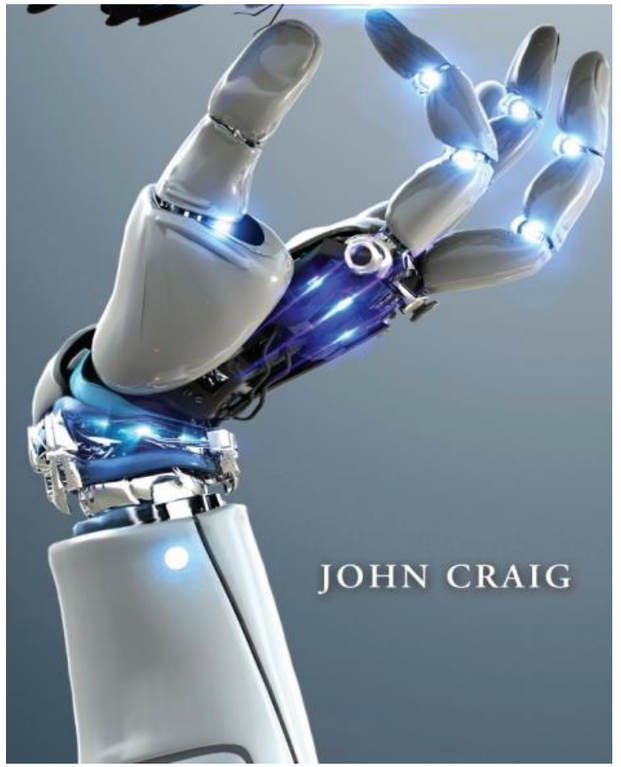
Chapter 2

Robotics Anatomy: Configuration



Robot's Work Volume

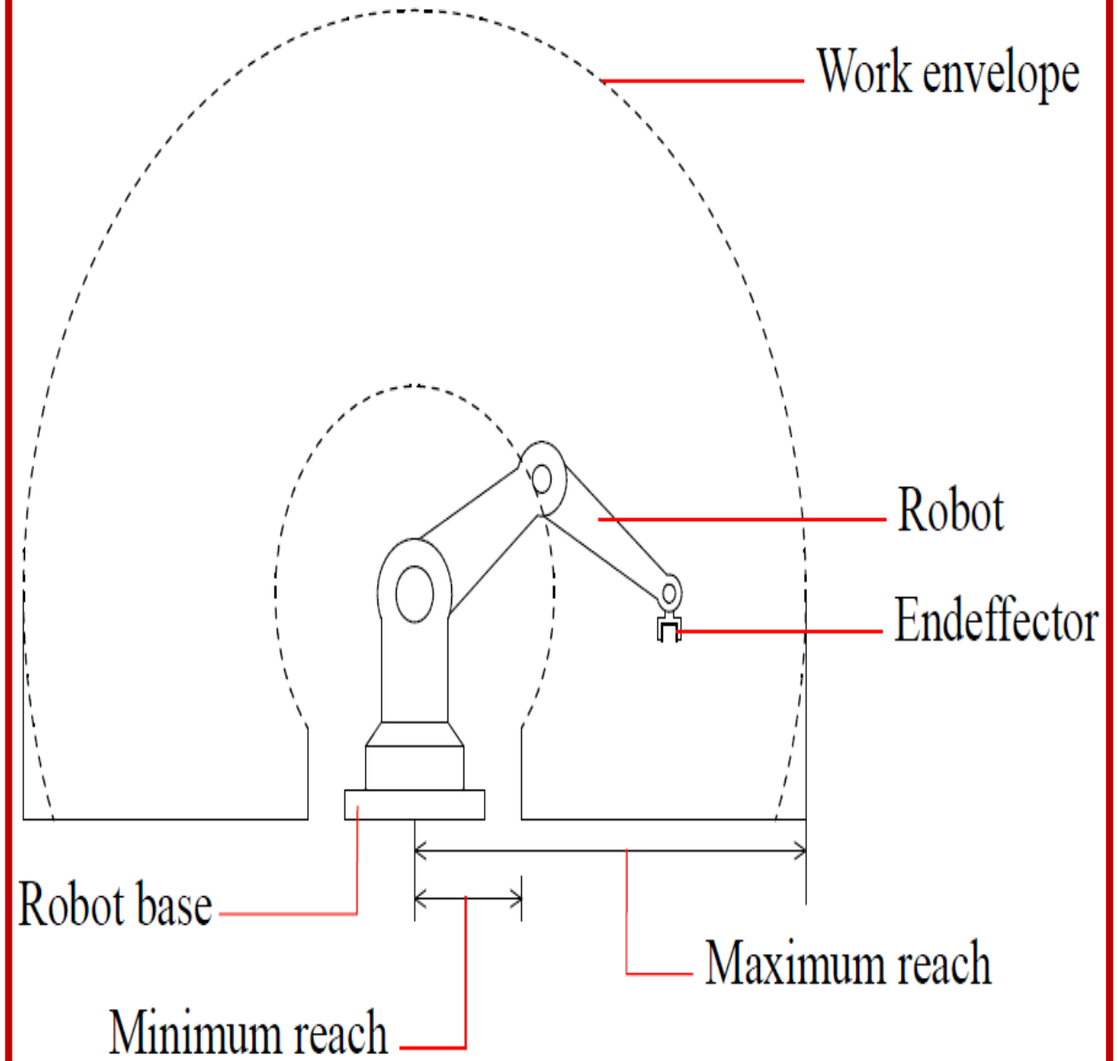
- It is the three dimensional space around the robot where it can sweep its wrist end within the points of maximum and minimum reach
- Maximum Reach is the point where the wrist end can go as far as possible from its base.
- Minimum reach is the point where the wrist end can go as close as possible to its base.

