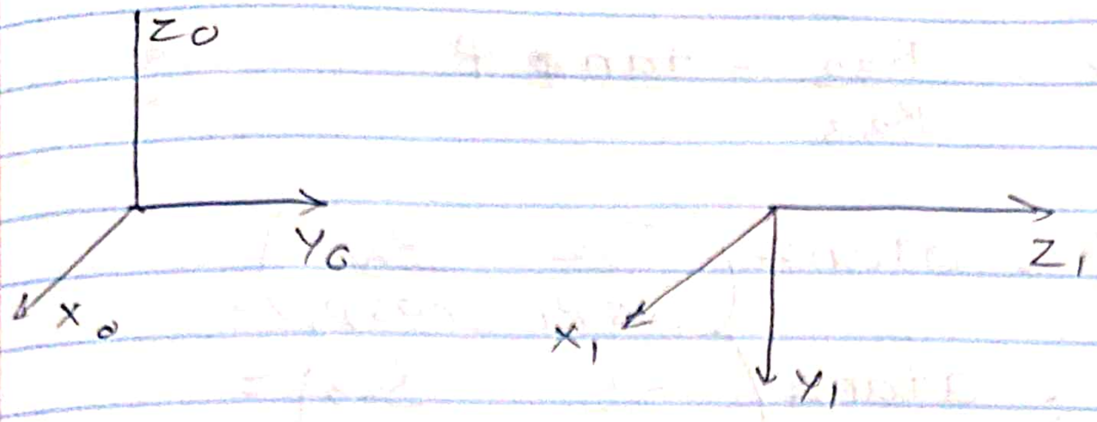
Prasanna Natu RBE- Robot Dynamic HW 1.

(1)



a) $R = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{bmatrix}$

b) Calculating Euler Angle

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

$$R_{31} = -\sin\theta.$$

$$\nu = \theta = \sin^{-1}(-R_{31})$$

$$= \theta = \sin^{-1}(0)$$

$$\nu = \theta = 0^\circ \text{ or } \pi$$

$$\therefore \nu = 0^\circ \text{ or } 180^\circ$$

1b) Now $\frac{R_{32}}{R_{33}} = \tan \cancel{\phi} \psi$

$$\therefore \psi = \operatorname{atan2}\left(\frac{R_{32}}{\cos \nu_1}, \frac{R_{33}}{\cos \nu_1}\right)$$

$$= \operatorname{atan2}\left(\frac{-1}{\cos 0}, \frac{R_{33}}{\cos 0}\right) =$$

$$\operatorname{atan2}\left(-\frac{1}{\cos 0}, \frac{0}{1}\right)$$

$$= -\frac{\pi}{2} \text{ or } \frac{3\pi}{4}$$

$$\phi = \operatorname{atan2}\left(\frac{R_{21}}{\cos \theta}, \frac{R_{11}}{\cos \theta}\right)$$

$$\phi = \operatorname{atan2}\left(\frac{0}{1}, \frac{1}{1}\right)$$

$$\phi = 0^\circ \text{ or } 2\pi$$

1c) $R^{-1} = R^T$

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

As Inverse of skew-symmetric Matrix is its transpose

~~a)~~ ~~R=~~

$$T = \begin{bmatrix} R & P \\ 0 & 1 \end{bmatrix}$$

1 d $\quad \cancel{B}\,T = \begin{bmatrix} R & P \\ 0 & 1 \end{bmatrix}$

$$T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 10 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2) a) $K = \begin{bmatrix} 0 & -0.0875 & 0.5670 \\ 0.0875 & 0 & -0.8190 \\ -0.5670 & 0.8190 & 0 \end{bmatrix}$ $\theta = 20^{0}$

$R = I + \sin\theta K + [1 - \cos(\theta)] K^2.$

Calculating K^2

$K \cdot K = \begin{bmatrix} 0 & -0.0875 & 0.5670 \\ 0.0875 & 0 & -0.8190 \\ -0.5670 & 0.8190 & 0 \end{bmatrix}^2.$

$K^2 = \begin{bmatrix} -0.329 & 0.4643 & 0.0716 \\ 0.4643 & -0.678 & 0.0496 \\ 0.0716 & 0.0496 & -0.992 \end{bmatrix}$

~~Sin2~~

$\sin 20 \times K = \begin{bmatrix} 0 & -0.029 & 0.1939 \\ 0.0299 & 0 & -0.28 \\ -0.193 & 0.28 & 0 \end{bmatrix}$

$(1-\cos 20) K^2 = \left[(1-\cos 20) \begin{bmatrix} 0 & -0.0875 & 0.5670 \\ 0.0875 & 0 & -0.8190 \\ -0.5670 & 0.8190 & 0 \end{bmatrix} \right]$

