Robotics Fundamentals

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Robot History

1. 1921: Czech playwright Karl Capek premiered his play R.U.R. in Prague . (machines conquer).
2. Definition: Robot the word comes from the Czech word robota which translates to labor or slave.

Eye on Robotics

Robotics is a multi-disciplinary field. Best robotics researchers and engineers will touch upon all disciplines:

- Electrical Engineering – concerned primarily with robot actuation, electronic interfacing to computers and sensors, and control algorithms.

- Mechanical Engineering – concerned primarily with manipulator/mobile robot design, kinematics, dynamics, compliance and actuation.

- Computer Science – concerned primarily with robot programming, planning, and intelligent behavior.
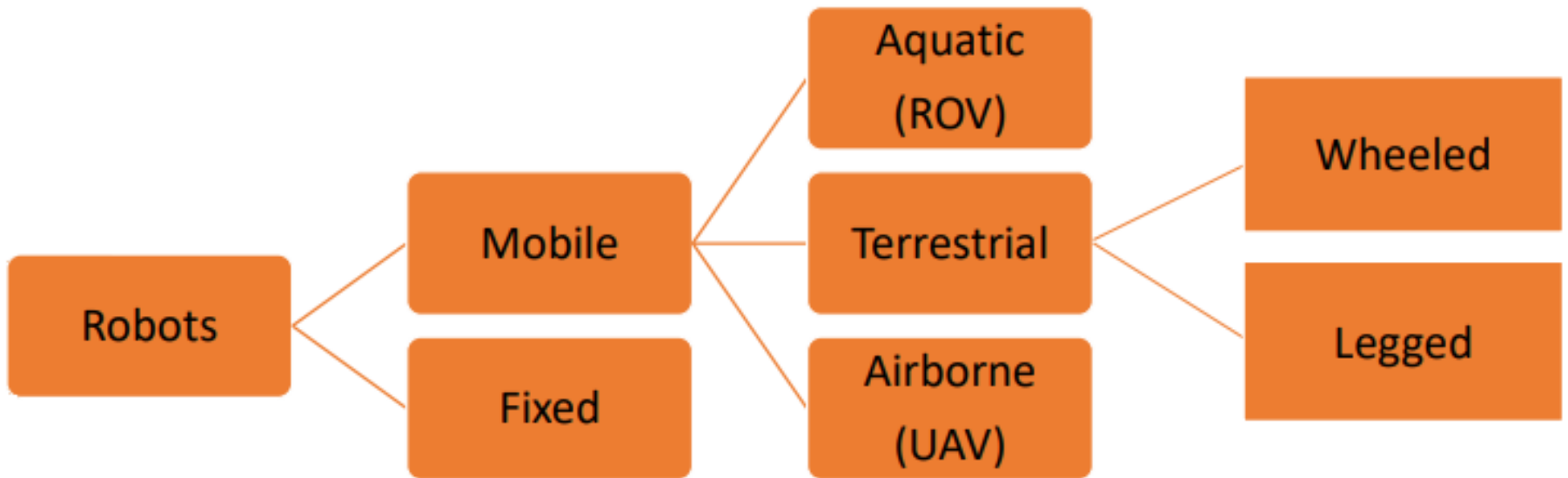
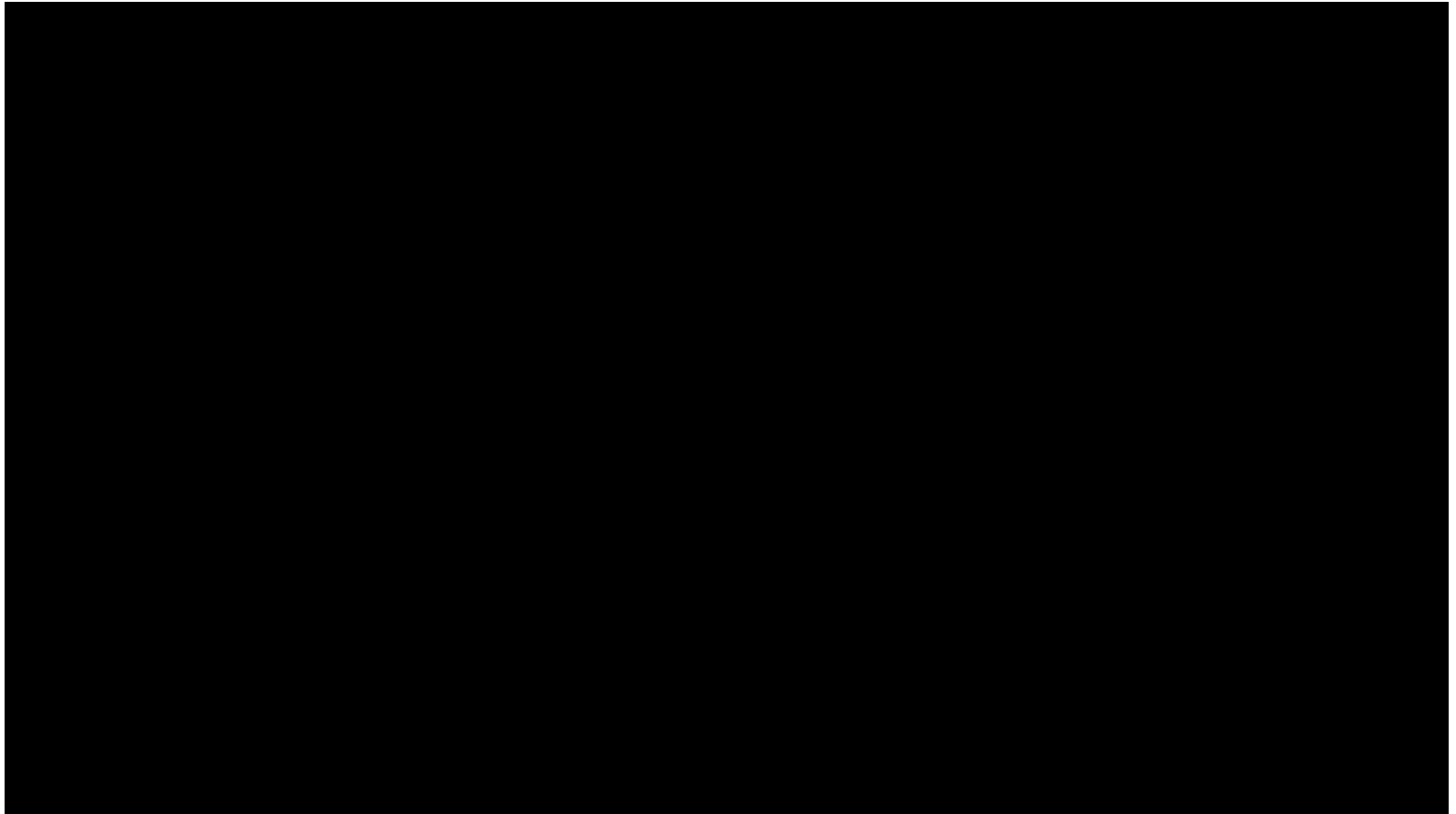# Locomotion and Manipulation

