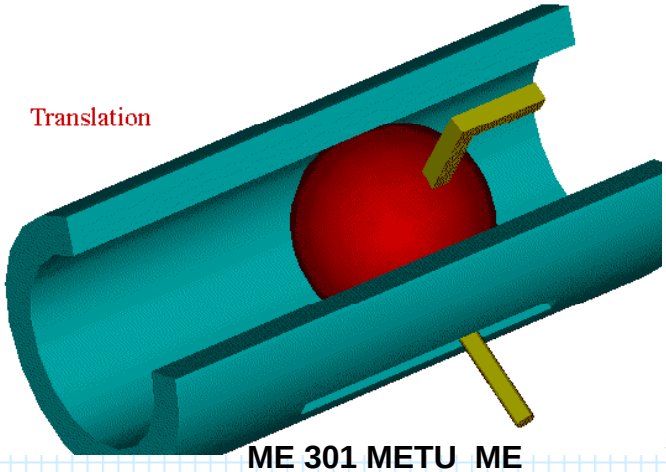
SPHERICAL PAIR
BALL JOINT (Ball-and-Socket Joint)

Rotation -I



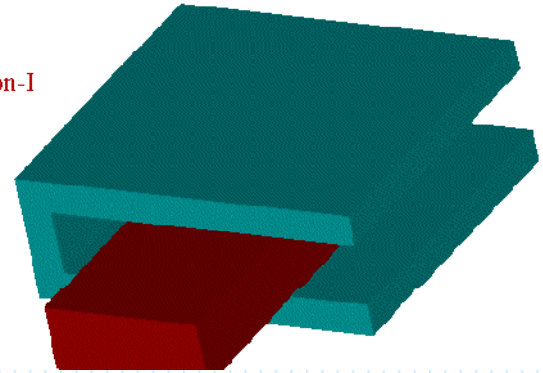
Sphere in a slotted cylinder

Translation



PLANE JOINT

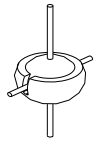
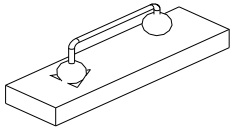
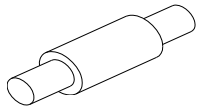
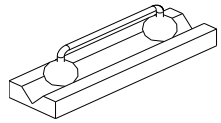
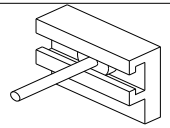
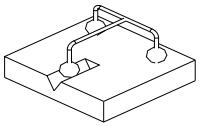
Translation-I



Mechanisms

TABLE I

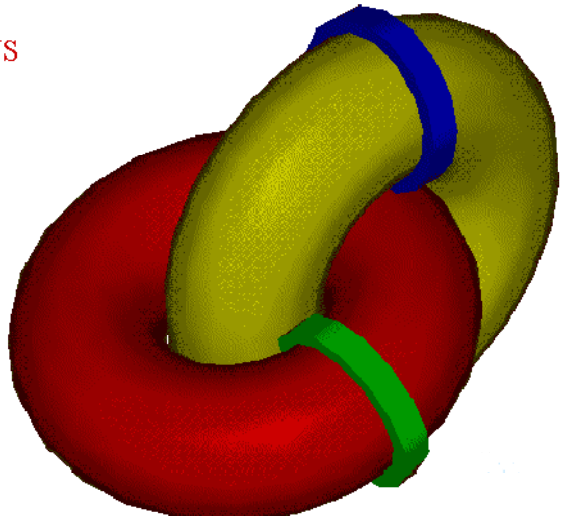
KINEMATIC PAIRS WITH INDEPENDENT ROTATIONAL AND TRANSLATIONAL MOTION

DEGREE OF FREEDOM	ROTATIONAL FREEDOM	TRANSLATIONAL FREEDOM	NAME	FORM CLOSED	FORCE CLOSED
2	2	0	Slotted sphere		
	2	0	Torus		
	1	1	Cylindrical joint		
	1	1	Slotted cylinder		

