Dynamics of Machinery

Credits: 3

Lecturer: Abbasi

Grading system

- Assignment 10% (Individual)
- Project 20% (Team work)
- Mid term 30%
- Final 40%

- Min. requirements to pass this course
- Project 50%
- Final 50%

Terminology

Statics ⟷ Frames & Stuctures

Dynamics

Kinematics ⟷ Mechanisms

is the study of motion, without considering the forces which produce that motion (m = 0)

A mechanism is a constrained kinematic chain that the motion of any one link in the kinematic chain will give a definite and predictable motion relative to each of the others.

Kinetics ⟷ Machineries

is the study of motion, without considering the forces which produce that motion (m ≠ 0)

A machine is a mechanism or collection of mechanisms, which transmit force from the source of power to the resistance to be overcome.

Terminology (continued…)

Machine $\neq$ Engine

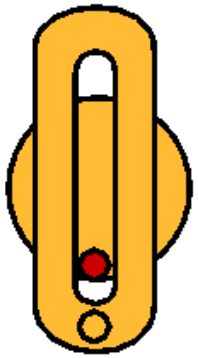
Machanism $\neq$ Machine

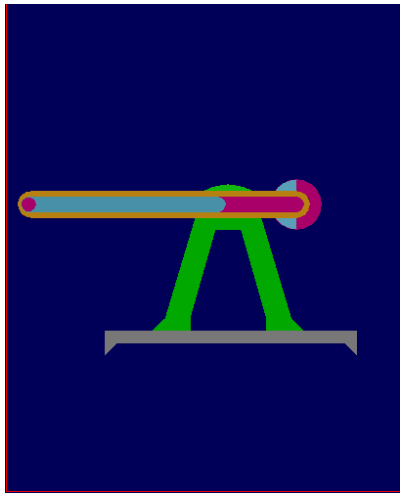
Terminology (continued…)

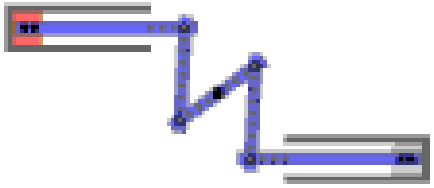
Plane motion: A body has plane motion, if all its points move in planes which are parallel to some reference plane.

Plane motion can be of three types.

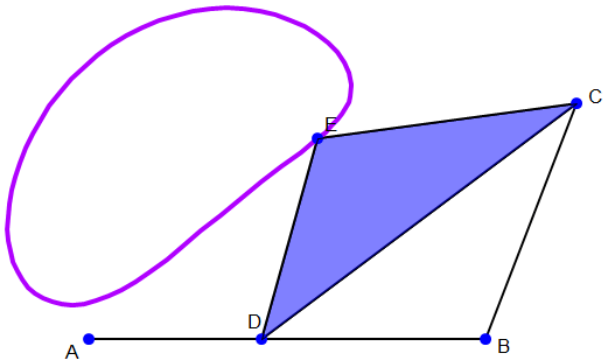
1) Translation
2) Rotation
3) Combination of translation and rotation.

