ASSIGNMENT - 3 & 4

1. A singular configuration is a configuration of a robot when it cannot move in certain directions ie, loses some of its degrees of freedom. Usually singular configurations are the points on the boundary of the workspace of the manipulator (or as they can the points of maximum reach).

At singularities, the manipulator Jacobian loses rank.

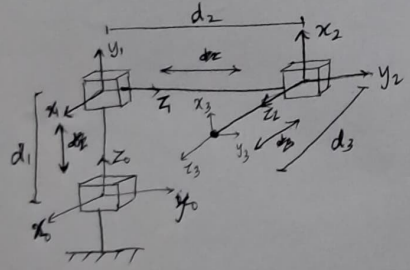
(ie if the Jacobian is square, determinant becomes zero)

Finite values of input force, torque may result in infinite joint velocity. At a singularity.

To find a singularity, look for points where the determinant of the Jacobian is zero / close to zero.

To detect if the robot is close to a singularity, check if the value of the determinant of the Jacobian is close to zero.

5.



PPP - configuration

Extension along Z axes.

d_1, d_2, d_3 → joint variables

DH Parameters:

link	d	θ	a	α	
1	d_1	0	0	$-\pi/2$	(CW rot)
2	d_2	$-\pi/2$	0	$-\pi/2$	
3	d_3	0	0	0	

$$H_0^1 = \text{Trans}_{Z,d_1}\ \text{Rot}_{Z,0}\ \text{Trans}_{x,0}\ \text{Rot}_{x,-\pi/2}$$

$$= \begin{bmatrix} c(0) & -s(0)c(-\pi/2) & s(0)s(-\pi/2) & 0 \\ s(0) & c(0)c(-\pi/2) & -c(0)s(-\pi/2) & 0 \\ 0 & s(-\pi/2) & c(-\pi/2) & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$H_0^1 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$H_1^2 = \begin{bmatrix} 0 & -(-1)\overset{0}{0} & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & -1 & 0 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$H_2^3 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} P_0 \\ 1 \end{bmatrix} = H_0^1 H_1^2 H_2^3 \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$

7. 2R Manipulator:

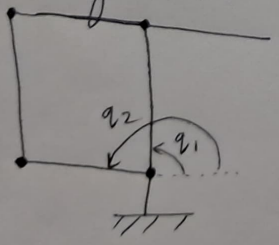
Direct drive configuration – Both links are actuated directly by corresponding motors at each joint.

Advantages →
- Both joints are independently controlled.
- It provides precise control over the end effector position.

Remotely driven – First joint is directly actuated by one of the motors while the other is turned via a gearing mechanism/belt.
~~Both motors~~ a

Advantages →
- Reduces load on the joints by relocating the motor elsewhere.
- Helps in making lightweight structures.

5-bar Parallelogram Arrangement-



→ Parallel motion of the second link relative to first link.
→ Advantages:
→ Ensures a constant orientation of the end-effector.