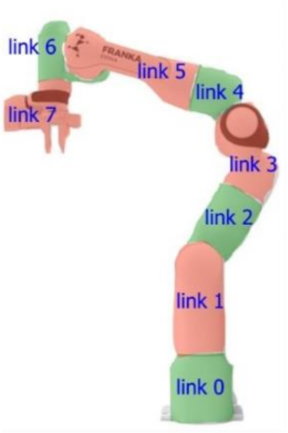
21AIE201-INTRODUCTION TO ROBOTICS

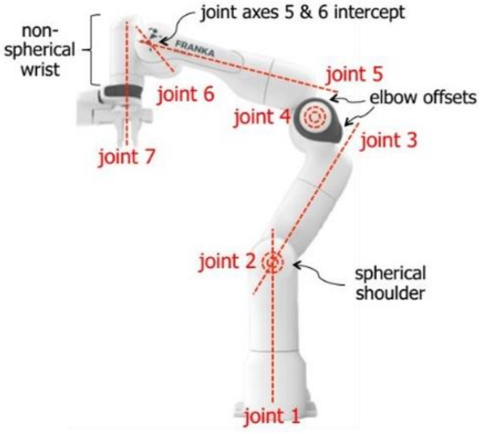
Lecture 5

Structure of Serial Robot manipulator

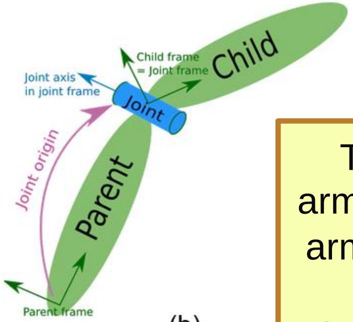
The following figure shows the structure of a typical robot manipulator



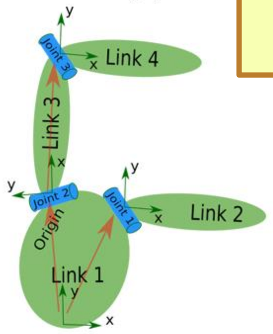
(a)



(b)



(b)

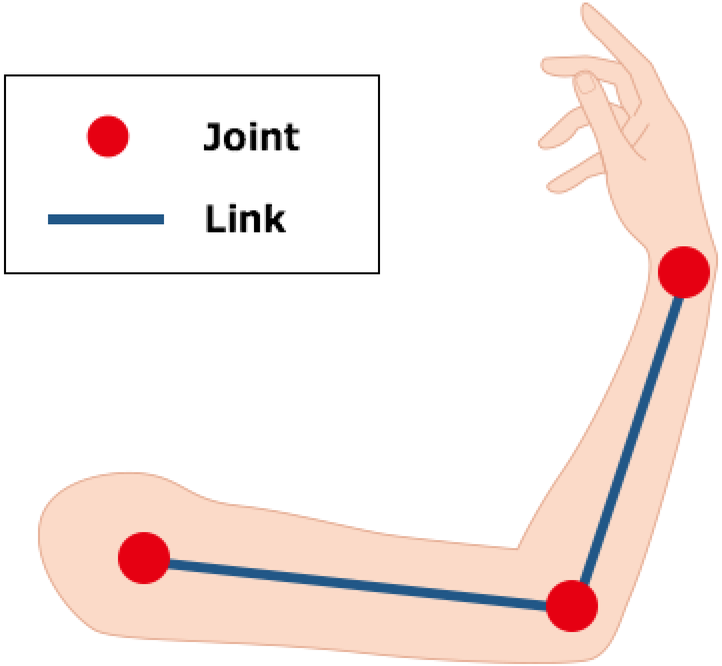


(c)

Two main parts of the robotic arm are ***Links*** and ***Joints***. A robotic arm is a chain of joints and links.

So let’s see what is a link and a joint.

Let's take an example from the human body. The links and joints of a human arm are demonstrated in the image below. The concept can be applied to robots too.



Joints and Links of a human arm

What is a link in a robot?

Here is one definition of a robot link.

- “A link is defined as a single part which can be a resistant body or a combination of resistant bodies having inflexible connections and having a relative motion with respect to other parts of the machine.

- A link is also known as a kinematic link or element.