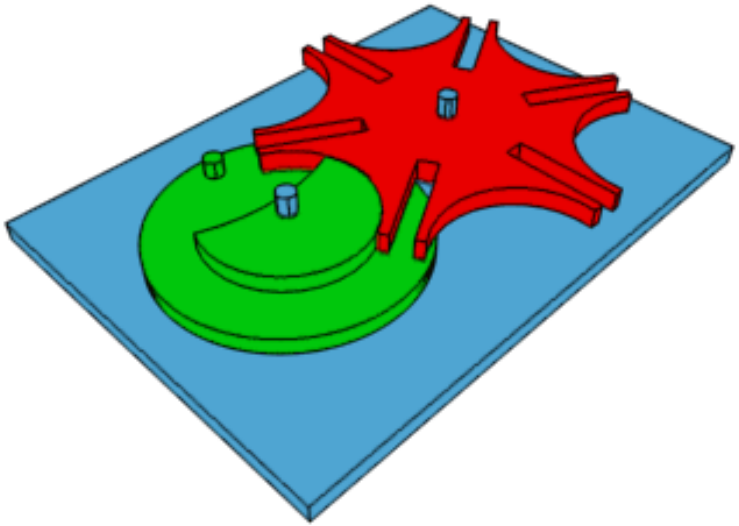




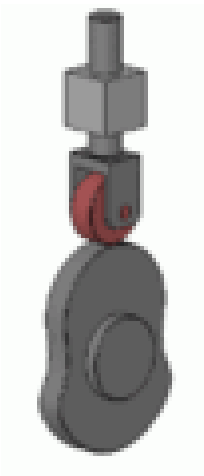


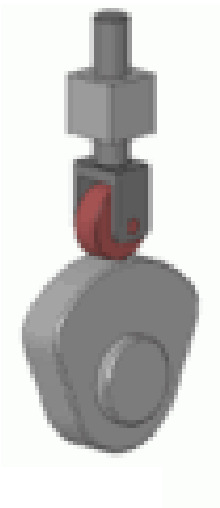
Examples

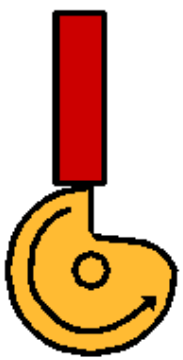


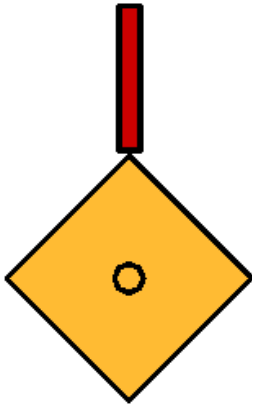


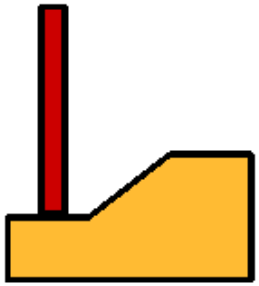
Examples



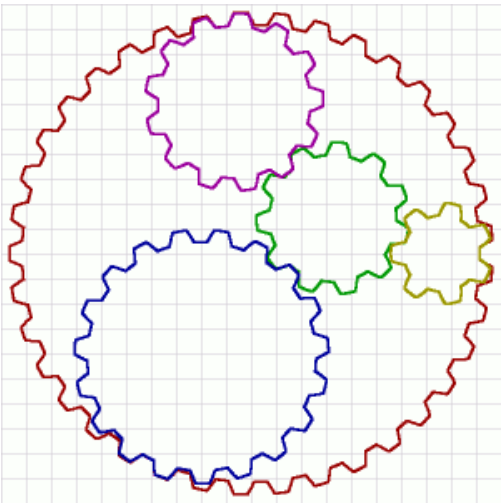


