

The National Engineering University

Alangilan Campus



Propelling Transformations and Accelerating Reforms for National Development

College of Engineering Department of Electronics Engineering

MECHATRONICS ENGINEERING - 3202 Second Semester, A.Y. 2023-2024

Laboratory Project in Robotics 2

Presented to Engr. Mikko De Torres Instructor

In Partial Fulfillment of the Requirements for the course MEXE 409 - Robotics 2

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JACOBIAN MATRIX

	PRISMATIC	REVOLUTE
LINEAR	R _{i-1} [0]	$R_{i-1}^{\circ} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} x \left(d_{n}^{\circ} - d_{i-1}^{\circ} \right)$
ROTATIONAL		R; 0 0 1

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times \begin{bmatrix} C\theta_1 C\theta_2 (\alpha_2 + \alpha_3 + d_3) \\ S\theta_1 C\theta_2 (\alpha_2 + \alpha_3 + d_3) \\ \alpha_1 + S\theta_2 (\alpha_2 + \alpha_3 + d_3) \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times \begin{bmatrix} C\theta_1 C\theta_2(a_2 + a_3 + d_3) \\ S\theta_1 C\theta_2(a_2 + a_3 + d_3) \\ a_1 + S\theta_2(a_2 + a_3 + d_3) \end{bmatrix} = \begin{bmatrix} R_0^8 \\ -S\theta_1 C\theta_2(a_2 + a_3 + d_3) \\ C\theta_1 C\theta_2(a_2 + a_3 + d_3) \\ 0 \end{bmatrix}$$

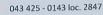
$$= \begin{bmatrix} S\theta_1 \\ -C\theta_1 \\ 0 \end{bmatrix} \times \begin{bmatrix} C\theta_1 C\theta_2 (a_2 + a_3 + d_3) \\ S\theta_1 C\theta_2 (a_2 + a_3 + d_3) \\ a_1 + S\theta_2 (a_2 + a_3 + d_3) \end{bmatrix} = \begin{bmatrix} R_1^0 \\ -C\theta_1 S\theta_1 (a_2 + a_3 + d_3) \\ -S\theta_1 C\theta_2 (a_2 + a_3 + d_3) \end{bmatrix} = \begin{bmatrix} R_1^0 \\ -C\theta_1 S\theta_1 (a_2 + a_3 + d_3) \\ -S\theta_1 C\theta_2 (a_2 + a_3 + d_3) \end{bmatrix}$$

$$\begin{bmatrix} C\theta_1 & 0 & S\theta_1 \\ S\theta_1 & 0 & -C\theta_1 \\ 0 & 1 & 1 \end{bmatrix} \times \begin{bmatrix} -S\theta_2 & 0 & C\theta_2 \\ C\theta_2 & 0 & S\theta_2 \\ 0 & 1 & 0 \end{bmatrix} = \begin{bmatrix} -C\theta_1S\theta_2 & S\theta_1 & C\theta_2C\theta_2 \\ -S\theta_1S\theta_2 & -C\theta_2 & S\theta_1C\theta_2 \\ C\theta_2 & 0 & S\theta_2 \end{bmatrix}$$

$$\begin{bmatrix} R_2^{\circ} & & & & \\ -C\theta_1S\theta_2 & S\theta_1 & C\theta_1C\theta_2 \\ -S\theta_1S\theta_2 & -C\theta_2 & S\theta_1C\theta_2 \\ C\theta_2 & 0 & S\theta_2 \end{bmatrix} \times \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} R_2^{\circ} \\ C\theta_1S\theta_2 \\ S\theta_1C\theta_2 \\ S\theta_2 \end{bmatrix}$$