➢ Larger volume costs more but can increase capabilities of robot

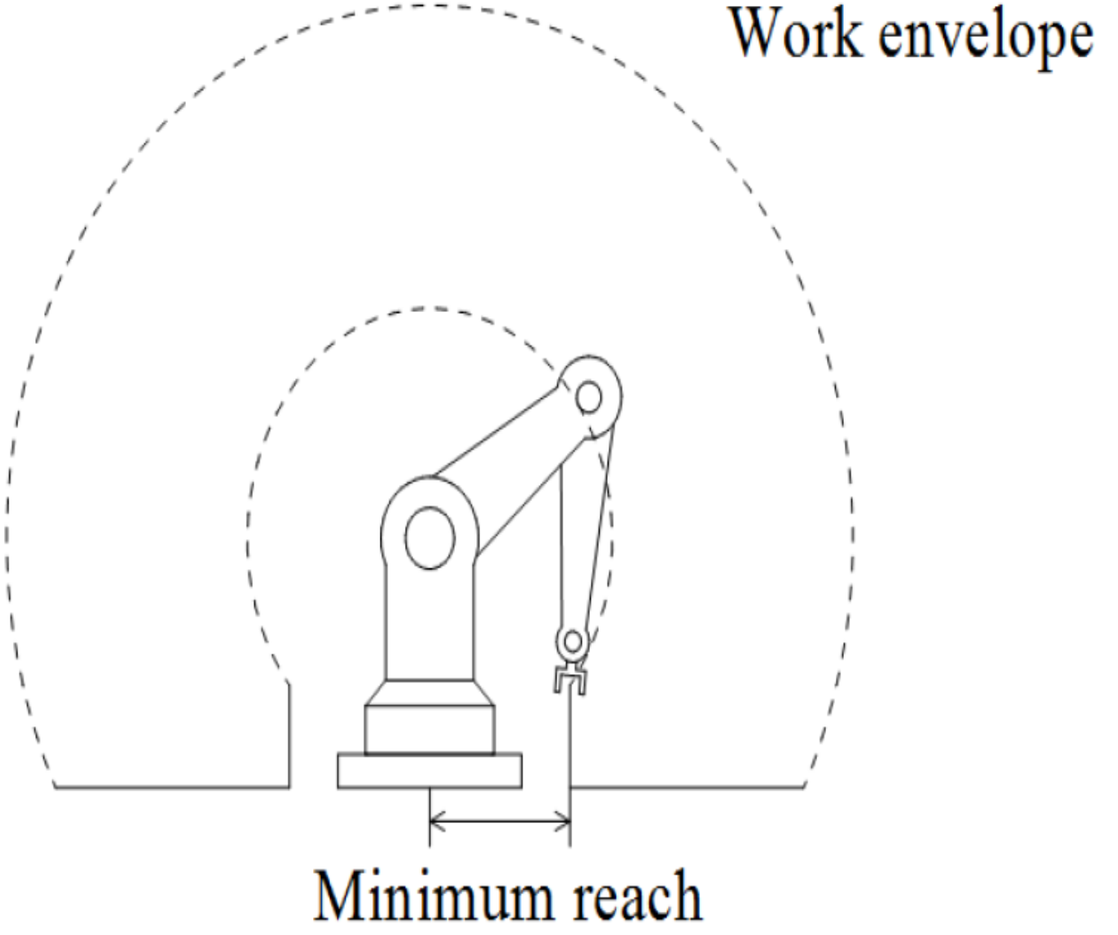
➢ It depends upon following physical characteristics:

  - Robot's configuration
  - Size of the body, arm and wrist components
  - Limits of the robot's joint movements

Robot Reach



Robot Reach



Robot Anatomy: Robot Configurations

- Robot configuration specifies the possible movements provided by different robots.
- The majority of present commercially available robots poses one of these configurations.
  - Cartesian Coordinates Configuration
  - Cylindrical Configuration
  - Polar or Spherical Configuration
  - Articulated or Jointed-arm Configuration
  - Selective Compliance Assembly Robot Arm (SCARA) Configuration

https://www.youtube.com/watch?v=R0eJXe6R8vY&t=109s

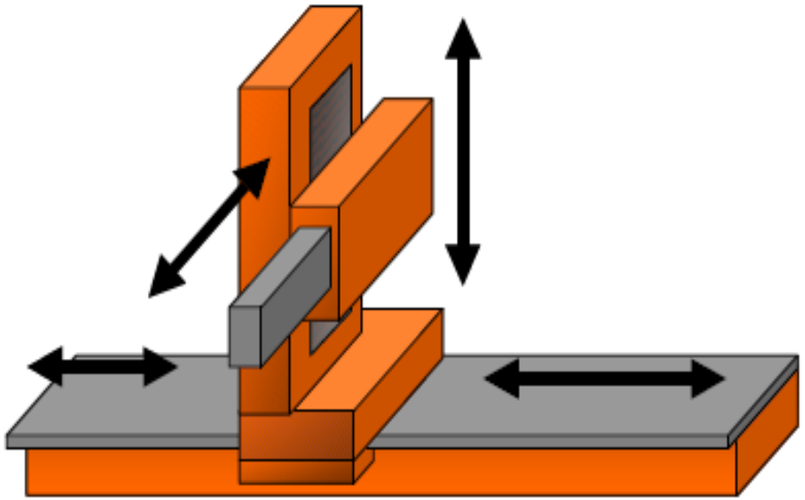
https://www.youtube.com/watch?v=FORcPhBaa50

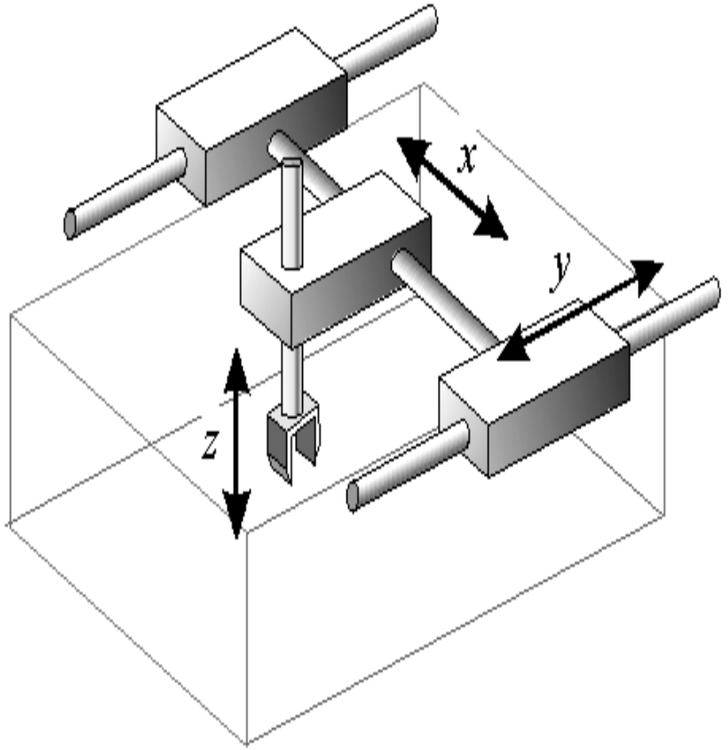
1. Cartesian Coordinate Configuration

- Uses three perpendicular slides to construct x, y and z axes
- X-axis represents right and left motions, Y-axis represents forward-backward motions and Z-axis represents up-down motions
- A robot with 3 prismatic joints (PPP/LLL).
- Other names are *xyz* robot or *Gantry* robot
- Operate within a rectangular (Box) work volume

3L/3P

moves in 3 linear directions/prismatic directions





Cartesian Coordinate Configuration

- **Advantages**
  - Linear motion in three dimension
  - Simple kinematic model
  - Rigid structure
  - Higher repeatability and accuracy
  - High lift-carrying capacity
  - Increase work volume easily
  - Inexpensive