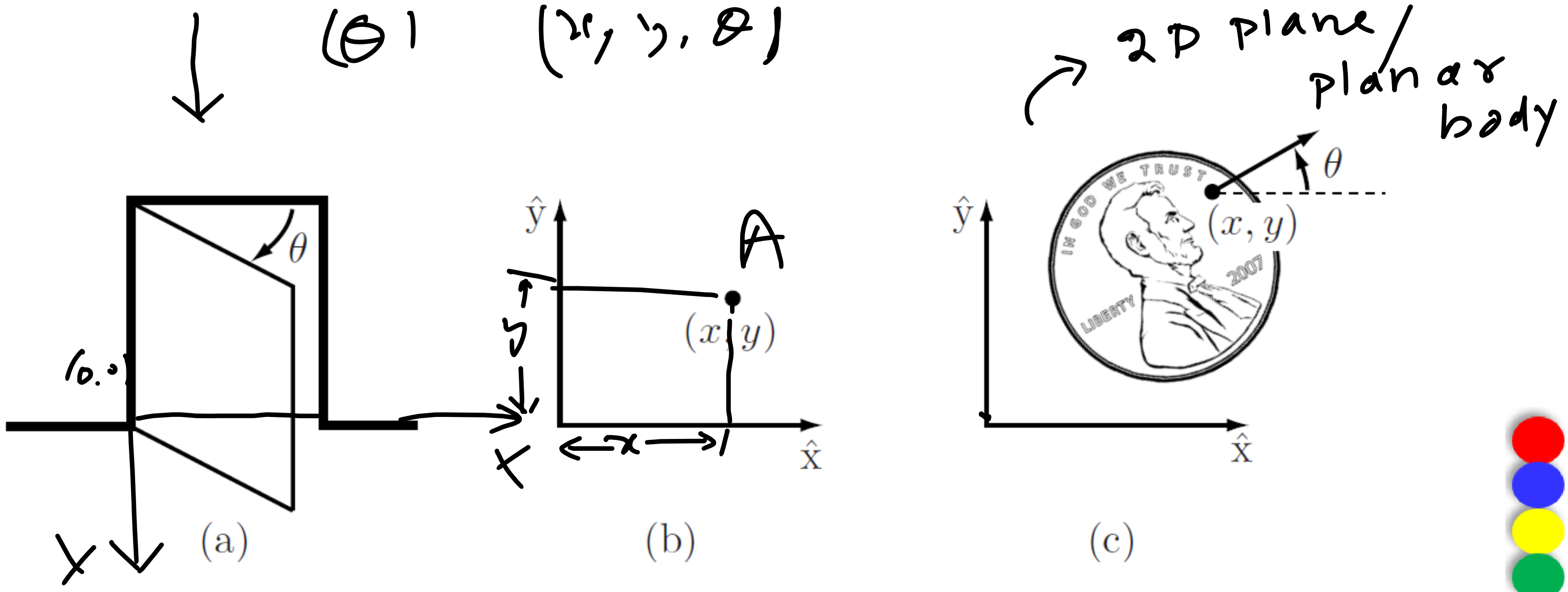
- A resistant body is one which does not go under deformation while transmitting the force.”

Perhaps the most fundamental question one can ask about a robot is, where is it?

- The answer is given by the **robot's configuration**: a specification of the positions of all points of the robot.
- Since the robot's links are rigid and of a known shape, only a few numbers are needed to represent its configuration

For example, to know where a door is, we only need to know the angle of its hinge when it changes from 0 to 180 degrees.

The configuration of a door can be determined by the angle about its hinge.



(a) The configuration of a door is described by the angle θ. (b) The configuration of a point in a plane is described by coordinates (x, y). (c) The configuration of a coin on a table is described by (x, y, θ), where θ defines the direction in which Abraham Lincoln is looking.

Configuration of a robot?

- The configuration of a robot is a complete specification of the position of every point of the robot.
- The minimum number n of real-valued coordinates needed to represent the configuration is the number of degrees of freedom (dof) of the robot.
- The n-dimensional space containing all possible configurations of the robot is called the configuration space (C-space).
- The configuration of a robot is represented by a point in its C-space.

