

1 Mechanical Design

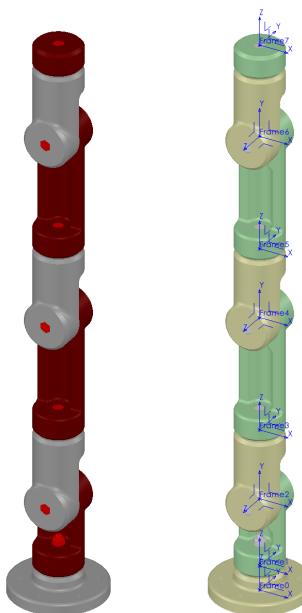
- Design commentary
 - ★ 7R spatial
- Selfies



Physical manipulator

2 Kinematics

- Frame definitions
- D-H parameters
- Forward kinematics



Frame definitions

Joint i	α_{i-1}	a_{i-1}	d_i	θ_i
1	0°	0	$l_1 + b + l_2$	q_1
2	90°	0	0	q_2
3	-90°	0	$l_2 + b + l_3$	q_3
4	90°	0	0	q_4
5	-90°	0	$l_2 + b + l_3$	q_5
6	90°	0	0	q_6
7	-90°	0	$l_2 + b + l_1$	q_7

where $b = \frac{1}{16}$ " is the plain bearing flange thickness, $l_1 = 1"$, $l_2 = 3"$, and $l_3 = 5"$.

$$\begin{aligned}
{}^0{}_1 T &= \begin{bmatrix} cq_1 & -sq_1 & 0 & 0 \\ sq_1 & cq_1 & 0 & 0 \\ 0 & 0 & 1 & l_1 + b + l_2 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} cq_1 & -sq_1 & 0 & 0 \\ sq_1 & cq_1 & 0 & 0 \\ 0 & 0 & 1 & 4.0625 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\
{}^1{}_2 T = {}^3{}_4 T = {}^5{}_6 T &= \begin{bmatrix} cq & -sq & 0 & 0 \\ 0 & 0 & -1 & 0 \\ sq & cq & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} cq & -sq & 0 & 0 \\ 0 & 0 & -1 & 0 \\ sq & cq & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\
{}^2{}_3 T = {}^4{}_5 T &= \begin{bmatrix} cq & -sq & 0 & 0 \\ 0 & 0 & 1 & l_2 + b + l_3 \\ -sq & -cq & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} cq & -sq & 0 & 0 \\ 0 & 0 & 1 & 8.0625 \\ -sq & -cq & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\
{}^6{}_7 T &= \begin{bmatrix} cq_7 & -sq_7 & 0 & 0 \\ 0 & 0 & 1 & l_2 + b + l_1 \\ -sq_7 & -cq_7 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} cq_7 & -sq_7 & 0 & 0 \\ 0 & 0 & 1 & 4.0625 \\ -sq_7 & -cq_7 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
\end{aligned}$$

where $q = q_i$ for ${}^{i-1}{}_i T$.

3 Control

- Description
- Lyapunov stability proof
- Impulse response plots

downflop_bullet.mp4
upflop_bullet.mp4