

ASSIGNMENT - 1

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2.

- **Manipulator:** These are replications of arms. They are mainly used for pick and place use in various fields. There are different types of manipulator robots having various degrees of freedom.
 - Puma Robot: It has an RRR configuration.
[▶ Puma 560 Robot Arm Simulation in Webots](#)
 - SCARA Robot: It has a RRP Configuration.
[▶ Fast Scara Robot](#)
- **Aerial Robots (UAV)** can fly and perform several in-air tasks. These also include autonomous robots.
 - [▶ Turkish Aerospace | Anka UAV](#)
- **Ground-Based Mobile Vehicles (UGV)** are automatic machines capable of locomotion on the ground. These are used for surveillance, rescue, transportation, etc.
 - [▶ Rheinmetall introduces its new A-UGV Mission Master SP – Armed ...](#)
- **Exoskeleton:** These are wearable devices/robots that enhance the wearer's performance.
 - [▶ One Horsepower AI Exoskeleton Powers Your Everyday Adventure](#)
- **Underwater:** These robots are mainly used for underwater exploration and any repair work.
 - [▶ Fifish V6 EXPERT - Professional underwater drone](#)
- **Soft Robots:** These perform tasks that are not possible using hard robots.
 - [▶ Life at the Lab: Soft Robots](#)
- **Micro:** These robots perform tasks on the micro-scale, even for surgery.
 - [▶ March of the microscopic robots](#)

3.

- **Brushed DC Motor:** This is the type of motor that is powered by DC current to power its rotating shaft. It has a commutator and brushes that mechanically

switch the current direction in the motor's windings, creating a rotating magnetic field.

- **Brushless DC Motor (BLDC):** These motors do not have brushes to flip the electromagnetic field, offering improved efficiency and durability compared to the normal Brushed DC Motor.
- **Stepper Motors:** These are the type of electric motors that rotates in discrete steps. This makes them well-suited for applications that require precise positioning.
- **Servo Motor:** It is the type of motor that rotates to a specific position or angle. These are used to convert the control signal into desired angular displacement or angular velocity.
- **AC Motor:** An AC motor is an electric machine that converts alternating current into mechanical rotation by creating a rotating magnetic field.

$$b. \quad R_0' = \begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 & \hat{j}_1 \cdot \hat{i}_0 & \hat{k}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 & \hat{j}_1 \cdot \hat{j}_0 & \hat{k}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 & \hat{j}_1 \cdot \hat{k}_0 & \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix}$$

The columns of the rotational matrix, R_0' are:

$$\vec{a} = \begin{bmatrix} \hat{i}_1 \cdot \hat{i}_0 \\ \hat{i}_1 \cdot \hat{j}_0 \\ \hat{i}_1 \cdot \hat{k}_0 \end{bmatrix}$$

$$\vec{b} = \begin{bmatrix} \hat{j}_1 \cdot \hat{i}_0 \\ \hat{j}_1 \cdot \hat{j}_0 \\ \hat{j}_1 \cdot \hat{k}_0 \end{bmatrix}$$

$$\vec{c} = \begin{bmatrix} \hat{k}_1 \cdot \hat{i}_0 \\ \hat{k}_1 \cdot \hat{j}_0 \\ \hat{k}_1 \cdot \hat{k}_0 \end{bmatrix}$$

For orthogonality, we need to prove,

$$\vec{a} \cdot \vec{b} = \vec{b} \cdot \vec{c} = \vec{c} \cdot \vec{a} = 0$$

$$\vec{a} \cdot \vec{b} \Rightarrow (\hat{i}_1 \cdot \hat{i}_0) \cdot (\hat{j}_1 \cdot \hat{i}_0) + (\hat{i}_1 \cdot \hat{j}_0) \cdot (\hat{j}_1 \cdot \hat{j}_0) + (\hat{i}_1 \cdot \hat{k}_0) \cdot (\hat{j}_1 \cdot \hat{k}_0) \quad \text{--- ①}$$

$$\vec{b} \cdot \vec{c} \Rightarrow (\hat{j}_1 \cdot \hat{i}_0) \cdot (\hat{k}_1 \cdot \hat{i}_0) + (\hat{j}_1 \cdot \hat{j}_0) \cdot (\hat{k}_1 \cdot \hat{j}_0) + (\hat{j}_1 \cdot \hat{k}_0) \cdot (\hat{k}_1 \cdot \hat{k}_0) \quad \text{--- ②}$$

$$\vec{a} \cdot \vec{c} \Rightarrow (\hat{i}_1 \cdot \hat{i}_0) \cdot (\hat{k}_1 \cdot \hat{i}_0) + (\hat{i}_1 \cdot \hat{j}_0) \cdot (\hat{k}_1 \cdot \hat{j}_0) + (\hat{i}_1 \cdot \hat{k}_0) \cdot (\hat{k}_1 \cdot \hat{k}_0) \quad \text{--- ③}$$

[Handwritten signature]

$$\textcircled{1} \Rightarrow i_1 j_1 (i_0)^2 + i_1 j_1 (j_0)^2 + (i_1 j_1 (k_0)^2) \\ = \underline{\underline{0}}$$

$$\textcircled{2} \Rightarrow j_1 k_1 (i_0)^2 + j_1 k_1 (j_0)^2 + j_1 k_1 (k_0)^2 \\ = \underline{\underline{0}}$$

$$\textcircled{3} \Rightarrow i_1 k_1 (i_0)^2 + i_1 k_1 (j_0)^2 + j_1 k_1 (k_0)^2 \\ = 0$$

$$\vec{a} \cdot \vec{b} = 0$$

$$\vec{b} \cdot \vec{c} = 0$$

$$\vec{c} \cdot \vec{a} = 0$$

\therefore The columns are orthogonal.

7. R_o' is an orthogonal matrix

$$\therefore R_o' (R_o')^T = I$$

Taking determinant,

$$|R_o'| \times |R_o'^T| = |I|$$

$$|R_o'|^2 = 1$$

$$(|R_o'| = |R_o'^T|$$

$$\therefore |R_o'| = \det \text{ of } R_o' = \underline{\underline{\pm 1}}$$