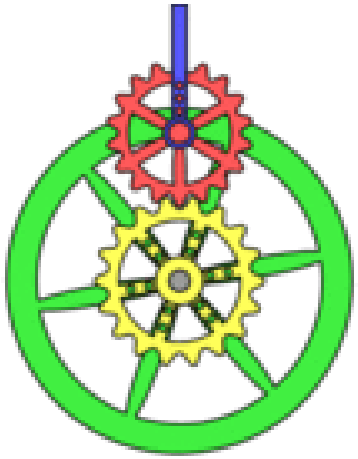


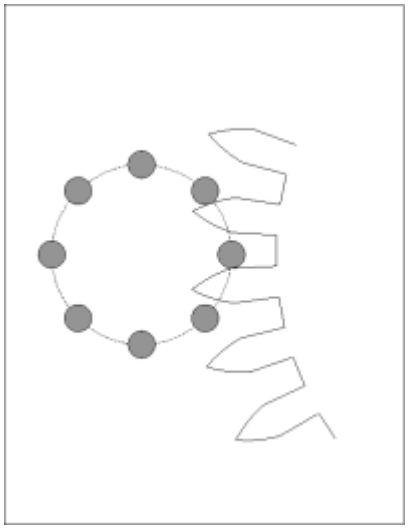


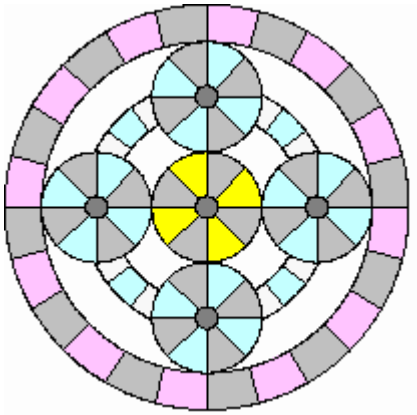


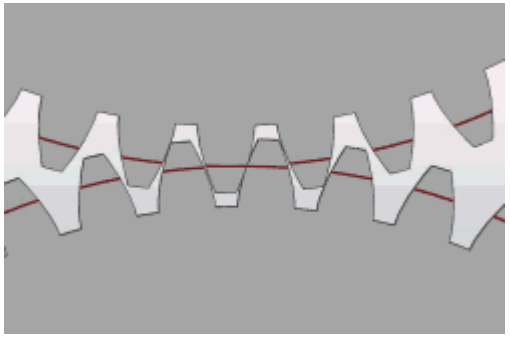
Examples



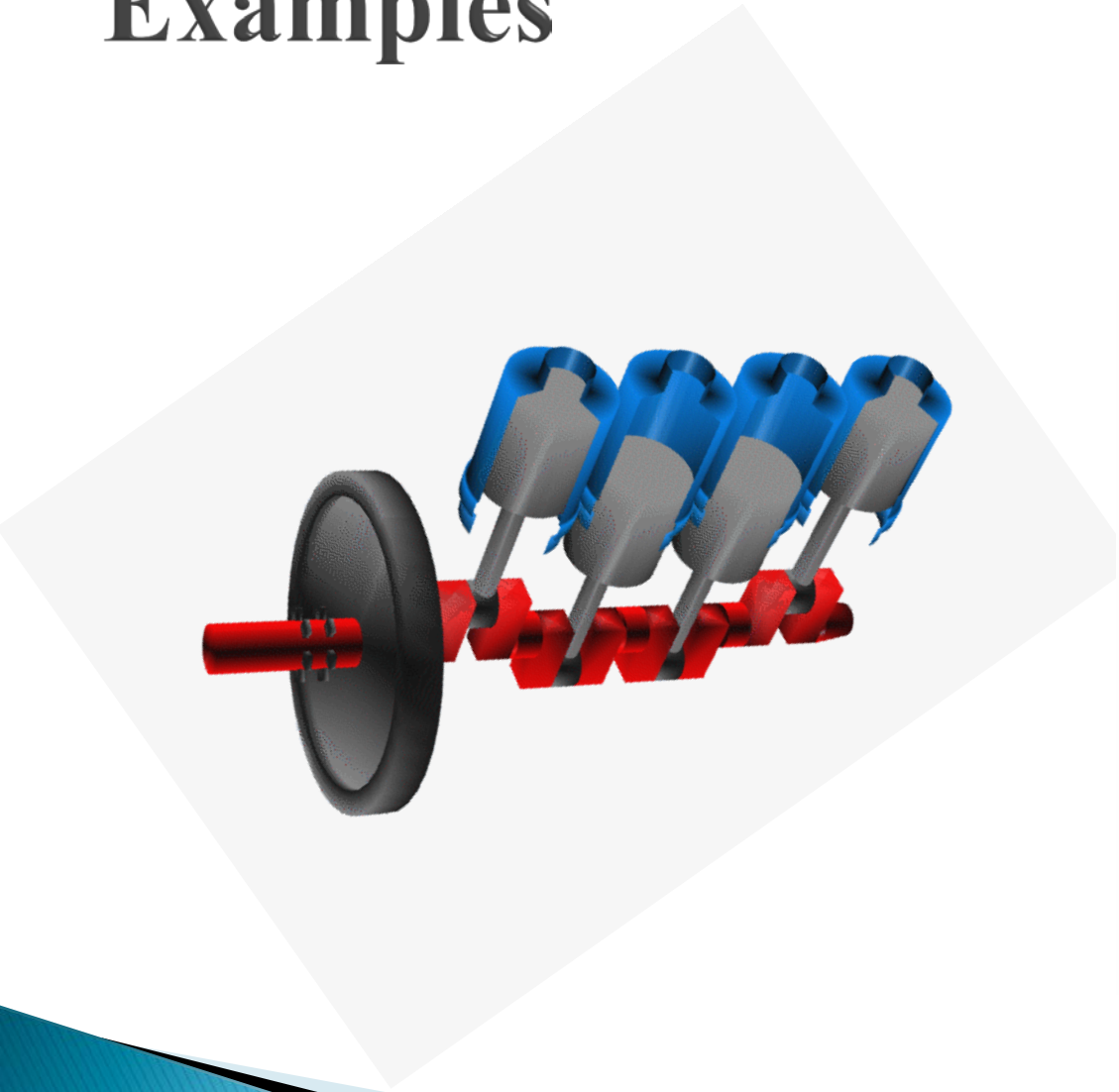


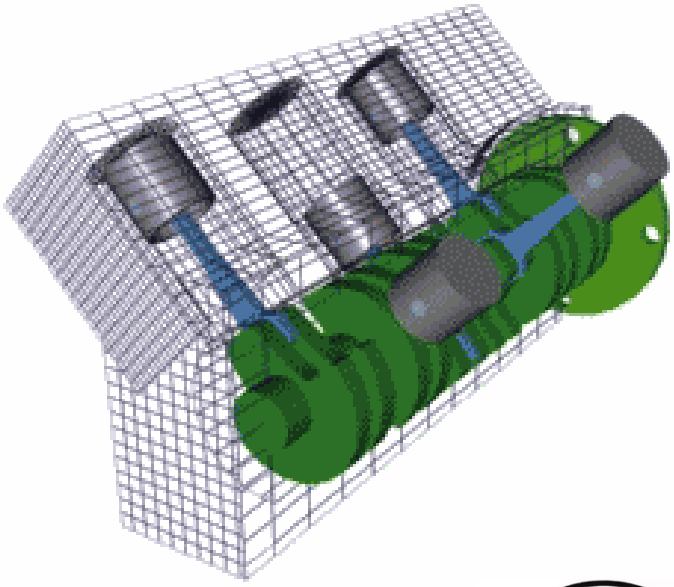






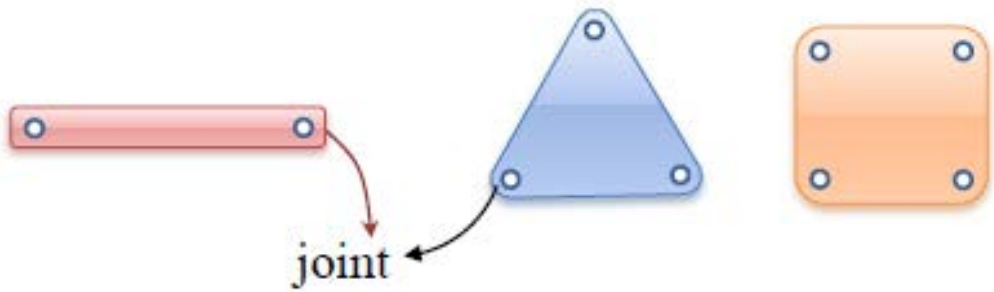
Examples





Terminology (continued…)