Degrees of Freedom of a Rigid Body

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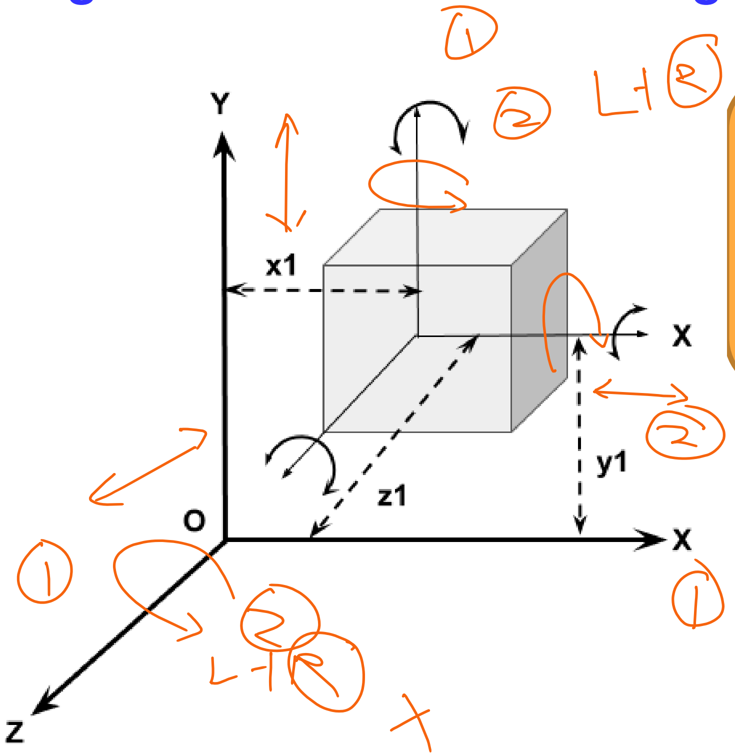
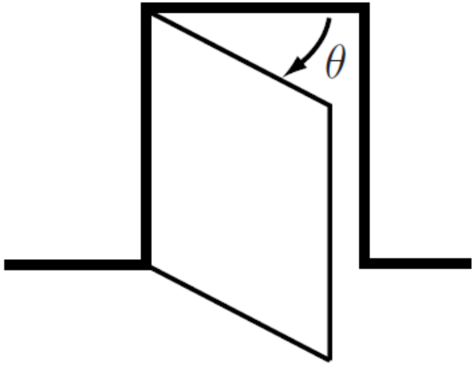
Degrees of Freedom of a Rigid Body



A rigid body moving in three-dimensional space, which we call a spatial rigid body, has six degrees of freedom.

Similarly, a rigid body moving in a two-dimensional plane, which we henceforth call a **planar rigid body**, has three degrees of freedom.

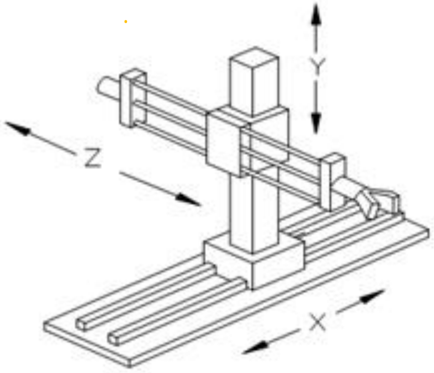
→ 3 DOF → 3P



- This observation suggests a formula for determining the number of degrees of freedom of a robot, simply by counting the number of rigid bodies and joints.
- one way to identify the number of DOF of a robot is to simply count its motors.