Disadvantages

- work space is smaller than robot volume
- unable to reach areas under objects

Applications

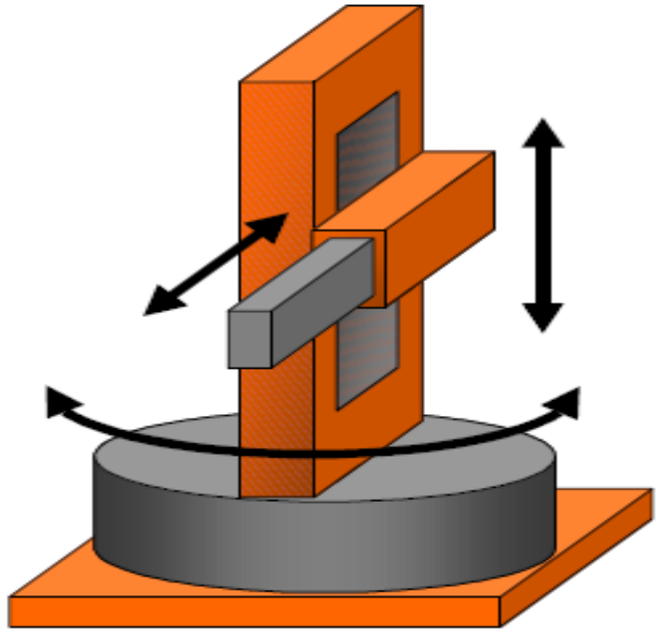
- Assembly operations
- Loading-unloading machine tools,
- Arc Welding

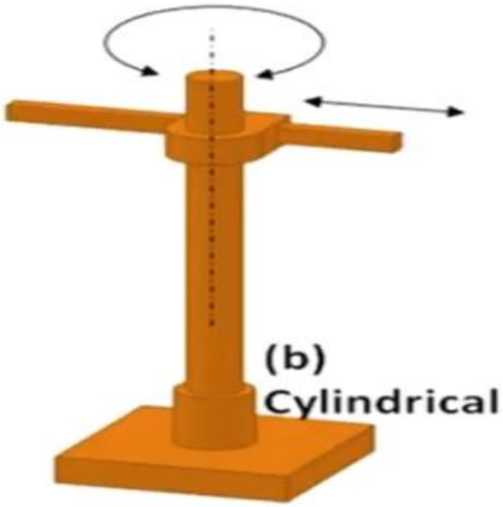
2. Cylindrical Coordinate Configuration

- Use vertical column which rotates and a slide that can be moved up or down along the column
- Arm is attached to slide which can be moved in and out
- Kinematic designation is RPP
- Operate within a cylinder work volume