- **Link or element**
- It is the name given to any body which has motion relative to another.
- All materials have some elasticity. A rigid link is one, whose deformations are so small that they can be neglected in determining the motion parameters of the link.

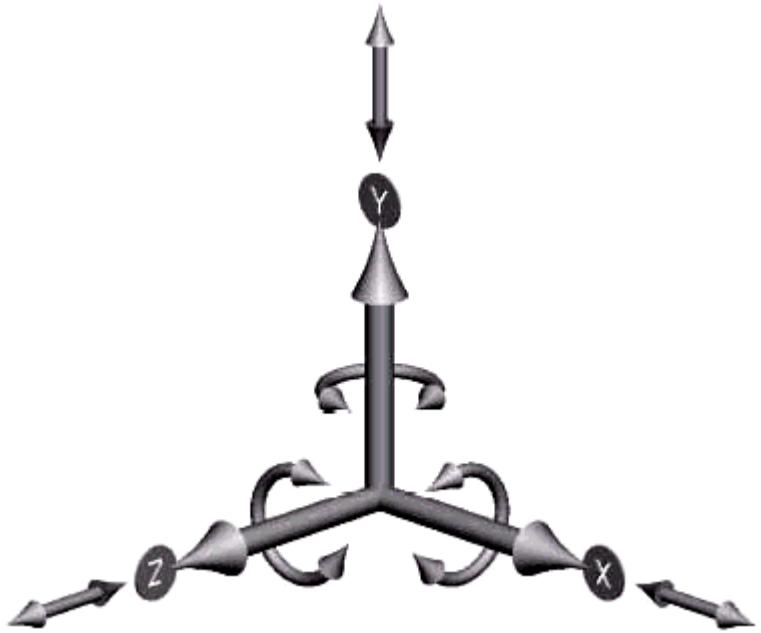


Terminology (continued…)

