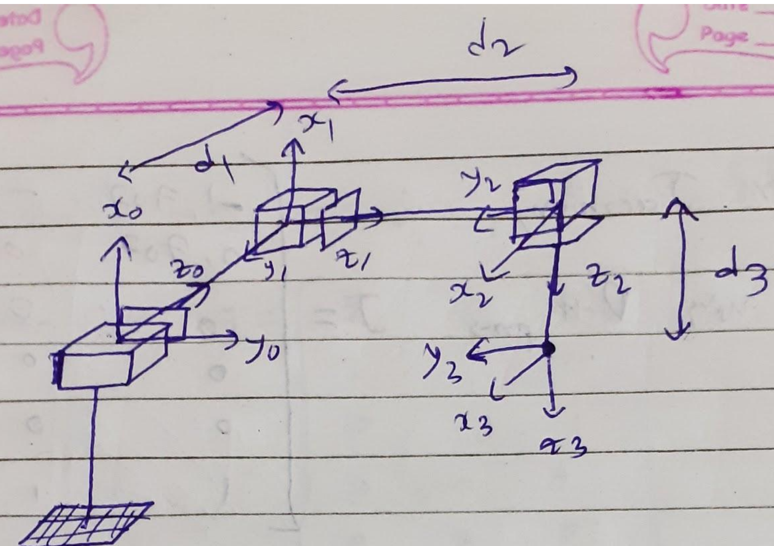
7. (my solution of question 5 of assignment-3 is also used)

Assignment -4

We can use cartesian manipulator for 3-D printer as the orientation is fixed and ~~aty~~ only special location matters in 3-D printing.

5.



→ D-H parameters table:-

Link	θ_i	d_i	a_i	α_i
1	0	d_1^*	0	$-\pi/2$
2	$\pi/2$	d_2^*	0	$-\pi/2$
3	0	d_3^*	0	0

7. for $d_1 = d_2 = d_3 = 1$,

$$T_0^3 = \begin{bmatrix} 0 & 0 & -1 & -1 \\ 0 & -1 & 0 & 1 \\ -1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$J_v = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

So, velocities $= J_v \begin{bmatrix} \dot{d}_1 \\ \dot{d}_2 \\ \dot{d}_3 \end{bmatrix}$

$$= \begin{bmatrix} -\dot{d}_3 \\ \dot{d}_2 \\ \dot{d}_1 \end{bmatrix}$$

→ for $d_1 = 1$, $d_2 = 2$, $d_3 = 3$,

$$T_0^3 = \begin{bmatrix} 0 & 0 & -1 & -3 \\ 0 & -1 & 0 & 2 \\ -1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

and $J_v = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$

∴ veolict of 3-D printer head (or-end effector)

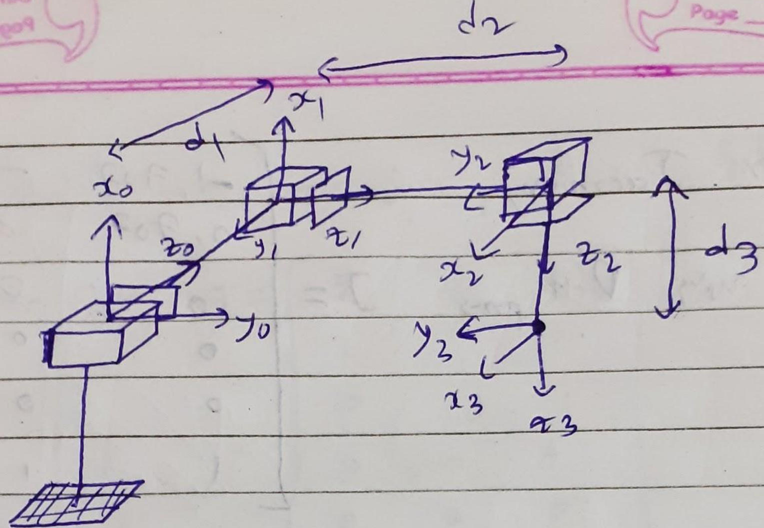
$$\vec{v} = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \dot{d}_1 \\ \dot{d}_2 \\ \dot{d}_3 \end{bmatrix}$$

$$= \begin{bmatrix} -\dot{d}_3 \\ \dot{d}_2 \\ \dot{d}_1 \end{bmatrix}$$

⇒ here, for any d_1, d_2, d_3, $\vec{v} = \begin{bmatrix} -\dot{d}_3 \\ \dot{d}_2 \\ \dot{d}_1 \end{bmatrix}$ and position,

$$\vec{p} = \begin{bmatrix} -d_3 \\ d_2 \\ d_1 \end{bmatrix}.$$

8.



→ D-H parameters table:-

Link	θ_i	d_i	a_i	α_i
1	0	d_1^*	0	$-\pi/2$
2	$\pi/2$	d_2^*	0	$-\pi/2$
3	0	d_3^*	0	0

$$\therefore A_1 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad A_2 = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_3 = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 0 & 1 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

8.

$\therefore T_0^3 = A_1 A_2 A_3$

$$= \begin{bmatrix} 0 & 0 & -1 & -d_3 \\ 0 & -1 & 0 & d_2 \\ -1 & 0 & 0 & d_1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

→ the orientation of the head of 3-D printer is

$R = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ -1 & 0 & 0 \end{bmatrix}$. Which make sence.

~~it's~~ 3-D printer's head's position is $[-d_3, d_2, d_1]^T$. Which is dependent upon d_1, d_2, d_3.

→ for any arbitrary position of 3-D printer's head,

So,
$$\begin{bmatrix} O_x \\ O_y \\ O_z \end{bmatrix} = \begin{bmatrix} -d_3 \\ d_2 \\ d_1 \end{bmatrix}$$

So, $\underbrace{d_3 = -O_x, \quad d_2 = O_y, \quad d_1 = O_z}$

So, we have join variables d_1, d_2, d_3 in terms of given position $O(x, y, z)$.