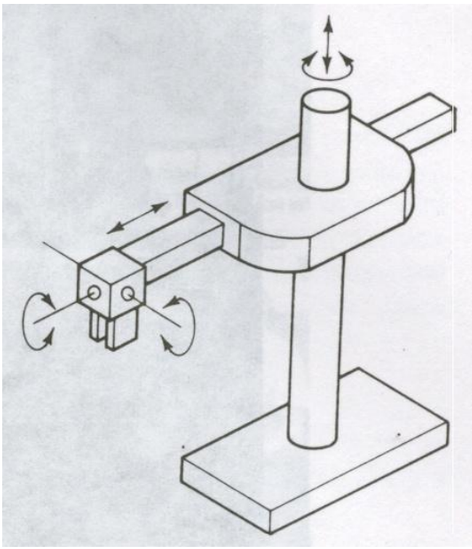
2l 1R motions

up down = stroke
left right = reach
rotate = swing



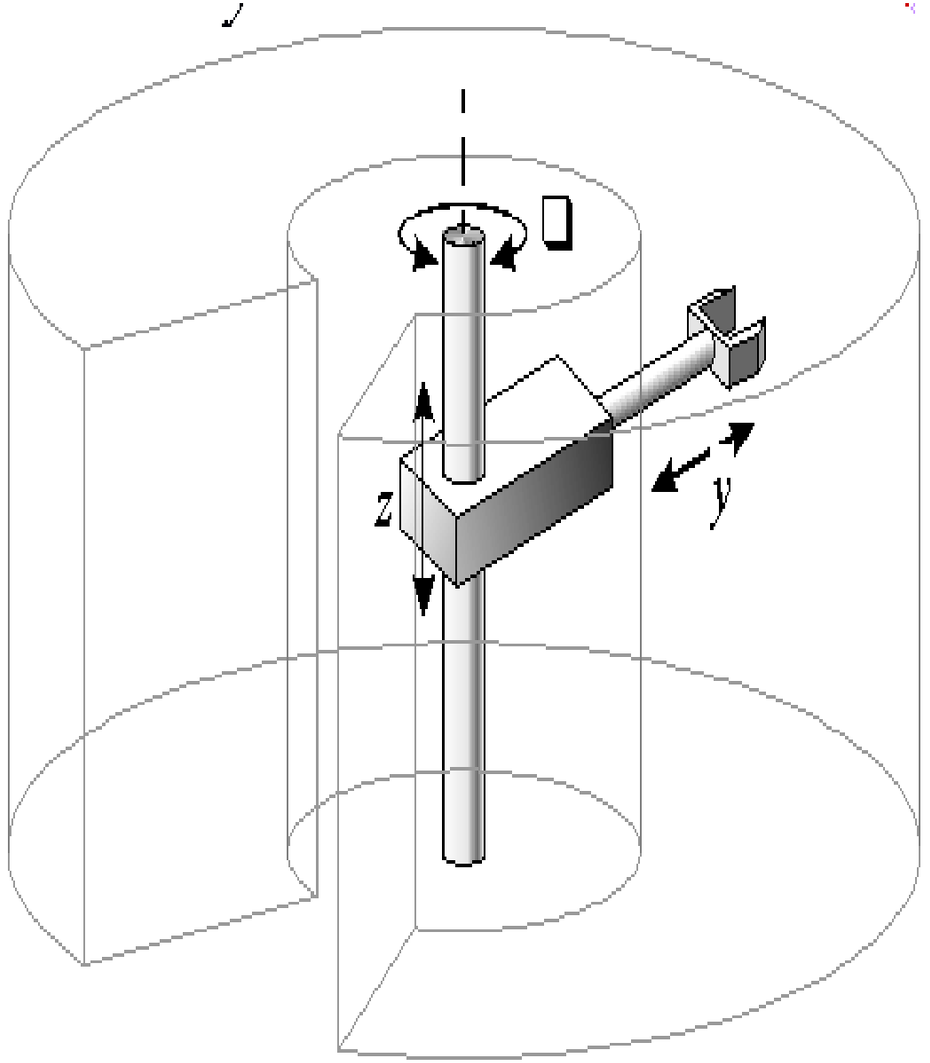


Robot



2. Cylindrical Coordinate Configuration

- A robot with 2 prismatic joints and a rotary join



Advantages

- Simple kinematic model
- Rigid structure & high lift-carrying capacity
- Very powerful when hydraulic drives used
- Can reach all around itself

Disadvantages

- Can’t reach above itself
- Won’t reach around obstacles
- Lower repeatability and accuracy
- Require more sophisticated control