- **Degrees of freedom (DOF)**

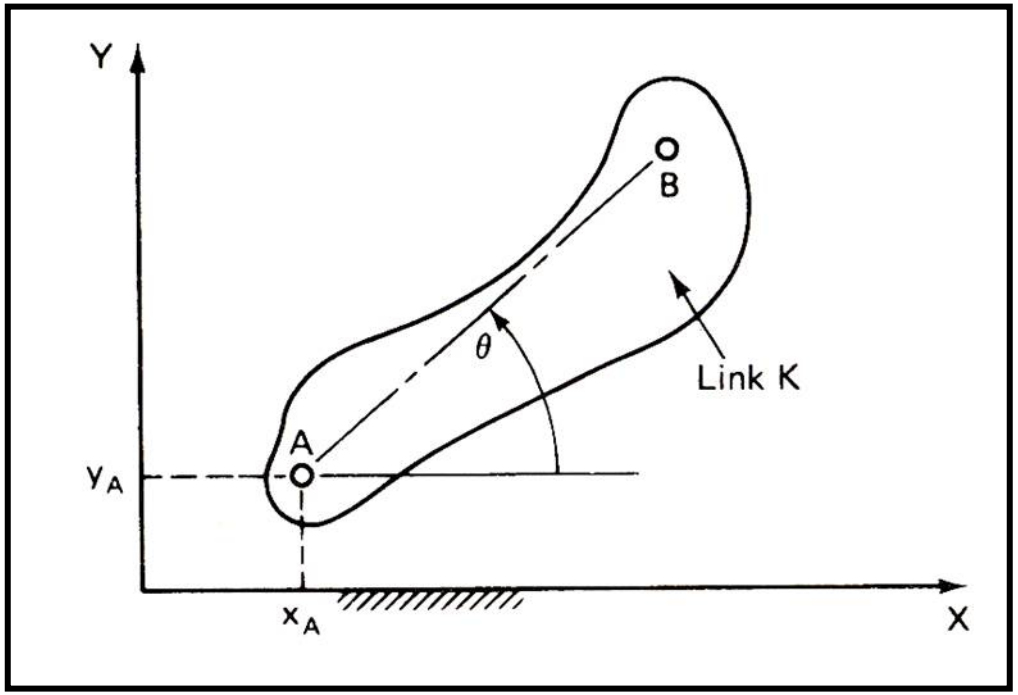
It is the number of independent coordinates required to describe the position of a body in space.

A free body in space can have six degrees of freedom. I.e., linear positions along x, y and z axes and rotational/ or angular positions with x, y and z axes.



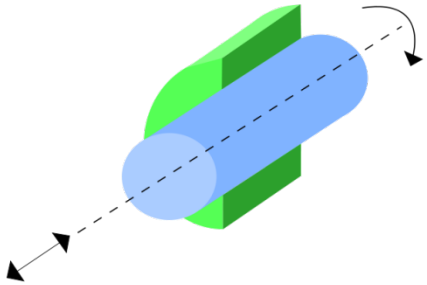
Motion in plane (General)

Three independent coordinates needed to specify the location of the link AB, x_A, y_A, **and angle** θ

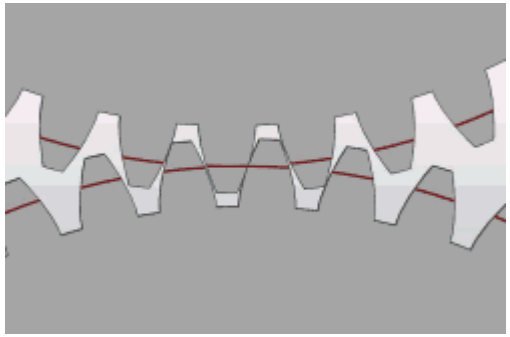


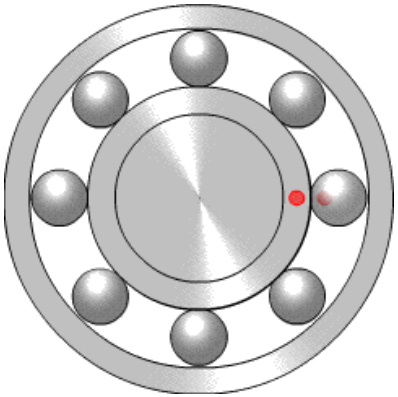
Type of Joints – Kinematic Pairs

Lower Pairs – motion is transmitted through an area contact, pin and slider joints.

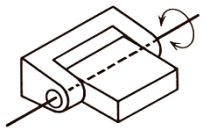
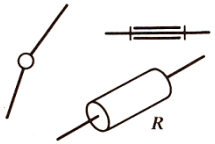
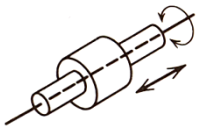
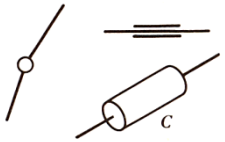
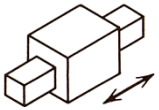
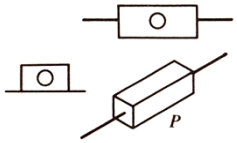
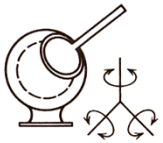
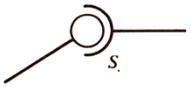
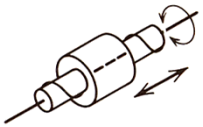
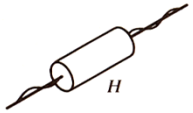
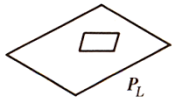


Higher Pairs – motion is transmitted through a line or a point contact; gears, rollers, and spherical joints.