SLOTTED SPHERE

Rotation-I

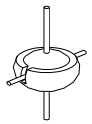
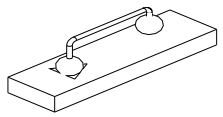
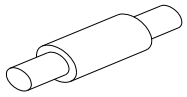
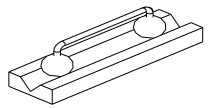
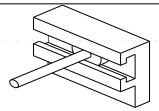
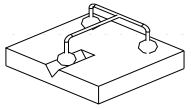
TORUS



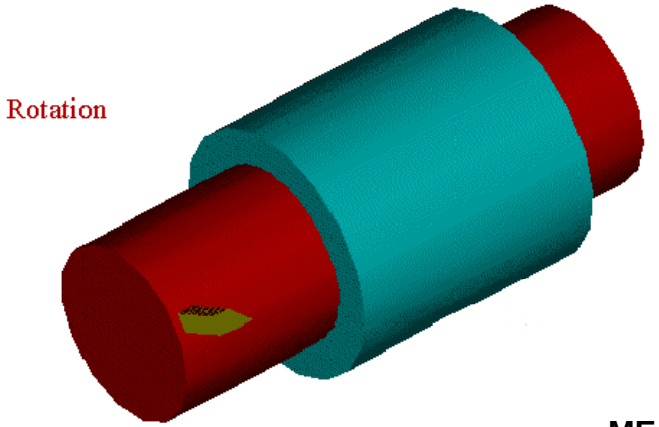
Mechanisms

TABLE I

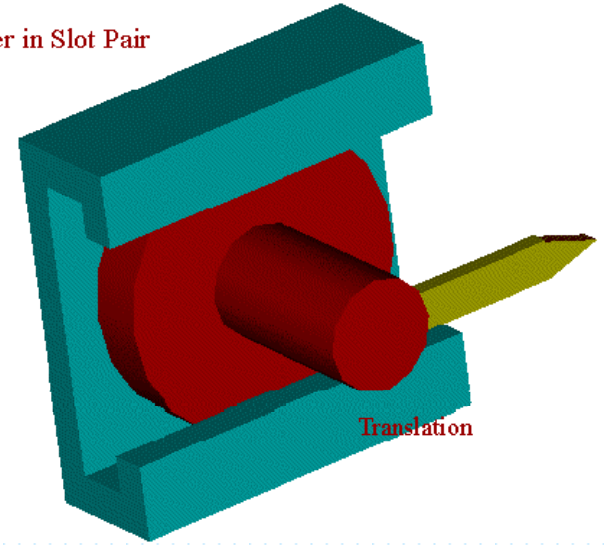
KINEMATIC PAIRS WITH INDEPENDENT ROTATIONAL AND TRANSLATIONAL MOTION

DEGREE OF FREEDOM	ROTATIONAL FREEDOM	TRANSLATIONAL FREEDOM	NAME	FORM CLOSED	FORCE CLOSED
2	2	0	Slotted sphere		
	2	0	Torus		
	1	1	Cylindrical joint		
	1	1	Slotted cylinder		

Cylindrical Pair



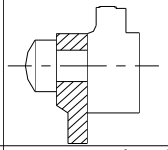
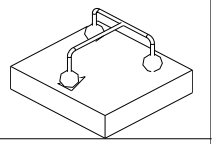
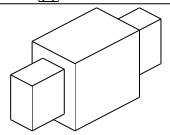
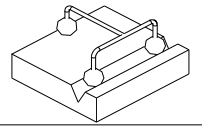
Cylinder in Slot Pair