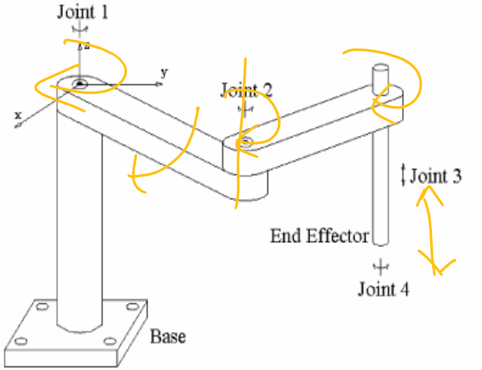
CNC Machine

3-axis



PPP

4-axis

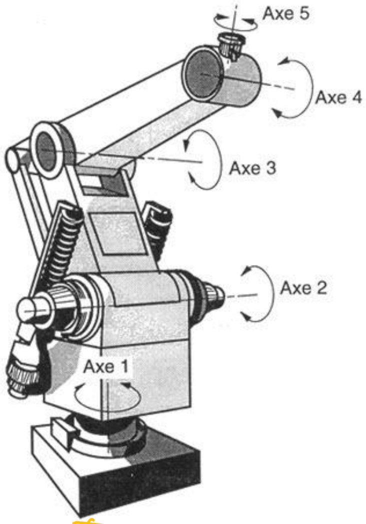


SCARA

4D

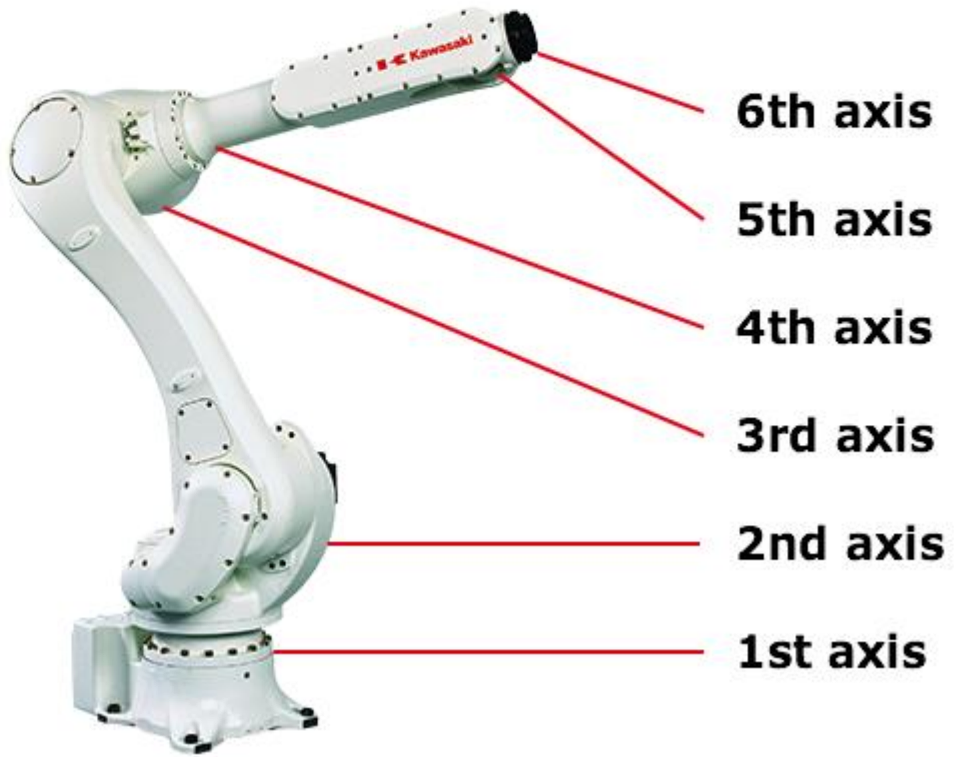
RRRP

5-axis

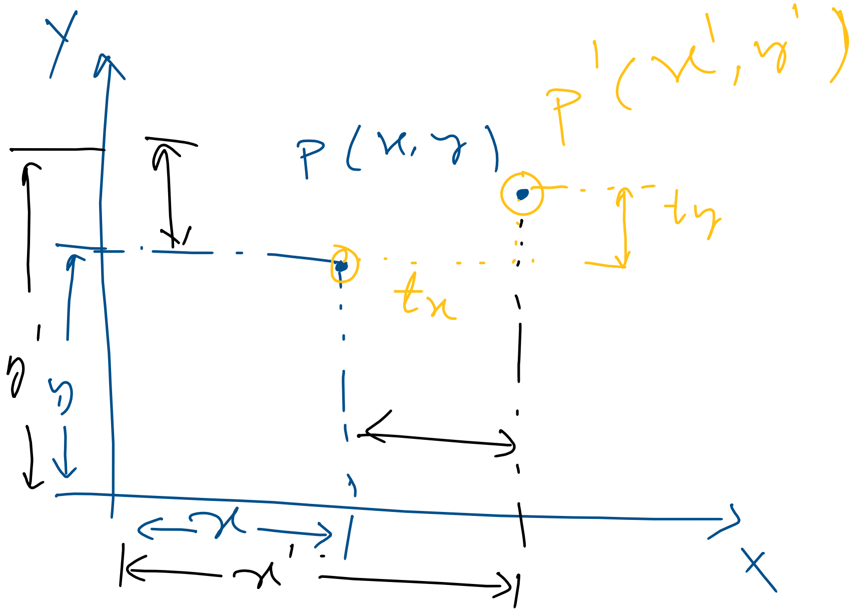


5R

6-axis



Kawasaki
6th axis
5th axis
4th axis
3rd axis
2nd axis
1st axis



Translation

Find the Co-ordinate of the new position $P'(x', y')$.