Degrees of Freedom (DOF) – Type of Joints, Lower Pairs

Name of Pair	Geometric Form	Schematic Representations	Degrees of Freedom
1. Revolute (R)			1
2. Cylinder (C)			2
3. Prism (P)			1
4. Sphere (S)			3
5. Helix (H)			
6. Plane (P_L)			

Degrees of Freedom (DOF)

$$\text{DOF} = 3(L - 1) - 2J_1 - J_2$$

DOF = degree of freedom or mobility

L = number of links, including ground link

J_1 = number of 1 DOF joints (full joints)

J_2 = number of 2 DOF joints (half joints)

DOF ≤ 0 ⟶ structure

DOF > 0 ⟶ mechanism

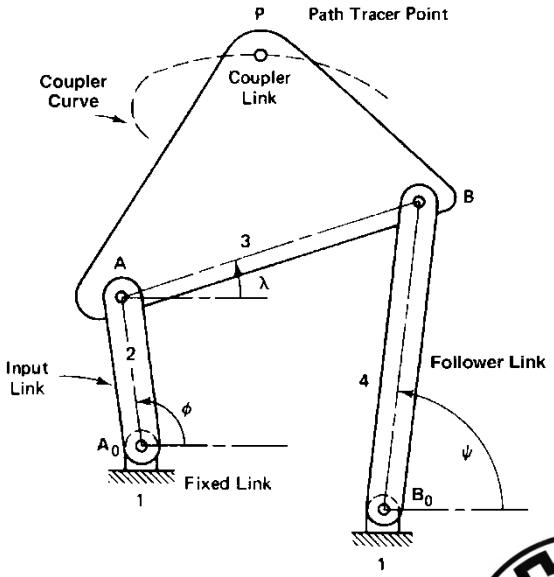
Degree of Freedom (DOF) – example

Four Bar mechanism

$L = 4$, $J_1 = 4$ pin connections, $J_2 = 0$

$\text{DOF} = 3(L - 1) - 2J_1 - J_2$

$\text{DOF} = 3(4 - 1) - 2(4) - (0) = 1$

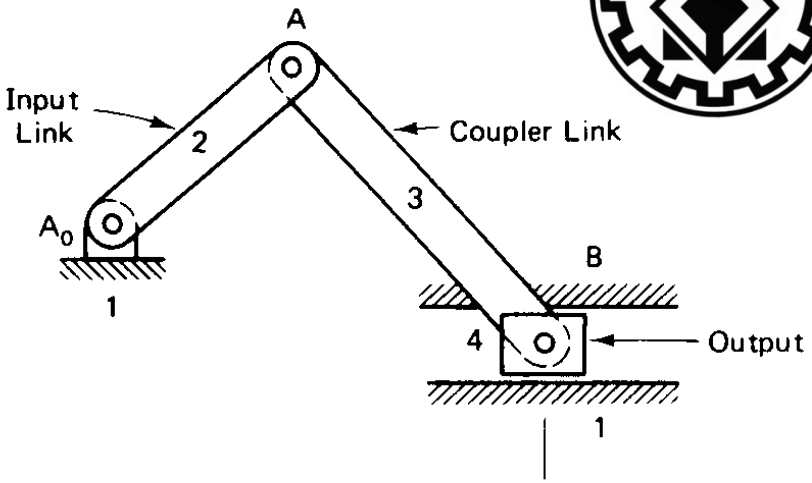


Slider crank mechanism

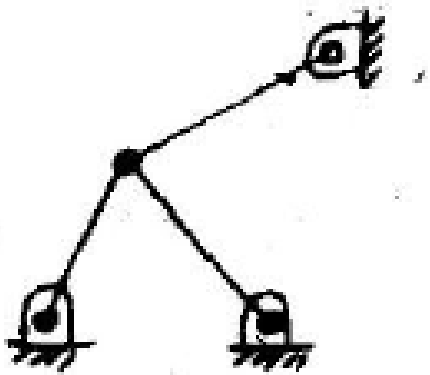
$L = 4$, $J_1 = 3$ pin connections + 1 slider = 4
$J_2 = 0$