$= \begin{bmatrix} -0.019 & 0.028 & 0.004 \\ 0.028 & -0.04 & 0.002 \\ 0.004 & 0.002 & -0.059 \end{bmatrix}$

$$R = \begin{bmatrix} 0.98 & -0.001 & 0.19 \\ 0.001 & 0.959 & -0.277 \\ -0.19 & 0.283 & 0.940 \end{bmatrix}$$

(2 b) Now To prove R is valid Rotational Matrix

$$R \cdot R^T = \begin{bmatrix} 0.98 & -0.001 & 0.19 \\ 0.001 & 0.959 & -0.277 \\ -0.19 & 0.283 & 0.940 \end{bmatrix} \begin{bmatrix} 0.98 & 0.001 & -0.19 \\ -0.001 & 0.959 & 0.283 \\ +0.19 & 0.277 & 0.940 \end{bmatrix}$$

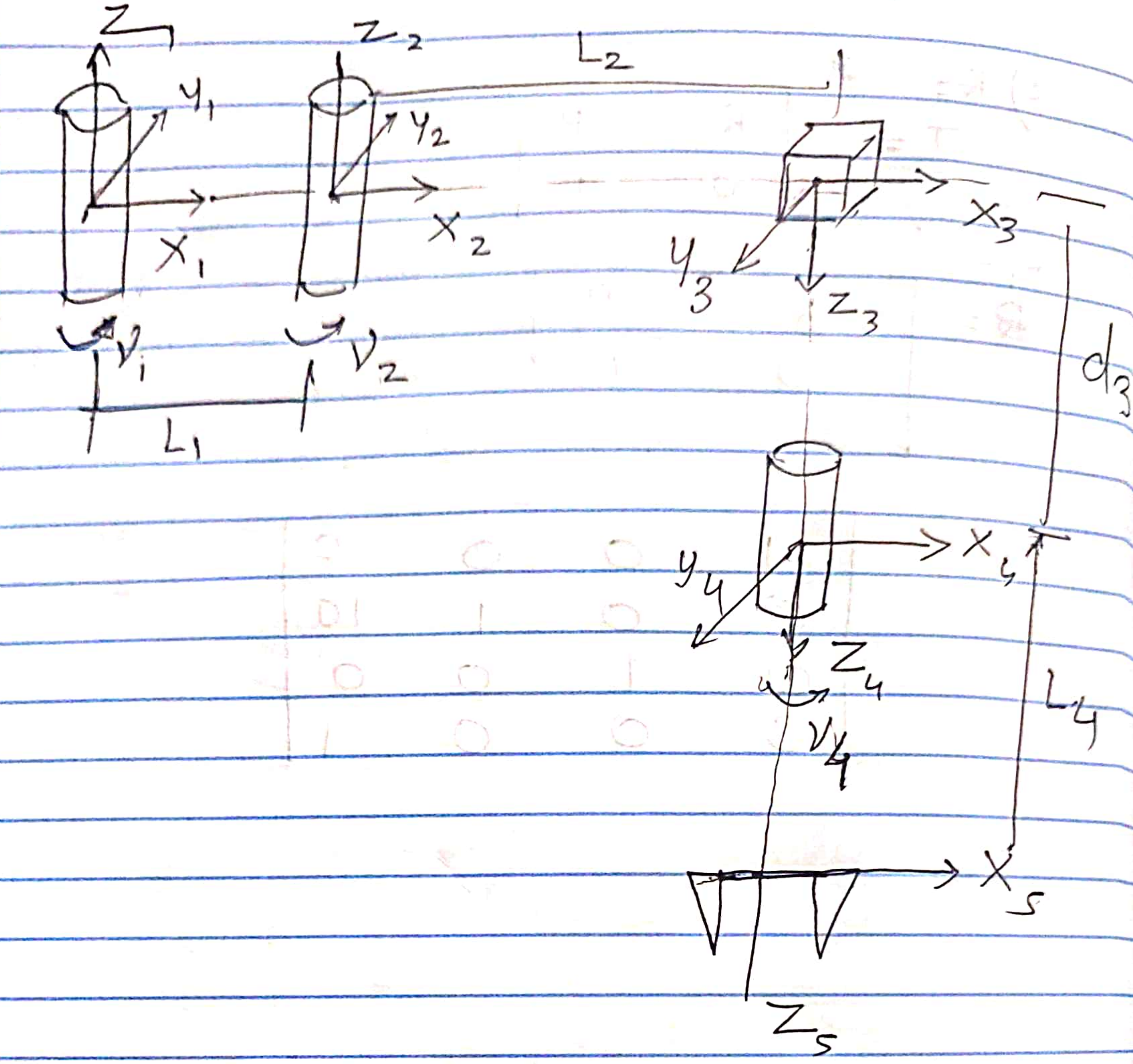
$$= \begin{bmatrix} 0.998 & 0.006 & 0.006 \\ 0.006 & 0.997 & 0.010 \\ -0.006 & 0.001 & 0.999 \end{bmatrix}$$

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

Hence we prove that R is a valid Rotational Matrix.