Mechanisms

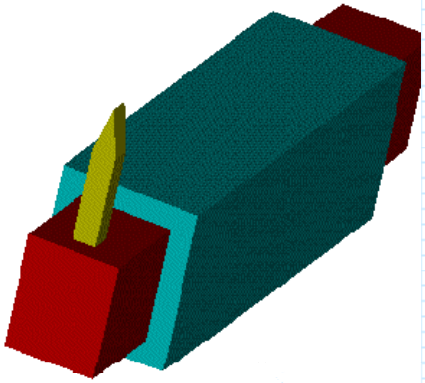
TABLE I

KINEMATIC PAIRS WITH INDEPENDENT ROTATIONAL AND TRANSLATIONAL MOTION

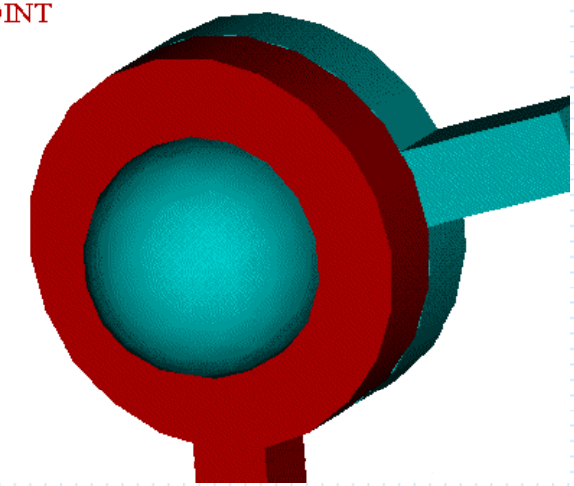
DEGREE OF FREEDOM	ROTATIONAL FREEDOM	TRANSLATIONAL FREEDOM	NAME	FORM CLOSED	FORCE CLOSED
1	1	0	Revolute pair (turning joint)		
	0	1	Prismatic pair (sliding joint)		

PRISMATIC PAIR

Translation



REVOLUTE JOINT



Mechanisms

TABLE II

KINEMATIC PAIRS IN WHICH ROTATION AND TRANSLATION ARE DEPENDENT

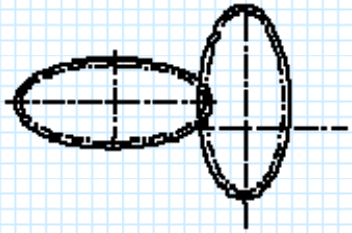
f= 1 Helical (screw) joint

f= 1 Slider in a circular slot pair

f= 2 Gear Pair

f= 2 Cam Pair

f= 2 Nonctcular gear pair

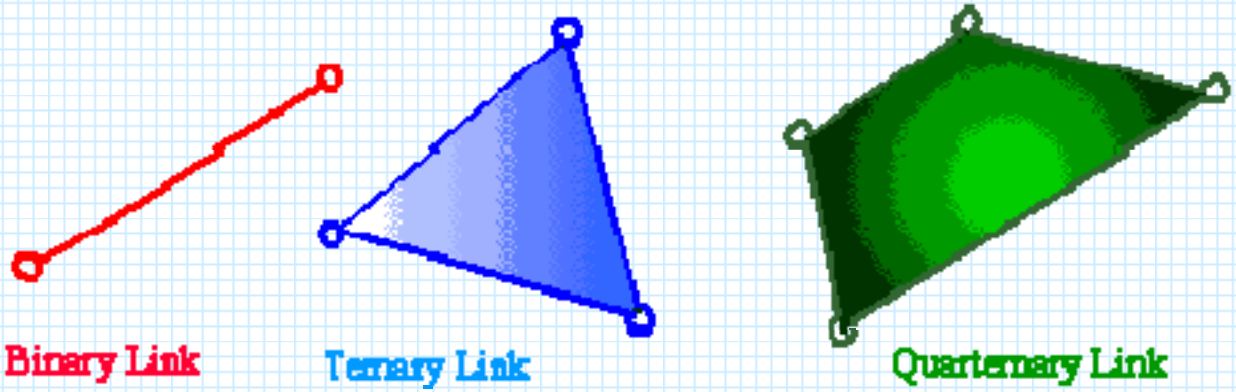


f= 1 Constant breadth cam pair (I)

f= 2 Constant breadth cam pair (II)