$\text{DOF} = 3(4 - 1) - 2(4) - (0) = 1$

1 DOF means only one input (power source) is needed to control the mechanism



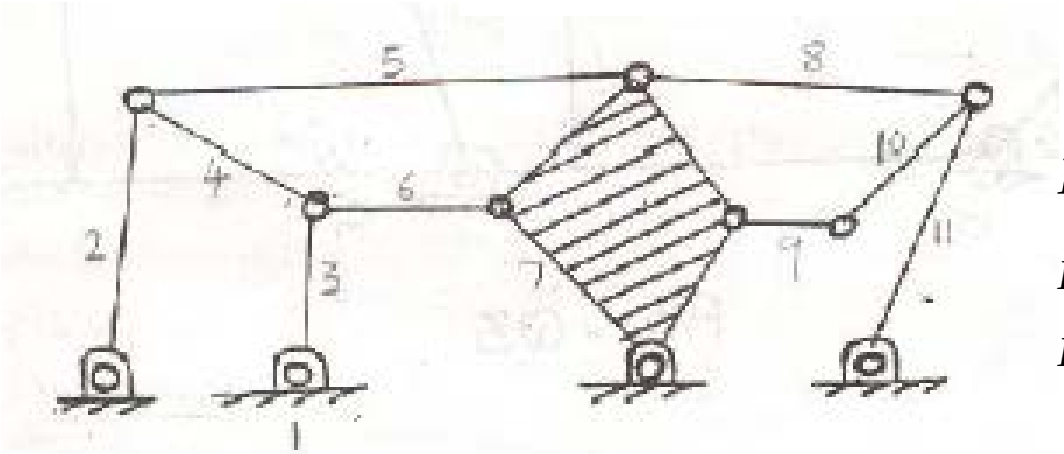
Examples



$$DOF = 3(L-1) - 2J_1 - J_2$$

L=4; J1=5; J2=0

DOF= -1



$$DOF = 3(L-1) - 2J_1 - J_2$$

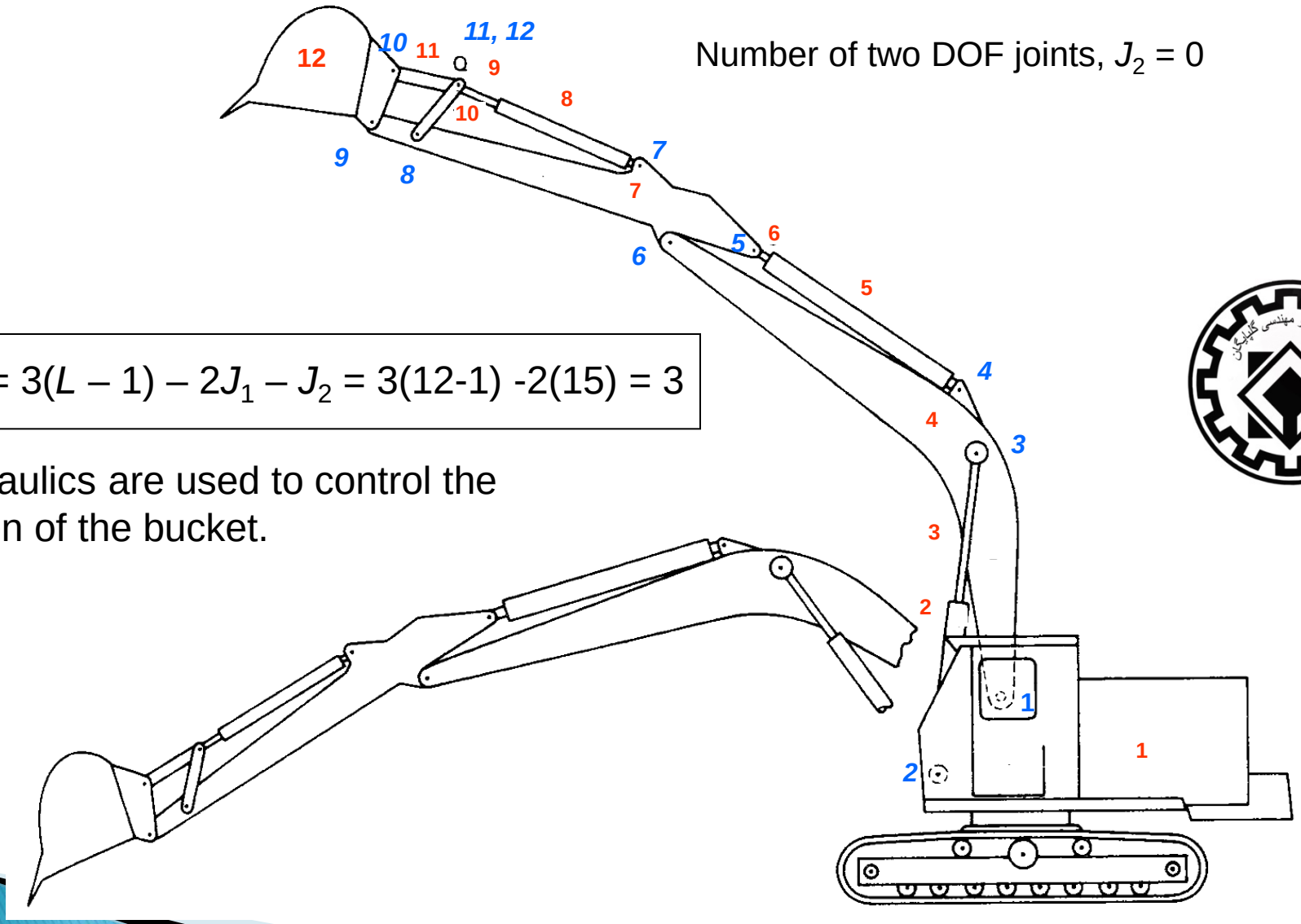
L=11; J1=15; J2=0

DOF=0

Example

Number of links, L = 12, Number of one DOF joints, J_1 = 12 (pins) + 3 (slider) = 15,

Number of two DOF joints, J_2 = 0



