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 RRR configuration.
    Puma 560 Robot Arm Simulation in Webots
  - SCARA Robot: It has a RRP Configuration.
    Fast Scara Robot
- **Aerial Robots:** These can fly and perform several in-air tasks. These also include autonomous robots.
  - Turkish Aerospace | Anka UAV

- **Ground Based Mobile Vehicles:** These are automatic machines that are capable of doing 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 performance of the wearer.
  - One Horsepower AI Exoskeleton Powers Your Everyday Adventure

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.

6 - $$R_0^1 = \begin{bmatrix} \hat{i}_1 \cdot i_0 & j_1 \cdot i_0 & k_1 \cdot i_0 \\ i_1 \cdot j_0 & j_1 \cdot j_0 & k_1 \cdot j_0 \\ i_1 \cdot k_0 & j_1 \cdot k_0 & k_1 \cdot k_0 \end{bmatrix}$$

The columns of the rotational matrix, R_0^1 are:

$$\vec{a} = \begin{bmatrix} i_1 \cdot i_0 \\ i_1 \cdot j_0 \\ i_1 \cdot k_0 \end{bmatrix} \quad \vec{b} = \begin{bmatrix} j_1 \cdot i_0 \\ j_1 \cdot j_0 \\ j_1 \cdot k_0 \end{bmatrix} \quad \vec{c} = \begin{bmatrix} k_1 \cdot i_0 \\ k_1 \cdot j_0 \\ k_1 \cdot k_0 \end{bmatrix}$$

For orthogonality, we need to prove,

$$a \cdot b = b \cdot c = c \cdot a = 0$$

$$\vec{a} \cdot \vec{b} \Rightarrow (i_1 \cdot i_0) \cdot (j_1 \cdot i_0) + (i_1 \cdot j_0) \cdot (j_1 \cdot j_0) + (i_1 \cdot k_0) \cdot (j_1 \cdot k_0) \quad \text{— ①}$$

$$\vec{b} \cdot \vec{c} \Rightarrow (j_1 \cdot i_0) \cdot (k_1 \cdot i_0) + (j_1 \cdot j_0) \cdot (k_1 \cdot j_0) + (j_1 \cdot k_0) \cdot (k_1 \cdot k_0) \quad \text{— ②}$$

$$\vec{a} \cdot \vec{c} \Rightarrow (i_1 \cdot i_0) \cdot (k_1 \cdot i_0) + (i_1 \cdot j_0) \cdot (k_1 \cdot j_0) + (i_1 \cdot k_0) \cdot (k_1 \cdot k_0) \quad \text{— ③}$$

① $\Rightarrow \quad i_1 \cdot j_1 \cdot (i_0)^2 + i_1 \cdot j_1 \cdot (j_0)^2 + (i_1 \cdot j_1 \cdot (k_0)^2)$

$= \underline{\underline{0}}.$

② $\Rightarrow \quad j_1 \cdot k_1 \cdot (i_0)^2 + j_1 \cdot k_1 \cdot (j_0)^2 + j_1 \cdot k_1 \cdot (k_0)^2$

$= \underline{\underline{0}}.$

③ $\Rightarrow \quad i_1 \cdot k_1 \cdot (i_0)^2 + i_1 \cdot k_1 \cdot (j_0)^2 + j_1 \cdot k_1 (k_0)^2$

$= 0$

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

$\therefore$ The columns are orthogonal.

7. R_0^1 is an orthogonal matrix

$\therefore R_0^1 (R_0^1)^T = I$

Taking determinant,

$|R_0^1| \times |R_0^{1T}| = |I|$

$|R_0^1|^2 = 1 \qquad (|R_0^1| = |R_0^{1T}|$

$\therefore |R_0^1| = \text{det of } R_0^1 = \pm 1$