lecture -5

Industrial Robots
Kinematic Structure

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Degrees of Freedom (DoF)

- General definition: Set of independent displacements specifying the position of a body or system.
- In robotics: Number of independent directions a robot joint can move.

Example: A robot with four joints, each moving in one direction, is a 4-DoF robot.

Human Arm

- Human arm has seven degrees of freedom:
  - 3 at the shoulder (pitch, yaw, roll)
  - 1 at the elbow
  - 3 at the wrist (pitch, yaw, roll)

Holonomic vs. Non-Holonomic

- Holonomic: Mechanisms control all six physical degrees of freedom.
- Non-Holonomic: Fewer controllable DoF than total DoF.

Redundant Systems

- More controllable DoF than necessary for the task.
- Example: Human arm with 7 DoF but only 6 needed for positioning and orienting.

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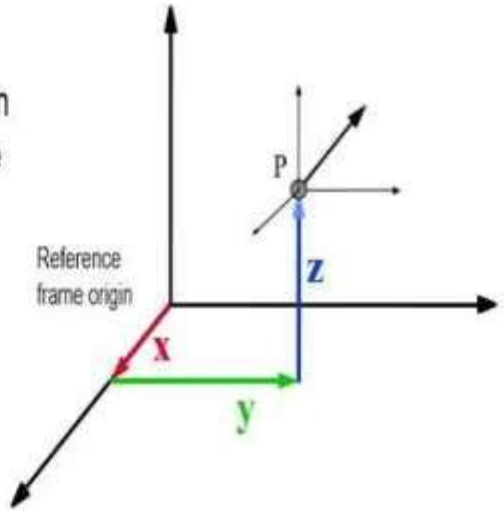
Positioning

Positioning the end effector in the 3D space, requires three DoF, either obtained from rotations or displacements.



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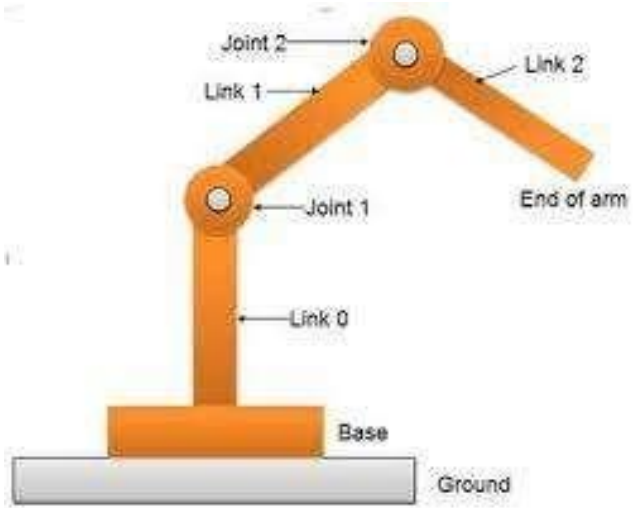
Robot Structure: Joint and Link Configuration

- **Configuration Overview**

Components:

- Base (Link 0)
- Joints (Joint 1, Joint 2, Joint 3, ...)
- Links (Link 1, Link 2, ...)



- **Joint and Link Series**

- **Base to Joint 1:** Link 0
- **Joint 1 to Joint 2:** Link 1
- **Joint 2 to Joint 3:** Link 2

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Robot Anatomy

- Manipulator consists of joints and links
  - Joints provide relative motion
  - Links are rigid members between joints
  - Various joint types: linear and rotary
  - Each joint provides a “degree-of-freedom”
  - Most robots possess five or six degrees-of-freedom
- Robot manipulator consists of two sections:
  - Body-and-arm – for positioning of objects in the robot's work volume
  - Wrist assembly – for orientation of objects

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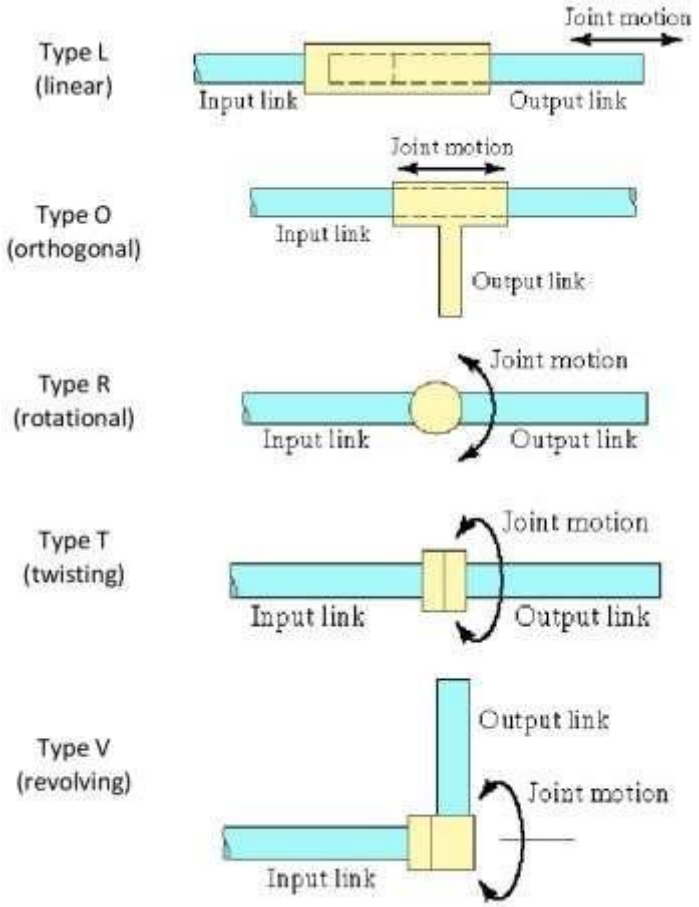
Types of Joints in Industrial Robots

Prismatic Joint (P):
- Linear or Orthogonal.
- Translational motion.
- Represented as L or O.

Rotary Joint (R):
- Rotary, Twist, or Revolute motion.
- Single degree of freedom.
- Represented as R.

Other Joint Types (Less Common):
- **Cylindrical Joint:** Sliding and Turning (2 DoF).
- **Screw or Helical Motion Joint:** Helical motion.
- **Spherical Joint:** Rotation in all 3 axes (3 DoF).
- **Planar Joint:** Motion in a plane (2 DoF).



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Robot Architecture is a combination and disposition of different kinds of joints that configure the robot kinematic chain.

Common Architectures

1. **Polar Coordinate Robot (RRP):**
    1. Two rotary joints, one prismatic joint.
    2. Allows positioning in a polar coordinate system.
2. **Cylindrical Body and Arm Assembly (RPP):**
    1. One rotary joint, two prismatic joints.
    2. Provides positioning and movement in cylindrical coordinates.
3. **Cartesian Coordinate Robot (PPP):**
    1. Three prismatic joints.
    2. Enables motion along X, Y, and Z axes for precise positioning.
4. **Jointed-Arm Body and Arm Assembly (RRR):**
    2. Three rotary joints.
    3. Offers flexibility with all three rotations, commonly used in industrial robots.
5. **Selective Compliance Assembly Robot Arm (SCARA - RRP):**
    2. Two rotary joints, one prismatic joint.
    3. Specialized for selective compliance in one plane.

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