$$\text{DOF} = 3(L - 1) - 2J_1 - J_2 = 3(12\text{-}1)\ \text{-}2(15) = 3$$

3 hydraulics are used to control the position of the bucket.

Example

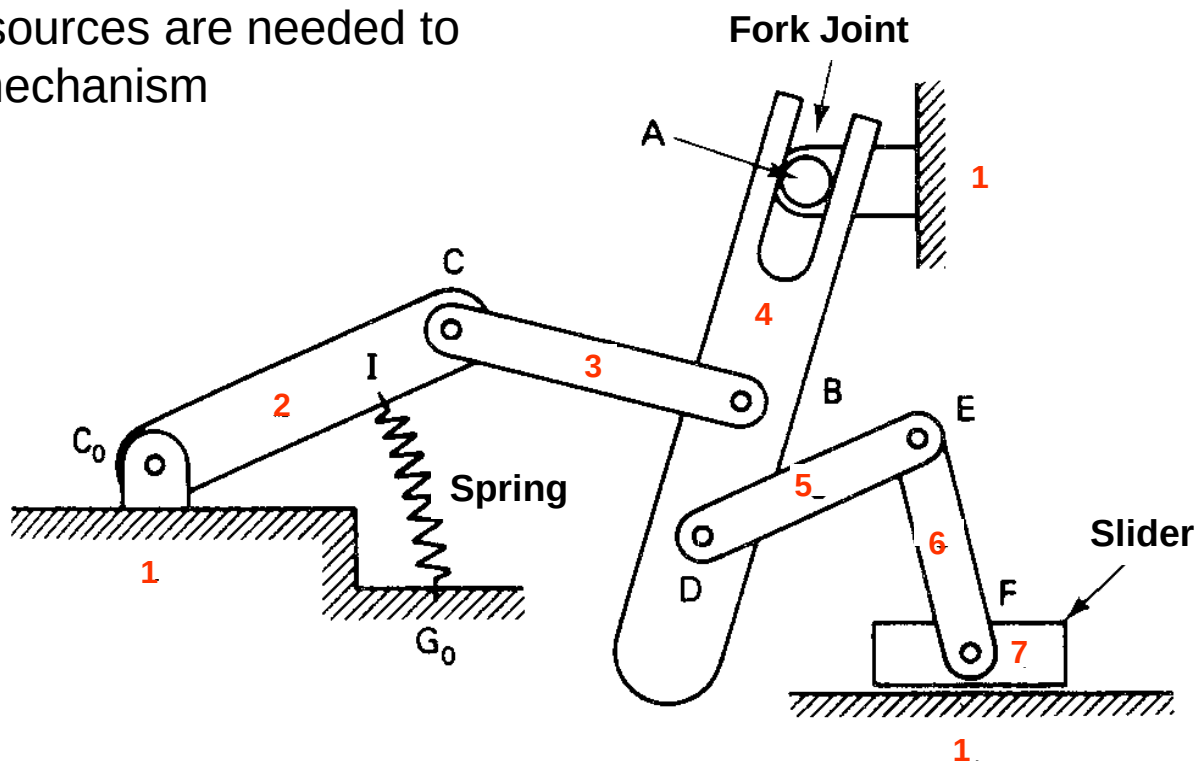
Number of links, L = 7,

Number of one DOF joints, J_1 = 6 (pins) + 1 (slider) = 7,

Number of two DOF joints, J_2 = 1 (fork joint)

$$\boxed{\text{DOF} = 3(L - 1) - 2J_1 - J_2 = 3(7\text{-}1) - 2(7) - 1 = 3}$$

Three input sources are needed to control the mechanism



Thank you for your attention!

Questions, please!