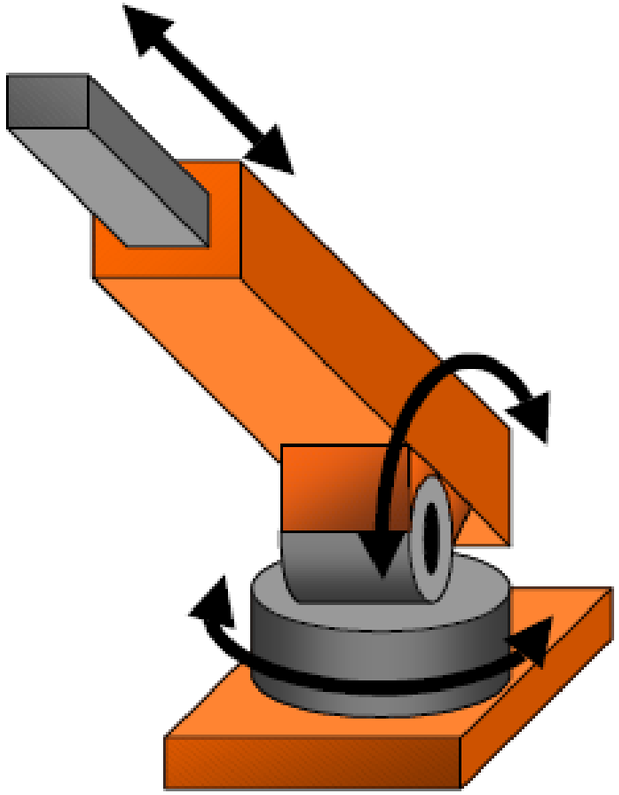
Applications

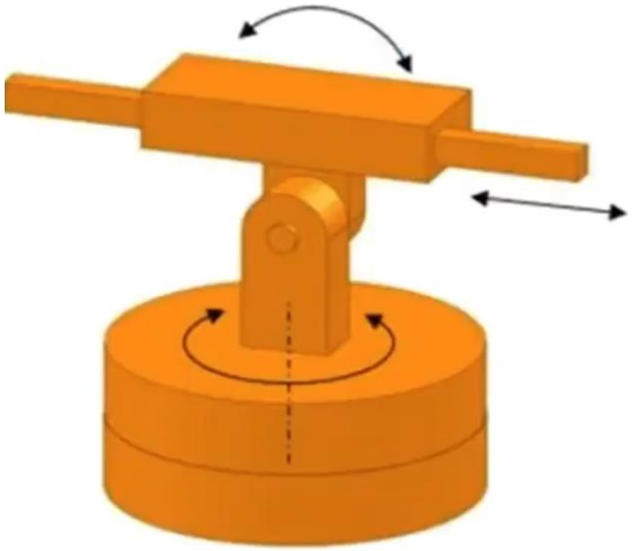
- Loading and unloading
- Material transfer

3. Polar (Spherical) Coordinate Configuration

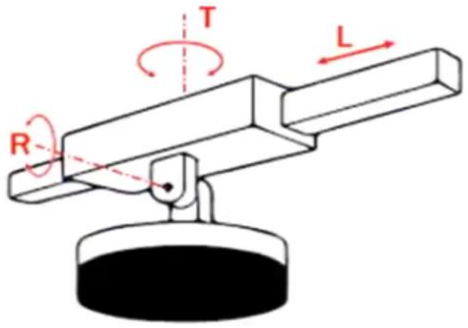
- It uses a telescopic arm that can be raised or lowered about a horizontal joint.
- Has one T-joint, one L-joint and one R-joint (TLR)
- The workspace is Spherical

2R 1L motions

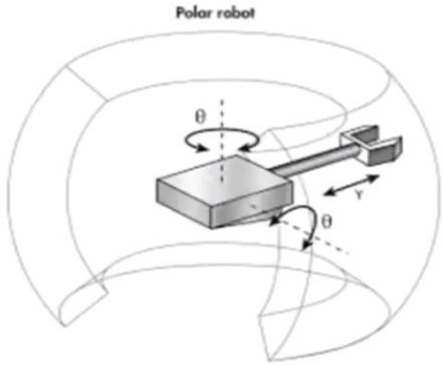




Polar Configuration Robot



Spherical Arm Geometry
Polar Coordinates / 2RP Geometry



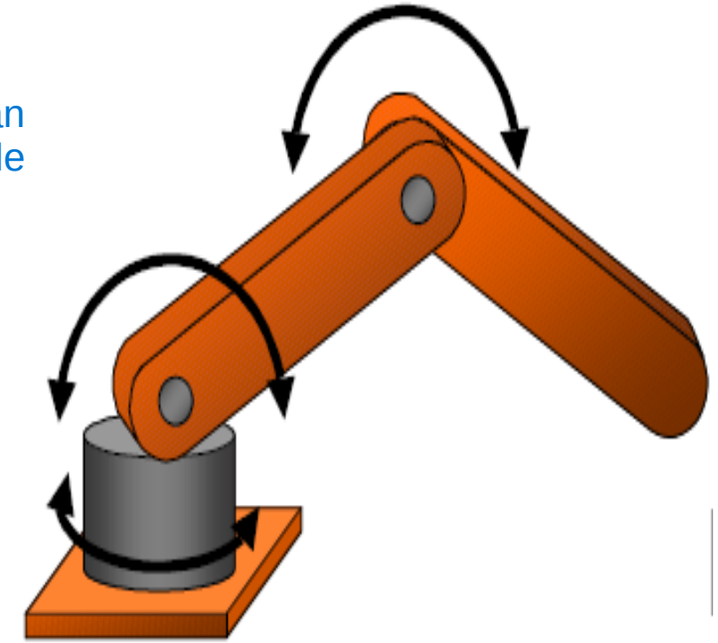
Work Volume

- **Advantages**
  - Covers a large volume
  - Can bend down to pick objects up off the floor
  - Higher reach ability
- **Disadvantages**
  - Complex kinematic model
  - Difficult to visualize
- **Applications**
  - Handling of heavy loads e.g. casting, forging