SCARA
FRAME ASSIGNMENT

3) a)



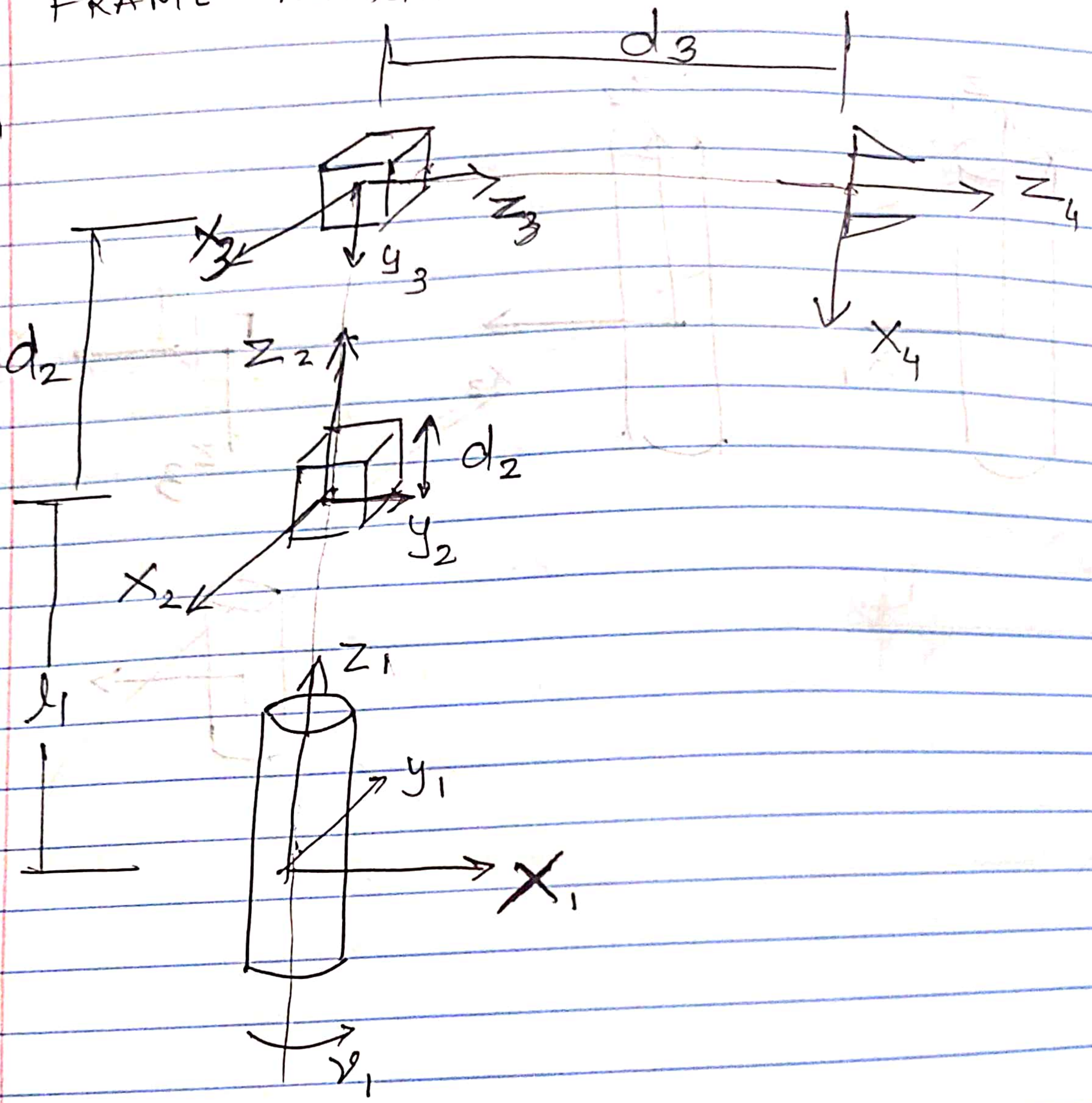
b) SCARA MANIPULATOR.

θ	d	a	α
ν_1	0	l_1	0
ν_2	0	l_2	180°
0	d_3^*	0	0
ν_4	l_4	0	0

RPP

FRAME ASSIGNMENT

4a



4b

θ	d	a	α
$\vartheta_1 - 90^\circ$	l_1	0	0
0	d_2^*	0	-90°
90°	d_3^*	0	0