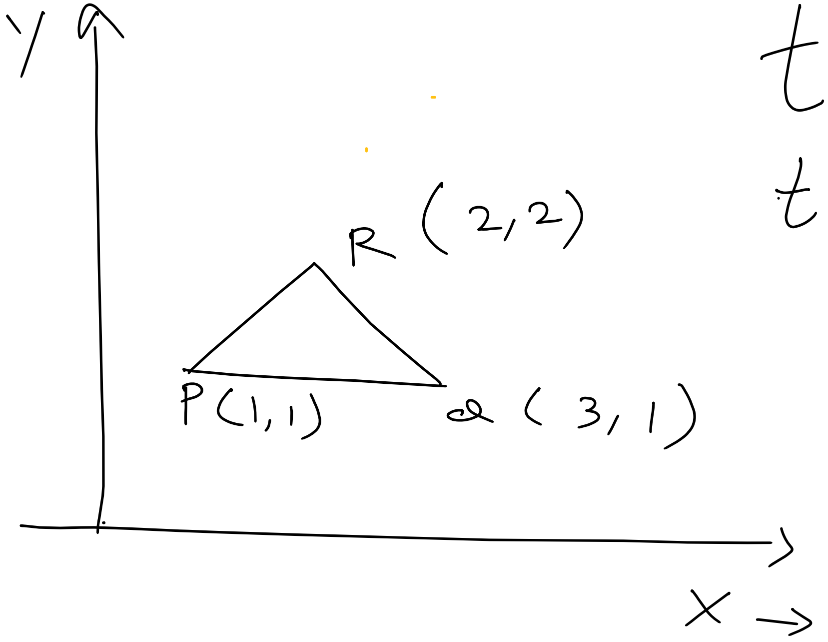
$$x' = x + t_x \quad \text{--- (1)}$$

$$y' = y + t_y \quad \text{--- (2)}$$

Matrix Form

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

Matrix addition



$t_x = 2$ units.

$t_y = 2$ units

What will be the new co-ordinate of the triangle PQR.

$\rightarrow P' Q' R'$

Numerical-1 :- A triangle PQR with vertices P(2,1), Q(4,1) and R(3,3) is to be moved 2-units in x-direction and 4-units in y-direction. Determine the new co-ordinate.

Given: $t_x = 2$,
$t_y = 4$

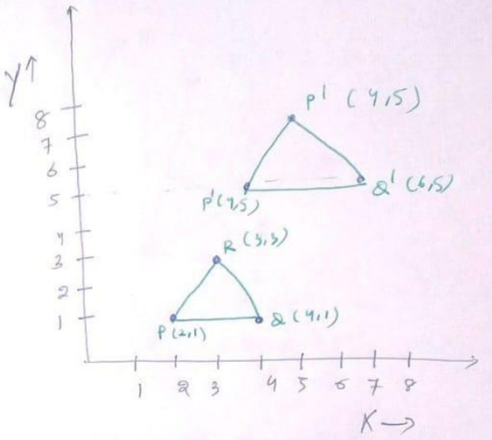
$$\{P'\} = \{T\} + \{P\}$$

$$\begin{bmatrix} x_1' \\ y_1' \end{bmatrix} = \begin{bmatrix} t_x \\ t_y \end{bmatrix} + \begin{bmatrix} x_1 \\ y_1 \end{bmatrix}$$

$$= \begin{bmatrix} 2 \\ 4 \end{bmatrix} + \begin{bmatrix} 2 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} x_1' \\ y_1' \end{bmatrix} = \begin{bmatrix} 4 \\ 5 \end{bmatrix}$$

$$[P'] = \begin{bmatrix} 4 \\ 5 \end{bmatrix}$$



Similarly, $[Q'] = [T] + \{Q\} = \begin{bmatrix} 2 \\ 4 \end{bmatrix} + \begin{bmatrix} 4 \\ 1 \end{bmatrix} = \begin{bmatrix} 6 \\ 5 \end{bmatrix}$

$[R'] = [T] + \{R\} = \begin{bmatrix} 2 \\ 4 \end{bmatrix} + \begin{bmatrix} 3 \\ 3 \end{bmatrix} = \begin{bmatrix} 5 \\ 7 \end{bmatrix}$

$\therefore$ New coordinate,

$\{P'\} = \begin{bmatrix} 4 \\ 5 \end{bmatrix}$ $[Q'] = \begin{bmatrix} 6 \\ 5 \end{bmatrix}$, $\{R'\} = \begin{bmatrix} 5 \\ 7 \end{bmatrix}$

Time for Discussions

Thank You!