Rolling,
Walking,
Running,
Jumping,
Sliding
Crawling,
Climbing,
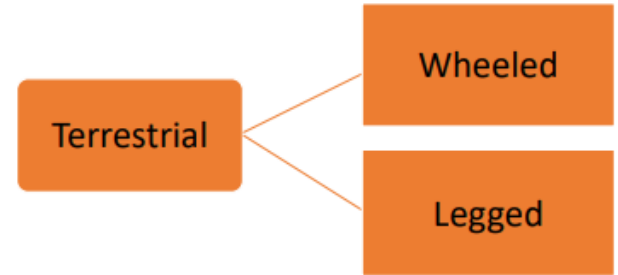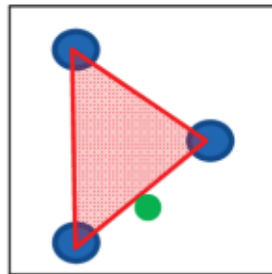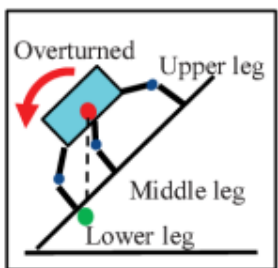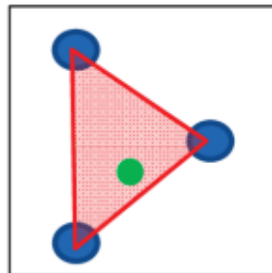Swimming, and
Flying, etc

Classification of Robots

ROV

Terrestrial

Stability and polygon of support

: Center of gravity
: P_G (Projection of center of gravity)
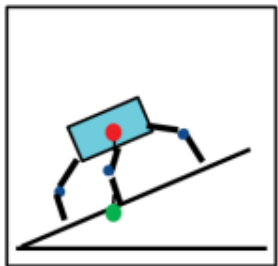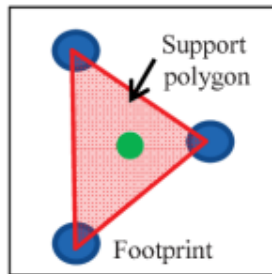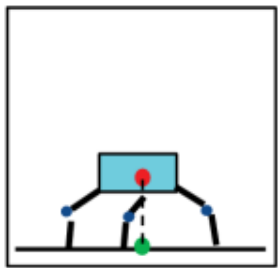
Center of gravity (COG) is within the polygon determined by the contact points of the robot on the ground, also called polygon of support.

Static: a statically stable robot can stand still without falling over.

Dynamic: a dynamically stable robot is stable only while moving

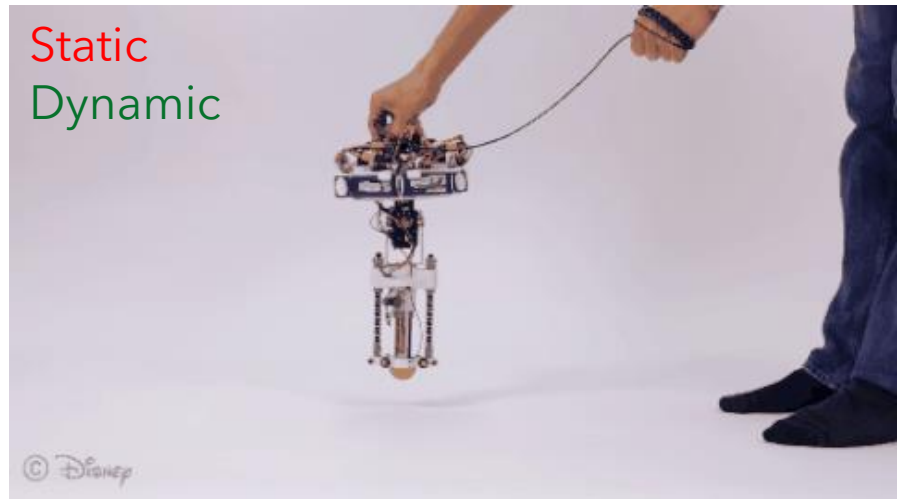# Stability and polygon of support

Static: a statically stable robot can stand still without falling over.
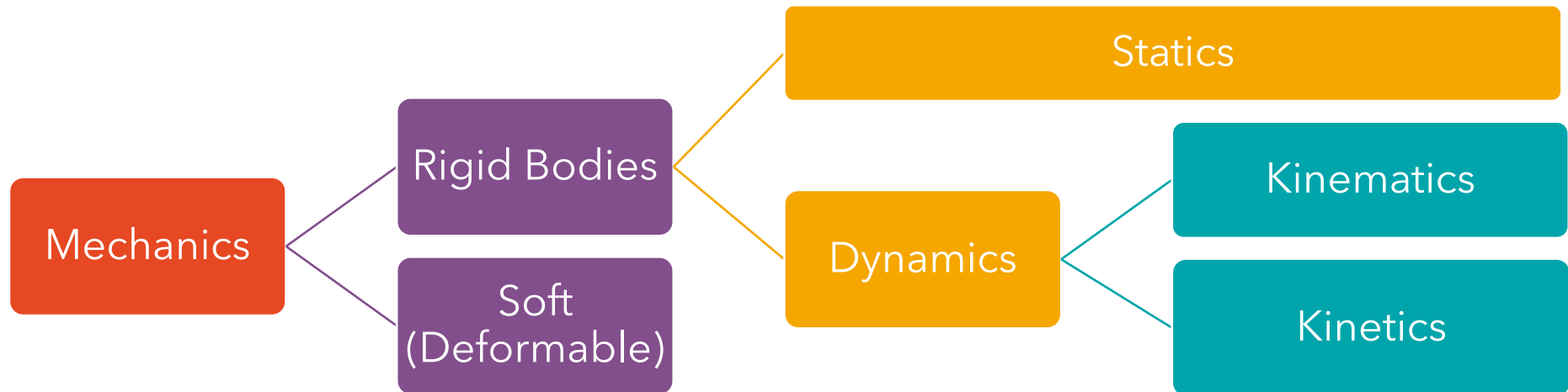Dynamic: a dynamically stable robot is stable only while moving
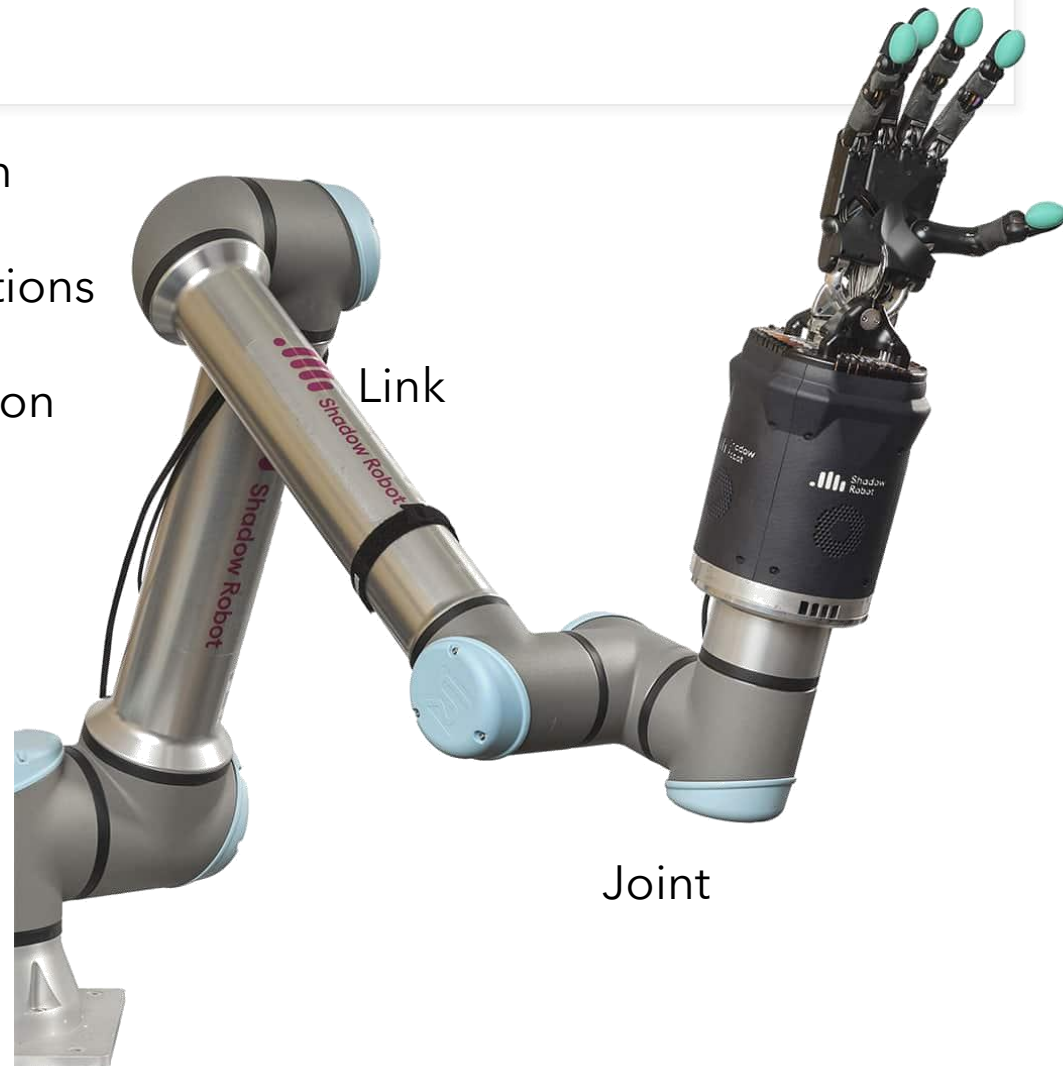