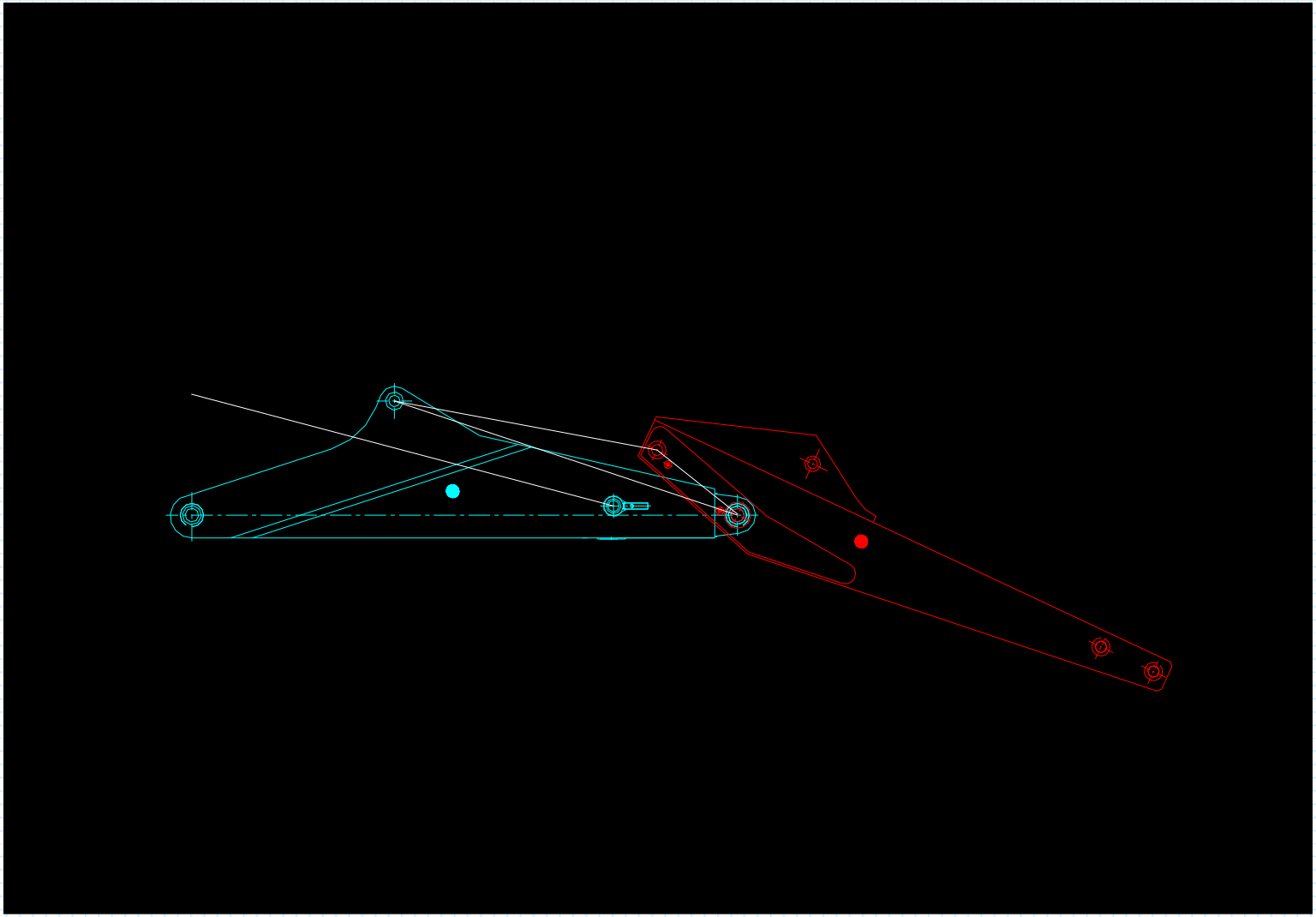
Link

- A rigid body that contains at least two kinematic elements



These figures are schematic representations

Link



Engineering Drawing

Link

Actual shape

Kinematic Chain

- Links connected to each other by kinematic pairs

  Open

  Kinematic Chains

  Closed

- A ***mechanism*** is a kinematic chain with one of the links as fixed