

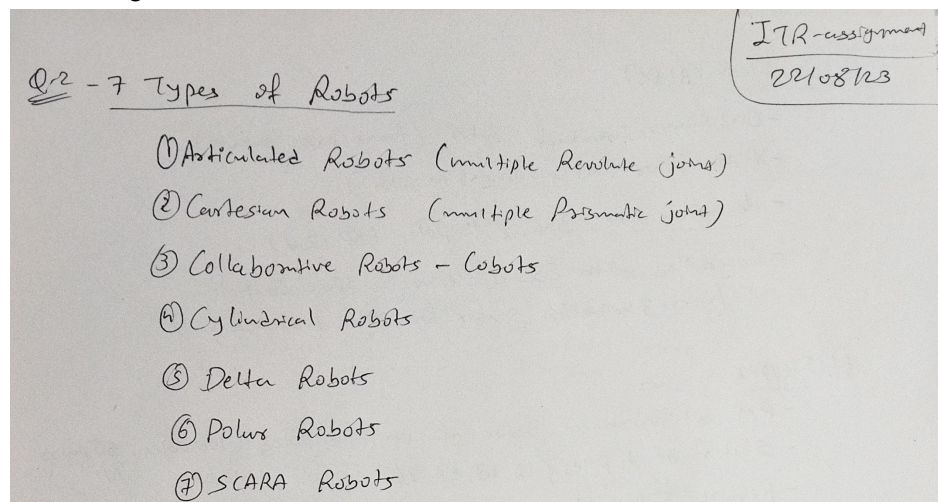
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## ITR Assignment-1

### Tasks:

1. Read Chapter 1 of the textbook.
2. Identify one or two examples of robots for each of the seven categories of robots mentioned in class. Submit your selected examples as a list of YouTube links with 2-3 line explanations for each.

=> 7 categories of Robot



1. Articulated Robot
  - RRR/RRRR/..type configuration
  - Multiple revolute joint in chain (SCM)
  - Mimics human arm
  - [Fanuc LR Mate 200iD/4S](#)
  - [Puma260](#)
2. Cartesian Robot
  - PPP type configuration
  - 3 principal axes of control are linear
  - [Kuka KR80L](#)
  - [ONEreach Cartesian robot](#)
3. Collaborative Robot (cobot)
  - Low force, human interaction, safe

- [Different from Traditional Robot](#)
- [Universal ur5e](#)
- [Kuka HRC](#)
  
- 4. Cylindrical Robot
  - RPP type configuration
  - [ANALEXrobot R19](#)
  
- 5. Delta Robot
  - Mostly used in pick & place
  - [Kuka KR Delta](#)
  
- 6. Polar Robot
  - Robot configuration with a combined linear joint & 2 rotary joint
  - Also known as special robot
  - [Stanford type robot](#)
  
- 7. SCARA Robot
  - PRR type configuration
  - Selective Compliance(flexibility in one direction) Assembly Robot Arm
  - Mostly used in P&P & assembly operations
  - [Kuka KR SCARA](#)

=> Ref:

- <https://robodk.com/download>
- <https://robodk.com/industrial-robots-reach/>
- <https://robodk.com/doc/en/Getting-Started.html>
- <https://robodk.com/blog/industrial-robot-reach-charts/>
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**3. Review the most common types of motors and summarize them with a 2-3 sentence description of each of them. The description offered in [this video](#) may be a good starting point.**

### Q-3 - Types of Motor

⇒ AC motors

{ Rotor,  
Stator  
& Core }

↳ Synchronous -  $RPM = RMP$

- Permanent magnet as Rotor

↳ Asynchronous -  $RPM < RMP$  { Core - Induction motor

- due to slip

↳ Control with VFD

(Variable Frequency Drive)

⇒ DC motors

① Brushed - 3 pole, 4 pole, 8 pole...

- Sometimes with gearbox (Gearred)

- Micro DC & Coreless are also subtypes

- Can be controlled with PWM

## ② Brushless (BLDC)

- Outrunner/Inrunner motor (front/back support)
- P.M. motor (no windings in rotor)
- description like: 3 phase 12 pole (3P 12N)
- Controlled with ESC (Electronic Speed Control)  
(uses 3 hall-effect sensor for rotor position state)

## ③ Stepper

- P.M. at inrunner motor of multiple poles ( $\underbrace{100 \text{ poles}}_{2N}$ ,  $\underbrace{50 \text{ pairs}}_{\tilde{N}}$ )
  - Stator of 4 poles (1A, 1B, 2A, 2B)
  - Require Stepper drivers like...  
A4988, TMC2209 (stealth driver)
- Ex: - Nema17 (most common)
- 28BYJ-48 unipolar Steppers (ULN2003 driver)
- step/rotation =  $4N$   
step angle =  $90/N$

## ④ Servo

- Feedback driven AC/DC motor
- can be linear/rotary, mostly potentiometer based  
↳ geared for more torque & precision

4. Review the basic kinematic principles summarized in [this video](#).

5. Review the key ideas related to connecting motor drivers, microcontrollers, and power supply to a motor described in the [link here](#). This information may be useful for future implementation.

6. Show that columns of the rotation matrix  $R(0, 1)$  are orthogonal.



Q6 - show that columns of rotation matrix  $R_0^1$  are orthogonal

$$\Rightarrow R^T = R^{-1} \Leftrightarrow R^T R = I, \text{ because orthogonal}$$

$$\text{let } R = \text{Rot}(x, \theta) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix}$$

$$R^T R = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & \sin\theta \\ 0 & -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos^2\theta + \sin^2\theta & 0 \\ 0 & 0 & \cos^2\theta + \sin^2\theta \end{bmatrix}$$

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

[Ref](#)

7. Show that  $\det(R_{0,1}) = 1$ .

Q.2 - Show that  $\det(R_0^1) = 1$

$$\Rightarrow \text{let } R_0^1 = \text{Rot}(x, \theta) = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix}$$

$$\det(R_0^1) = 1(\cos\theta \cdot \cos\theta - (-\sin\theta) \cdot \sin\theta) + 0(\cos\theta \cdot 0 - (-\sin\theta) \cdot 0) + 0(\sin\theta \cdot 0 - \cos\theta \cdot 0)$$

$$= 1(\cos^2\theta + \sin^2\theta) + 0(0) + 0(0)$$

$$\boxed{\det(R_0^1) = 1}$$

8. Read about the order of rotations and sample examples in the textbook.

9. Review the textbook explanation and example related to a rotation matrix for rotation about an arbitrary axis  $k$ .

Submit the assignment in the form of a PDF with active links for Task 2 and appropriate explanations for Task 3, 6, and 7. Nothing is to be submitted for tasks 1, 4, 5, 8 and 9.