Static
Dynamic

Static
Dynamic

Classification of mechanics

Robot components

End effector

1. Manipulators are composed of an assembly of links and joints.
2. Links are defined as the rigid sections that make up the mechanism
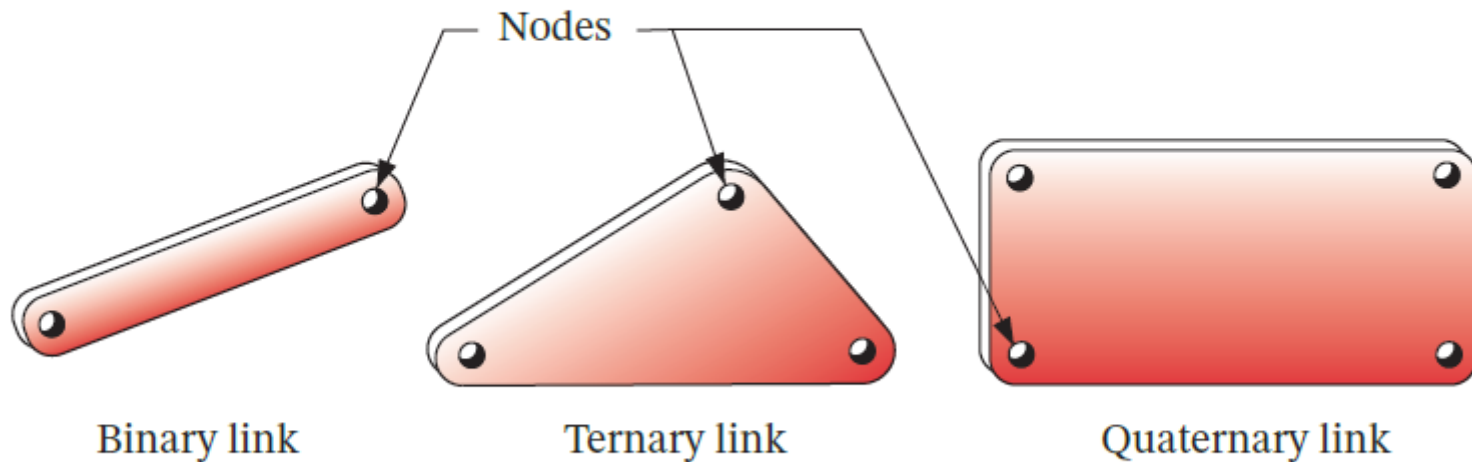3. joints are defined as the connection between two links.

Link

Joint

Links

rigid body that possesses at least two **nodes** that are *points for attachment to other links*.

Binary link   - *one with two nodes.*

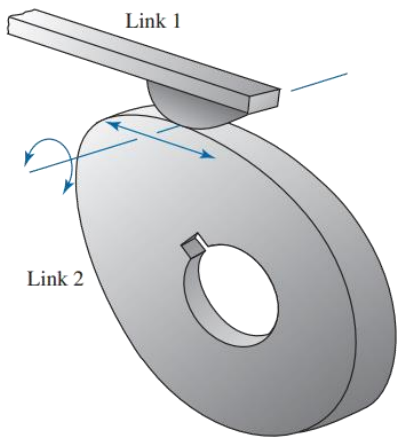**Ternary link**   - *one with three nodes.*
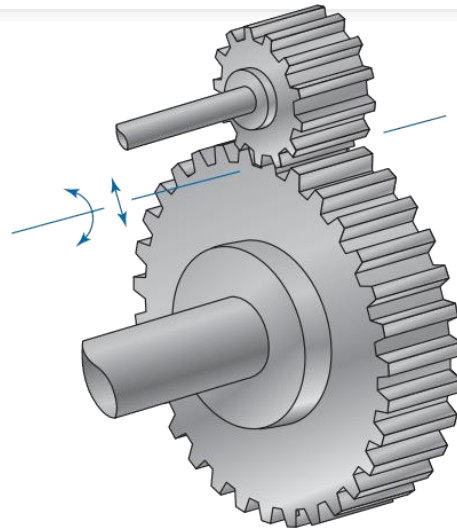
Quaternary link   - *one with four nodes.*

Binary link   Ternary link   Quaternary link

FIGURE 2-2

Links of different order

Joints

- **lower pair** to describe joints with surface contact
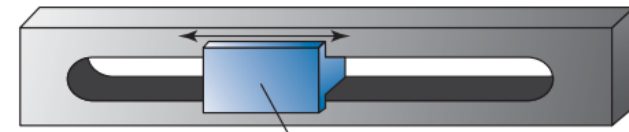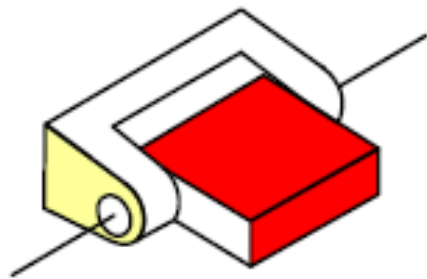- **higher pair** to describe joints with pointor line contact.