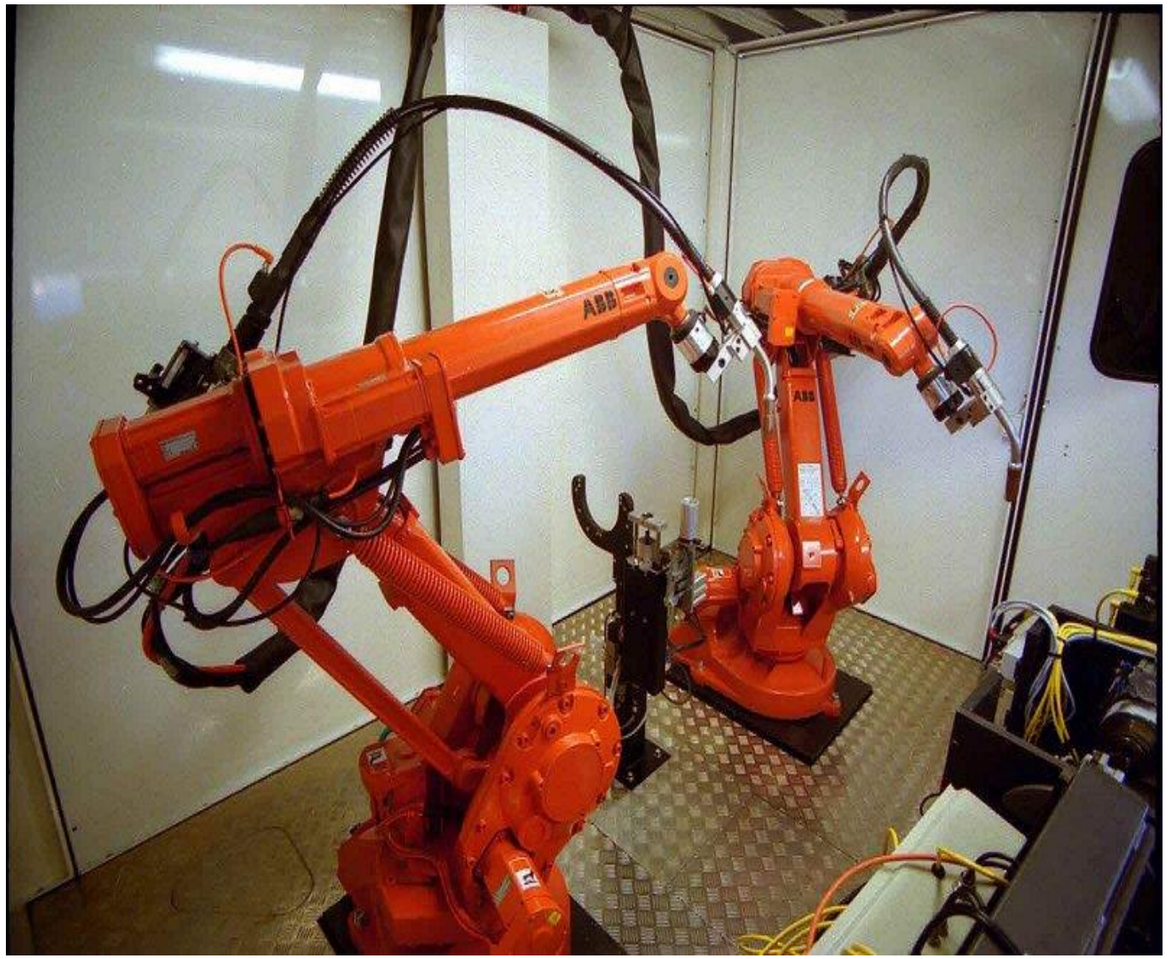
4. Jointed Arm Coordinate (Articulated) Configuration

- Similar to human arm
- Consists of two straight components like human forearm and upper arm, mounted o a vertical pedestal
- Two rotary joints corresponding to the shoulder and elbow
- Kinematic designation is RRR
- Work volume is irregular