GCH, Alangilan, Batangas City, Philippines





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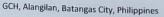
$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \\ u_{x} \\ u_{y} \\ u_{z} \end{bmatrix} = \begin{bmatrix} -S\Theta_{1}C\Theta_{2}(\alpha_{2}+\alpha_{3}+\alpha_{3}) & -C\Theta_{1}S\Theta_{2}(\alpha_{2}+\alpha_{3}+\alpha_{3}) & C\Theta_{1}S\Theta_{2} \\ C\Theta_{1}C\Theta_{2}(\alpha_{2}+\alpha_{3}+\alpha_{3}) & -S\Theta_{1}C\Theta_{2}(\alpha_{2}+\alpha_{3}+\alpha_{3}) & S\Theta_{1}C\Theta_{2} \\ 0 & C\Theta_{2}(\alpha_{2}+\alpha_{3}+\alpha_{3}) & S\Theta_{2} \\ 0 & S\Theta_{1} & 0 \\ 0 & -C\Theta_{1} & 0 \\ 1 & 0 & 0 \end{bmatrix} = \begin{bmatrix} \dot{\theta}_{1} \\ \dot{\theta}_{2} \\ \dot{d}_{3} \end{bmatrix}$$

$$X = -S\Theta_1C\Theta_2\Theta_1(02+03+03) - C\Theta_1S\Theta_2\Theta_2(02+03+03) + C\Theta_1S\Theta_2O_3$$

SINGULARITY

$$DET(J) = \begin{bmatrix} -9\theta_1C\theta_2(a_2+a_3+d_3) & -C\theta_19\theta_2(a_2+a_3+d_3) & C\theta_1S\theta_2 \\ C\theta_1C\theta_2(a_2+a_3+d_3) & -S\theta_1C\theta_2(a_2+a_3+d_3) & S\theta_1C\theta_2 \\ 0 & C\theta_2(a_2+a_3+d_3) & S\theta_2 \end{bmatrix}$$

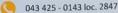
 $DET(J) = -S^2 \theta_1 C \theta_2 (\alpha_2 + \alpha_3 + \alpha_3)^2 + C^2 \theta_1 S^2 \theta_2 C \theta_2 (\alpha_2 + \alpha_3 + \alpha_3)^2 + C^3 \theta_2 (\alpha_2 + \alpha_3 + \alpha_3)$





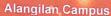








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INVERSE VELOCITY

GIYEN:

LINK LENGTHS: 01 = 50, 02 = 20, 02 = 20

JOINT VARIABLES: 0, = 0, 02 = 90°, ds = 30

FROM JACOBIAN MATRIX.

$$\begin{bmatrix} -S\theta_1C\theta_2(a_2+a_3+d_3) & -C\theta_1S\theta_2(a_2+a_3+d_3) & C\theta_1S\theta_2 \\ C\theta_1C\theta_2(a_2+a_3+d_3) & -S\theta_1C\theta_2(a_2+a_3+d_3) & S\theta_1C\theta_2 \\ 0 & C\theta_2(a_2+a_3+d_3) & S\theta_2 \end{bmatrix} = \begin{bmatrix} 0 & -70 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$C_{ij} = (-1)^{(i+j)} \cdot \det(M_{ij})$$

$$det(M_{11}) = 0$$

$$det(M_{12}) = 0$$

$$C_{12} = (-1)^{(1+2)} \cdot 0$$

$$C_{12} = 0$$

$$det(M_{13}) = 0$$

$$C_{13} = (-1)^{(1+3)} \cdot 0$$

$$det(M_{21}) = -70$$

$$det(M_{22}) = 0$$

$$det(M_{23}) = 0$$

$$C_{23} = 0$$

$$det(Max) = 0$$

$$C_{31} = (-1)^{(3+1)} \cdot 0$$

$$det(M_{32}) = 0$$

$$C_{32} = 0$$

$$det(Mas) = 0$$

$$C_{33} = (-1)^{(3+3)} \cdot 0$$

$$C_{33} = 0$$



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INVERSE YELOCITY

$$\begin{bmatrix} 0 & 0 & 0 \\ 70 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{z} \\ \omega_{x} \\ \omega_{y} \\ \omega_{z} \end{bmatrix} \Rightarrow \begin{bmatrix} \theta_{1} \\ \theta_{2} \\ d_{3} \end{bmatrix}$$

INVERSE VELOCITIES