(a) Cam joint

Link 1

Link 2

(b) Gear joint

Link 2

Link 1

(a) Pin

Link 1

Link 2
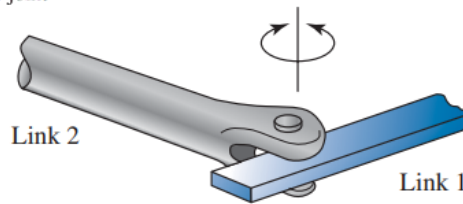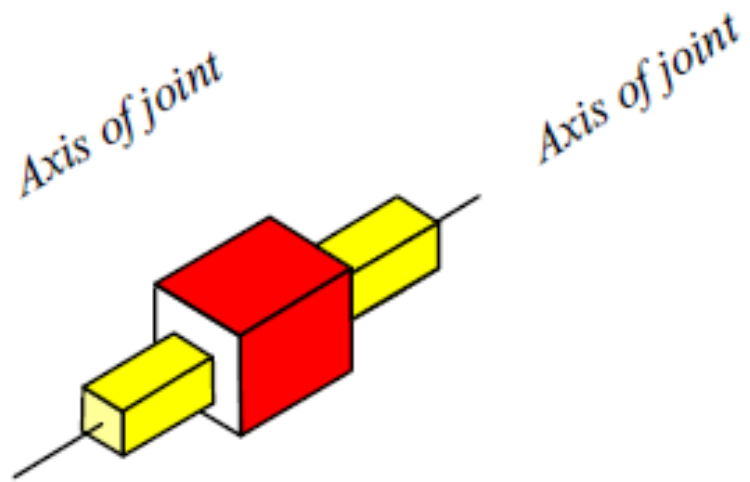
(b) Sliding

Types of motion
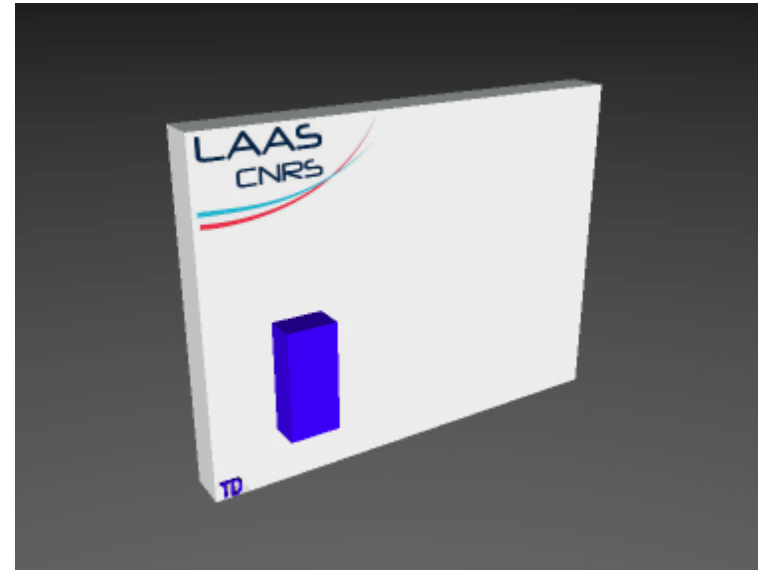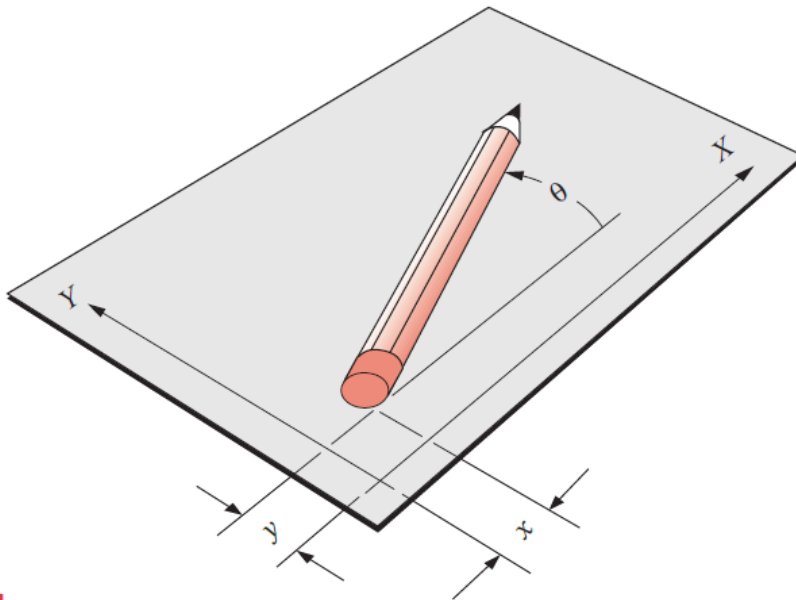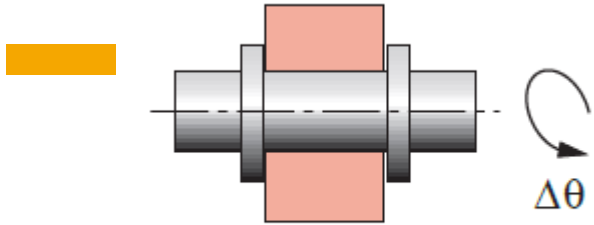