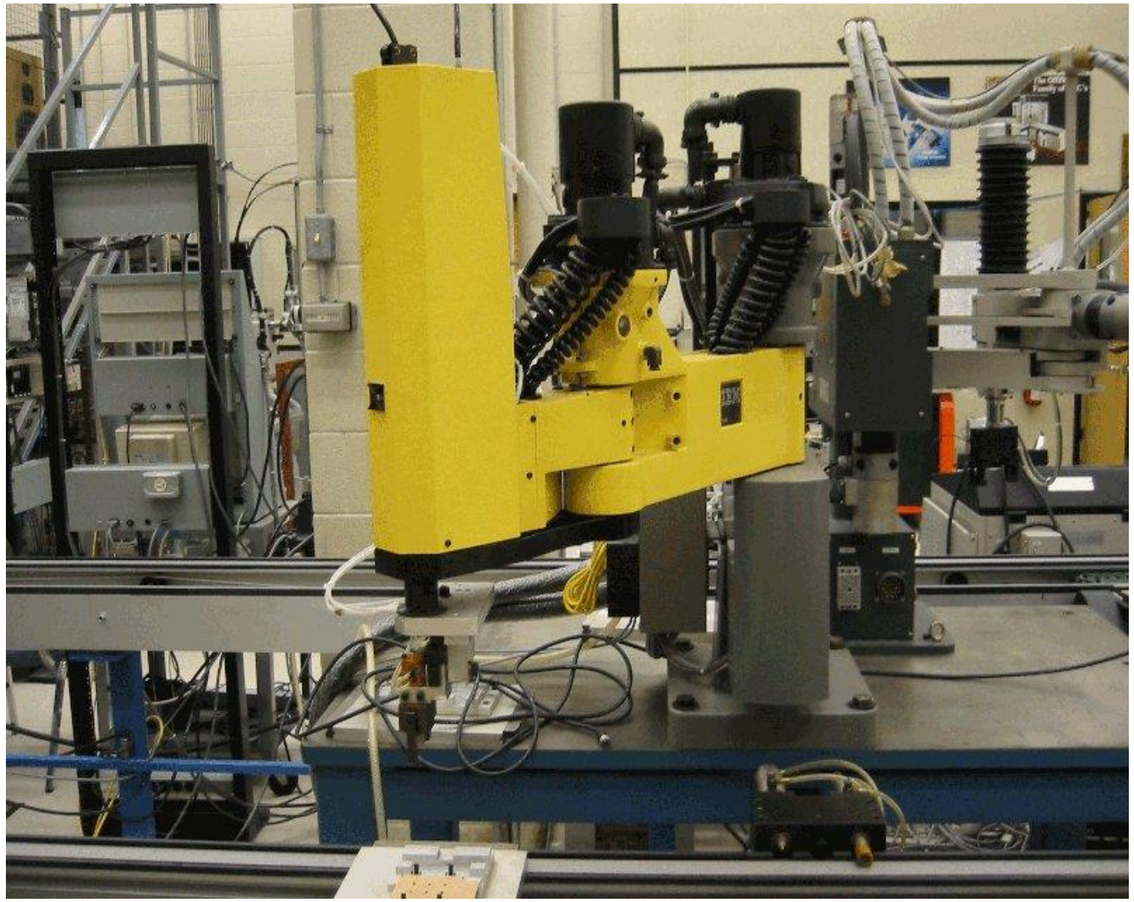
3R Motion. more costly than the other types. very flexible



Vertically Articulated Robot



Horizontally Articulated Robot



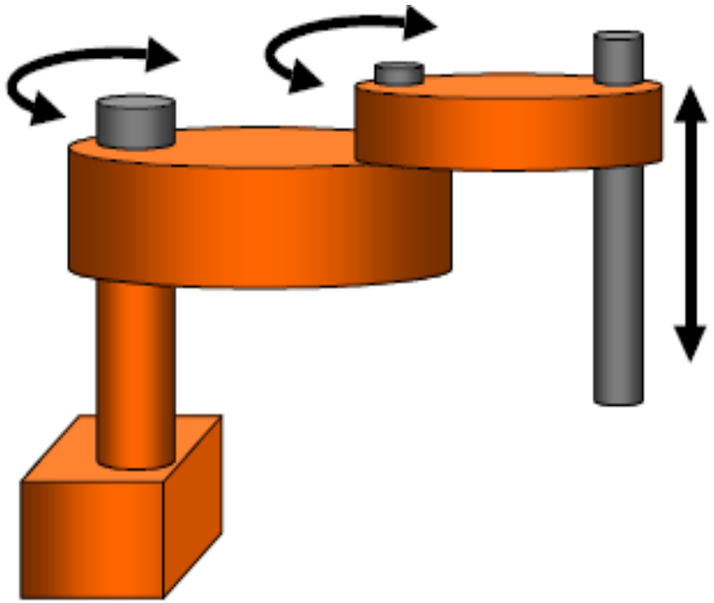
Jointed Arm Coordinate Configuration

- **Advantages**
  - Maximum flexibility
  - Cover large space relative to work volume objects up off the floor
  - Suits electric motors
  - Higher reach ability
- **Disadvantages**
  - Complex kinematic model
  - Structure not rigid at full reach
- **Applications**
  - Spot welding, Arc welding

5. SCARA Coordinate Configuration

- It is acronym for *Selective Compliant Assembly Robot Arm*.
- Two horizontal revolute joints at the waist and elbow and a final prismatic joint
- Can reach at any point within horizontal planar defined by two concentric circles
- Kinematic designation is TTP
- Work volume is cylindrical in nature

3R 1L. most expensive



SCARA Robot

SCARA Coordinate Configuration

- **Advantages**
  - Floor area is small compare to work area
  - Compliance
- **Disadvantages**
  - Rectilinear motion requires complex control of the revolute joints
- **Applications**
  - Assembly operations
  - Inspection and measurements
  - Transfer or components