Revolute   Prismatic

Degree of freedom

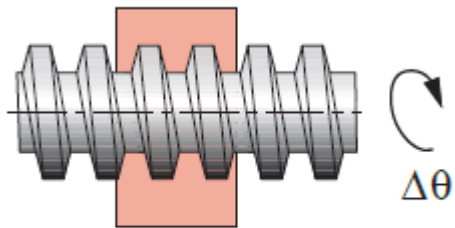is the number of independent movements that a robot can make
(x, y, θ)
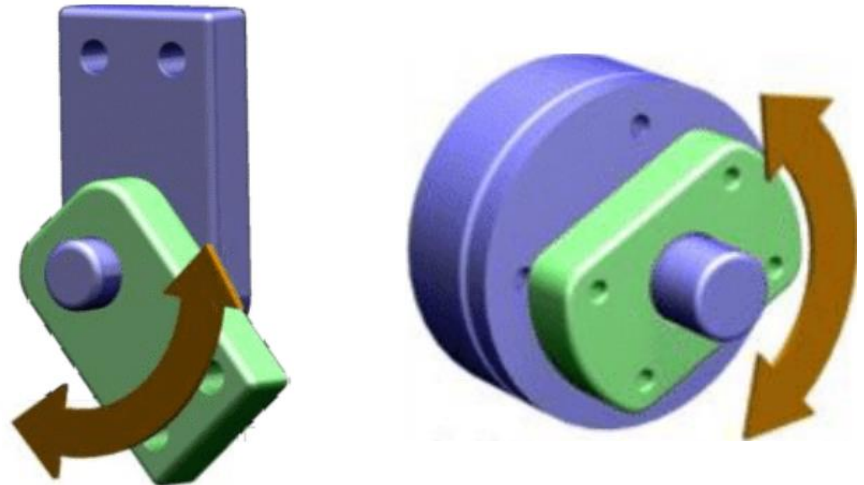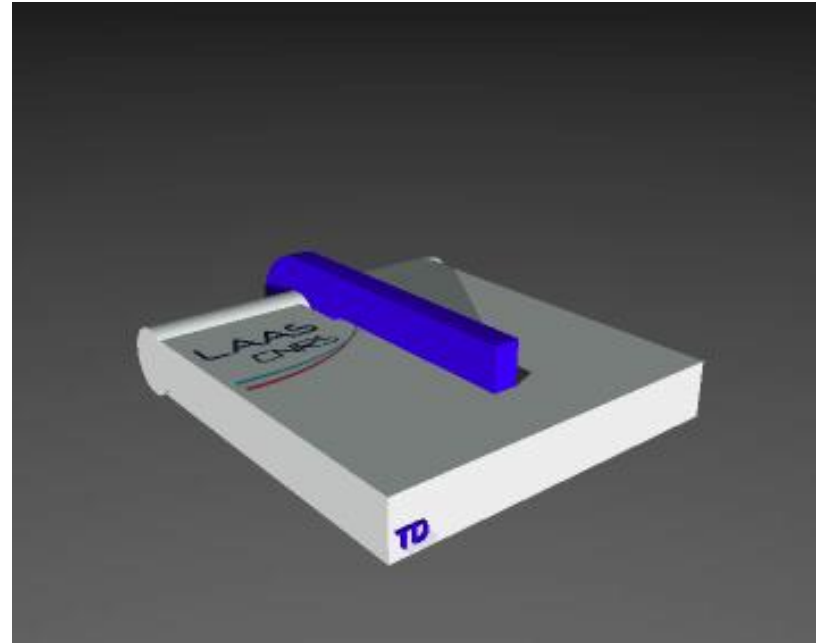

FIGURE 2-1

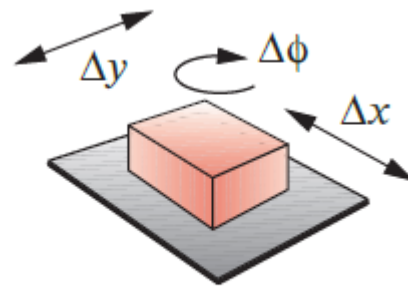A rigid body in a plane has three *DOF*

Revolute (R) joint—1 DOF

Joint types (**Revolute joint**)

Helical (H) joint—1 DOF

Planar Joint

Planar (F) joint—3 DOF
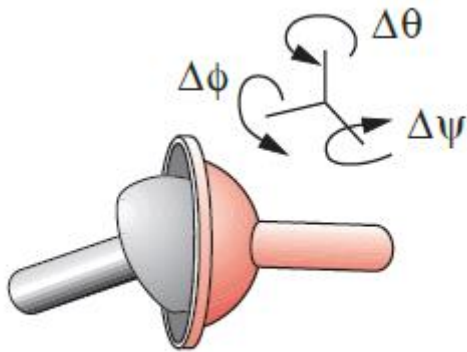
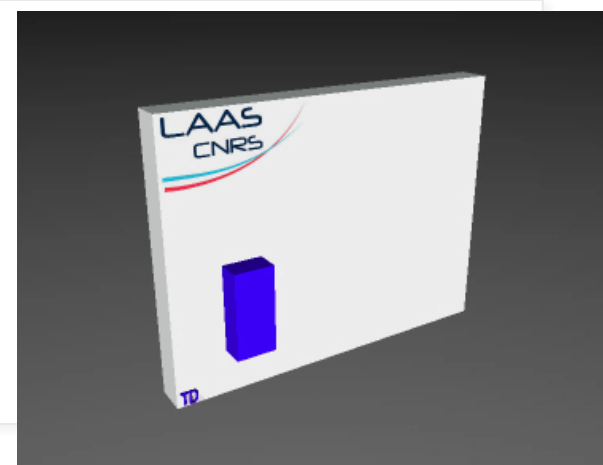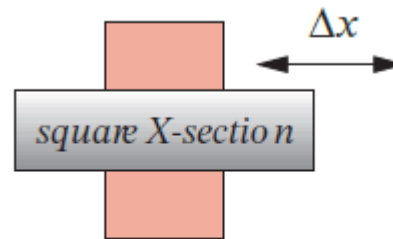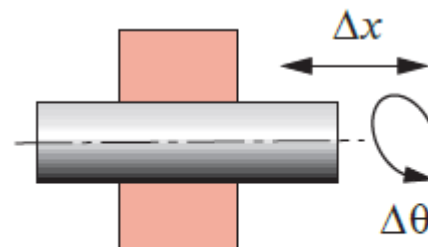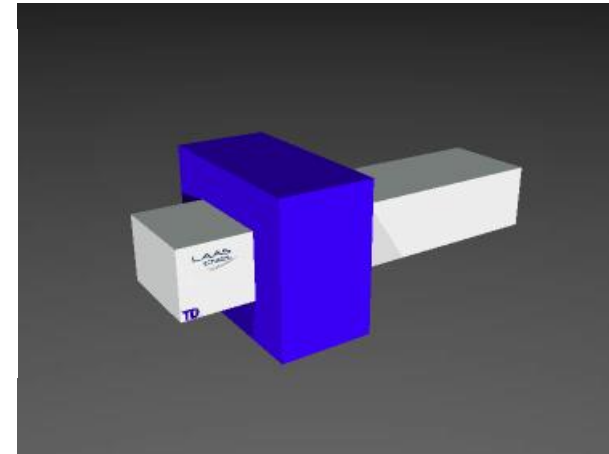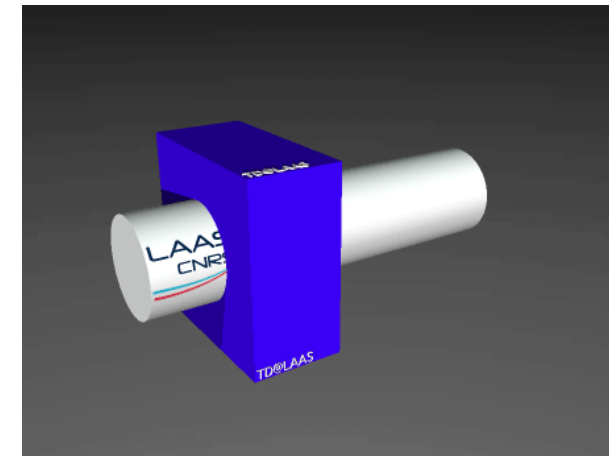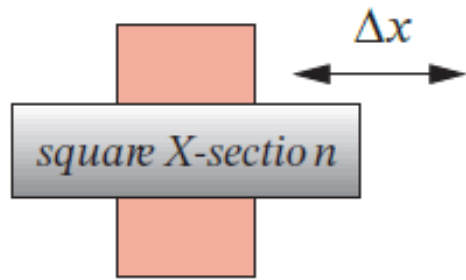Spherical (S) joint—3 DOF

Prismatic (P) joint—1 DOF

square X-section

Cylindric (C) joint—2 DOF

Prismatic (P) joint—1 *DOF*

square X-section

Δx
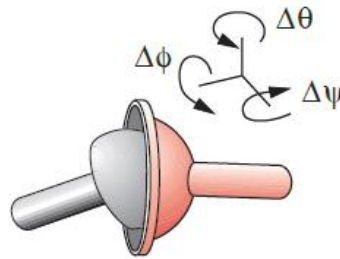
Spherical (S) joint—3 *DOF*

$\Delta\phi$ $\Delta\theta$ $\Delta\psi$
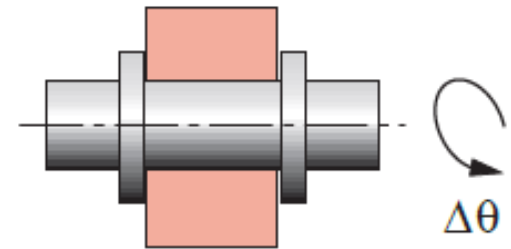
Revolute (R) joint—1 *DOF*

$\Delta\theta$

TABLE 2-1

The Six Lower Pairs

Name (Symbol)	DOF	Contains
Revolute (R)	1	R
Prismatic (P)	1	P
Helical (H)	1	RP
Cylindric (C)	1	RP
Spherical (S)	3	RRR
Planar		
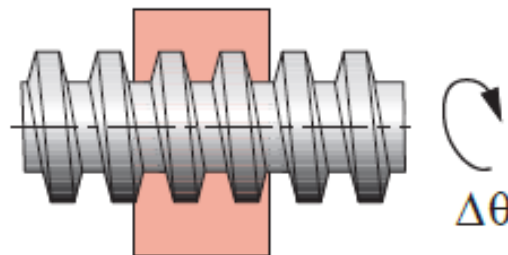
Helical (H) joint—1 *DOF*

$\Delta\theta$

Cylindric (C) joint—2 *DOF*

Δx

$\Delta\theta$
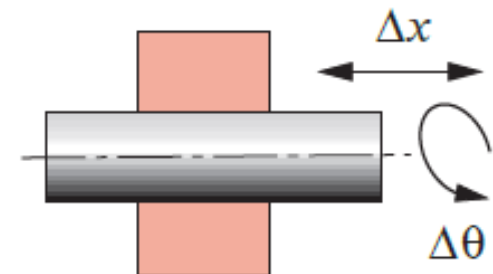
Degree of freedom

Translation: x, y, z
Rotation: Roll, Pitch, Yaw
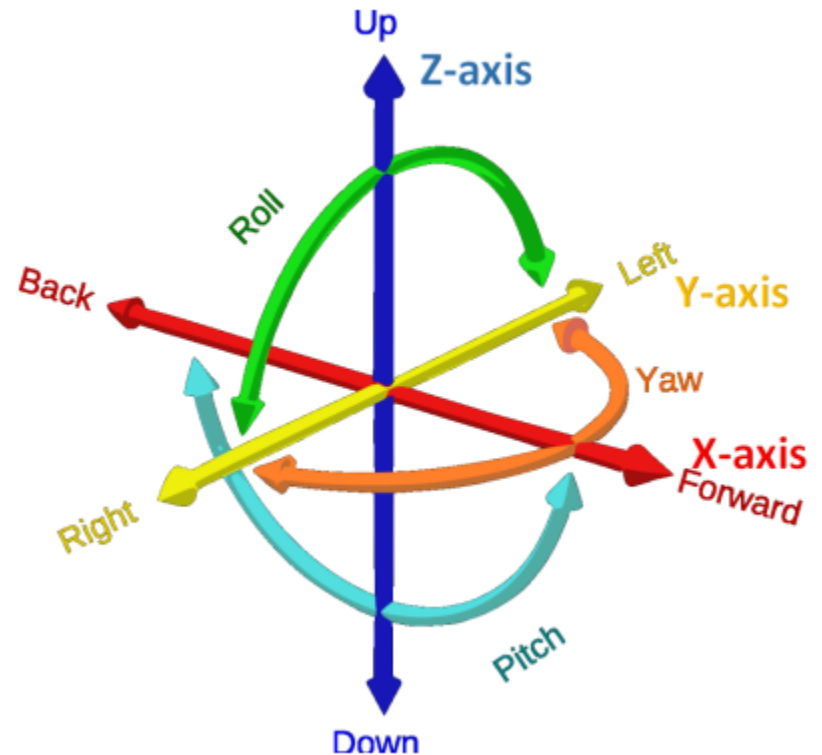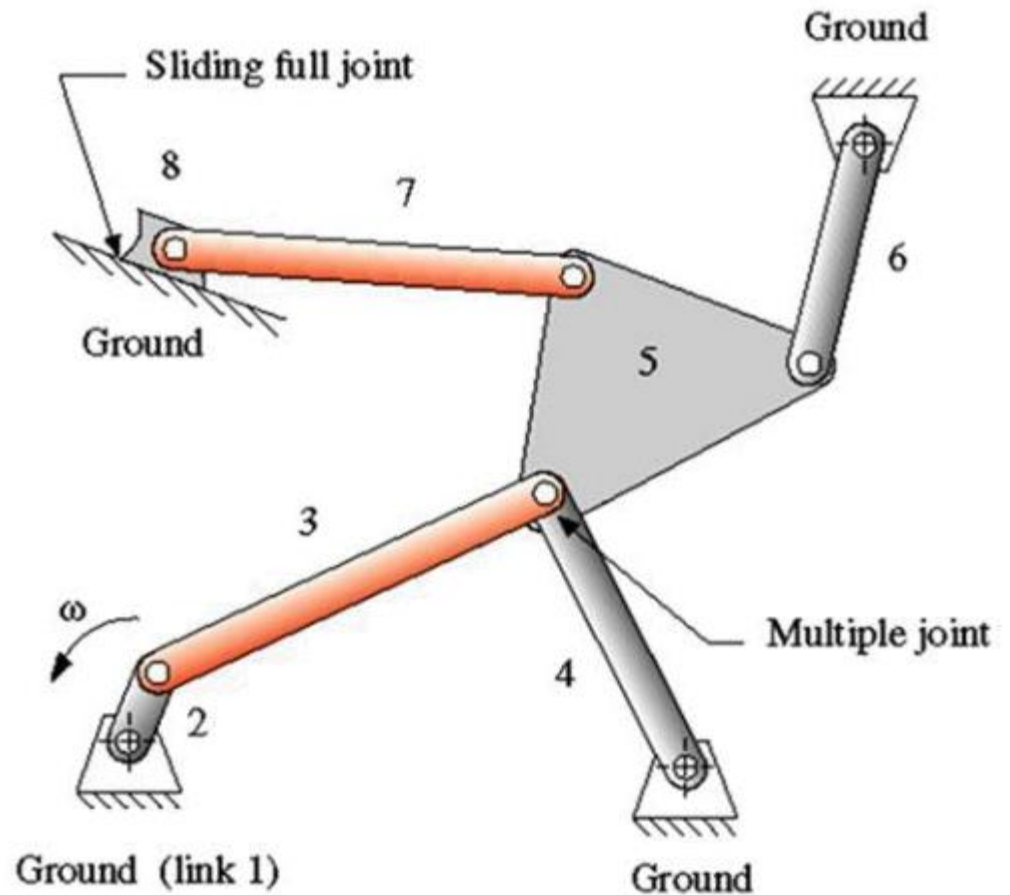
Grübler's Formula

General rules:-

      1. Any links (L) has 3 DOF.

      2. Any ground (G) link reduces DOF by 3

      3. Any full joints (J_f) reduces DOF by 2
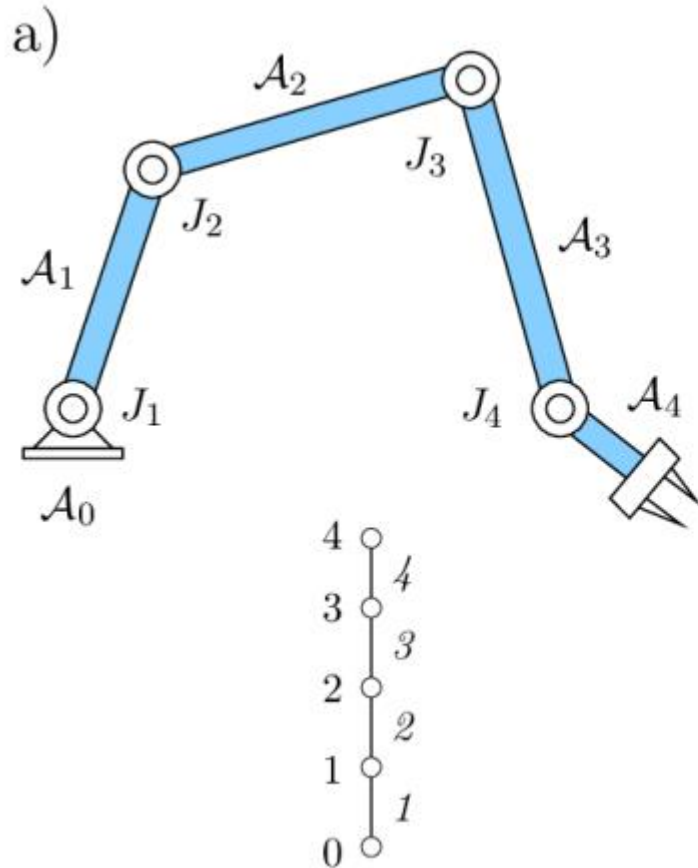
      4. Any half joints (J_h) reduces DOF by 1

$$DOF = 3(L - 1) - 2J_f - J_h$$

Example:

$$DOF = 3(L - 1) - 2J_f - J_h$$
$$= 3(8\text{-}1)\text{-}2*10\text{-}0 = 1$$

Sliding full joint

8

7

Ground

Ground

5

6

3

ω

Multiple joint

2

4

Ground (link 1)

Ground
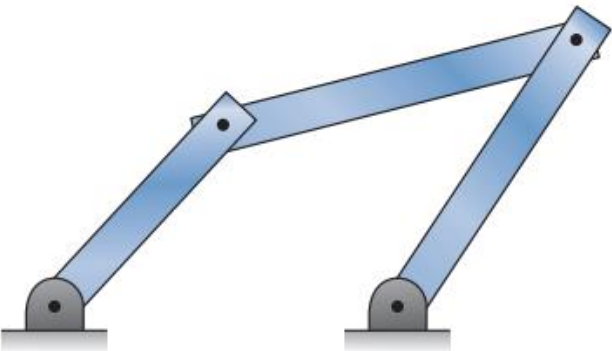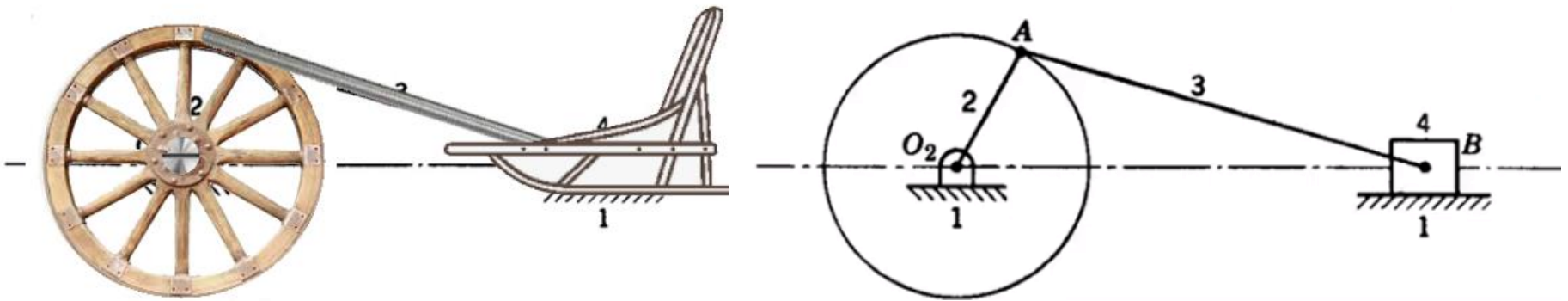
DOF

a)

b)

$$DOF = 3(L - 1) - 2J_f - J_h$$
$$= 3(5-1)-2*4-0 = 4$$
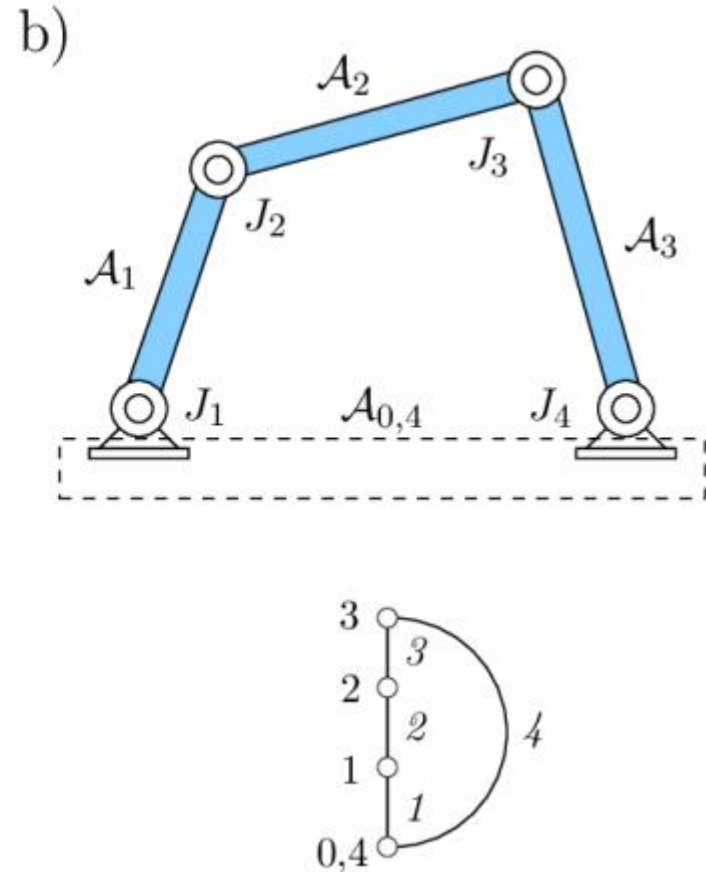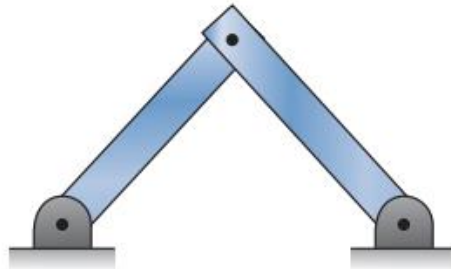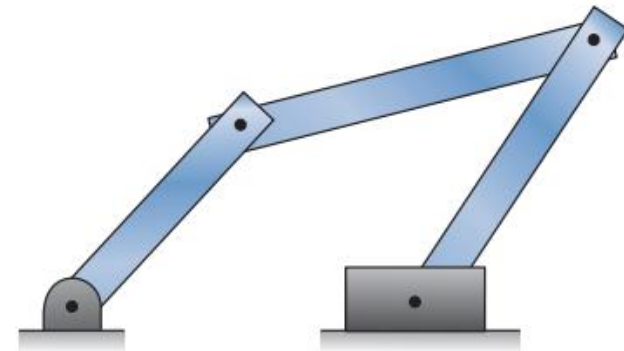
$$DOF = 3(L - 1) - 2J_f - J_h$$
$$= 3(4-1)-2*4-0 = 1$$

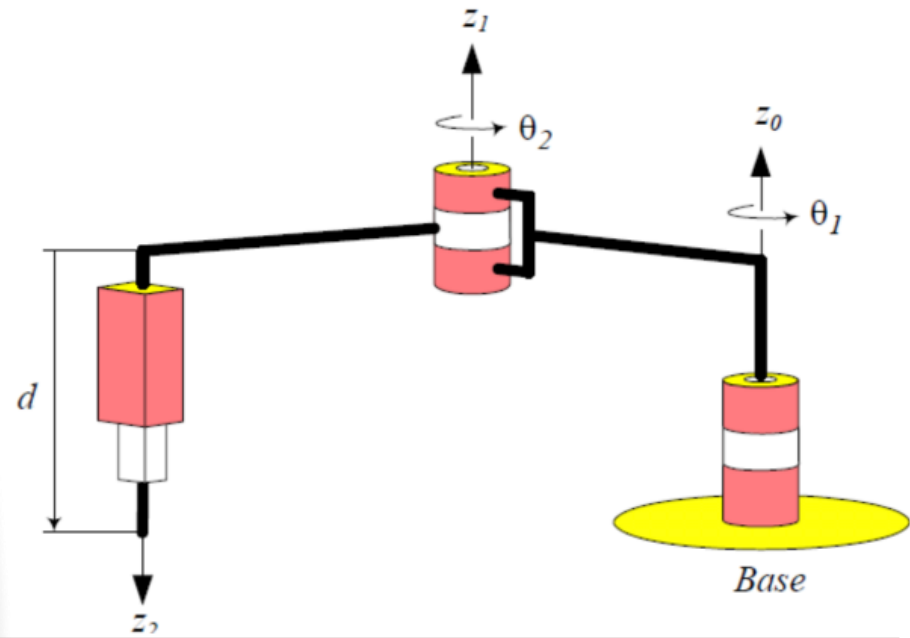# Kinematics diagram (1DOF!!)

(a) Single degree-of-freedom ($M = 1$)

(b) Locked mechanism ($M = 0$)

(c) Multi-degree-of-freedom ($M = 2$)

Selective Compliant Articulated Robot for Assembly

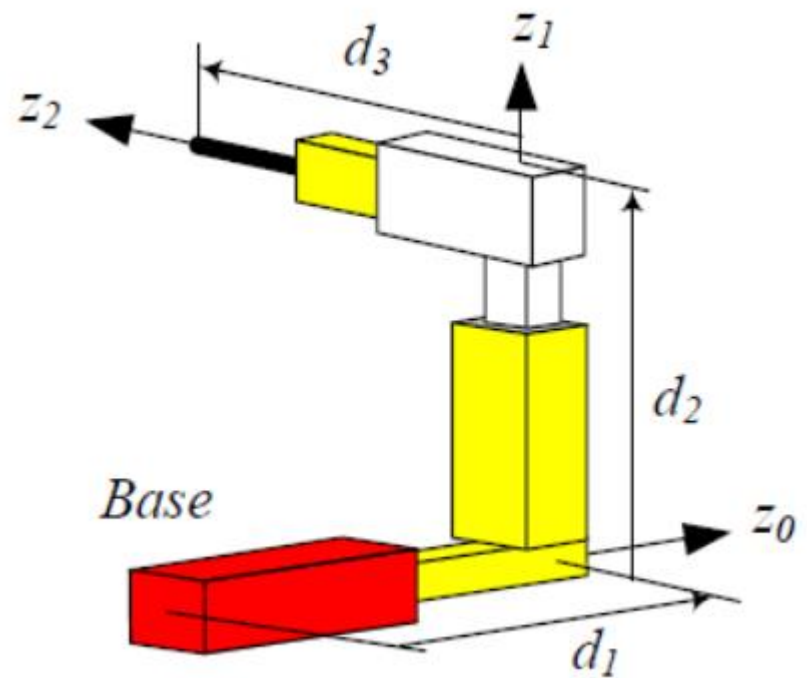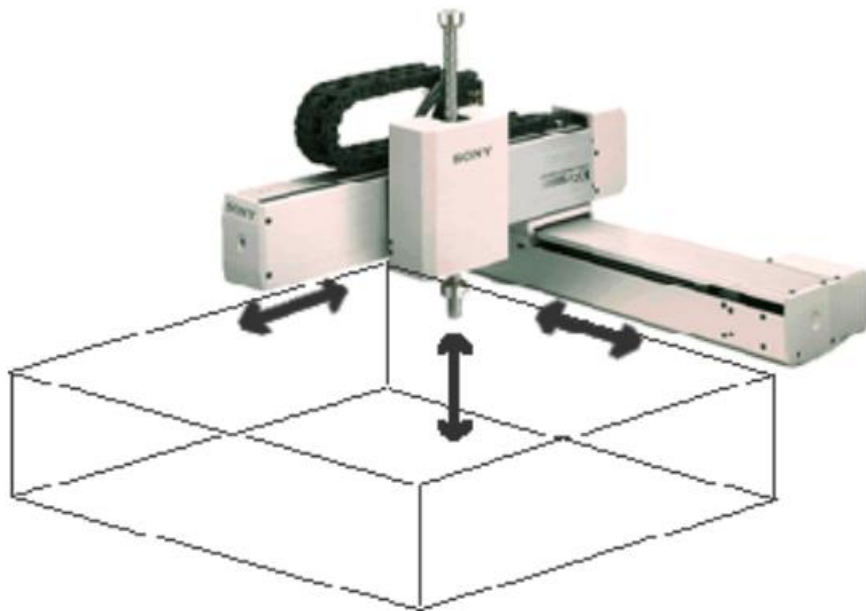SCARA arm (R‖R‖P manipulator VVP)

Cartesian configuration

P⊢P⊥P (PPP)

Soft robots

END