UNIT-V INDUSTRIAL ROBOTICS

1. Define – Robot

Robot is a programmable, multifunction manipulator designed to move materials, parts, tools or special devices through variable programmed motions for the performance of the variety of tasks.

2. Write the types of joint notations.

1. Linear joint (type L joint), the relative movement between the input link and the output link is a translational sliding motion, with the axes of the two links parallel.

2. Orthogonal joint (type O joint), this is also a translational sliding motion, but the input and output links are perpendicular to each other during the move.

3. Rotational joint (type R joint), it provides rotational relative motion, with the axis of rotation perpendicular to the axes of the input and output links.

4. Twisting joint (type T joint), involves rotary motion, but the axis of rotation is parallel to the axes of the two links.

5. Revolving joint (type R joint) the axis of the input link is parallel to the axis of rotation of the joint, and the axis of the output link is perpendicular to the axis of rotation.

3. What are the four basic robot configurations available commercially?

1. Cartesian coordinate robot
2. Cylindrical configuration
3. Polar configuration
4. Jointed arm robot
5. SCARA

4. What is meant by Work space?

The space in which the end point of the robot arm is capable of operating is called as workspace in other words reach ability of robot arm is known as workspace.

5. Define – Work Volume

The work volume of the manipulator is defined as the envelope or 3D space within which the robot can manipulate the end of its wrist.

6. What is an end effector?

The end effector enables the robot to accomplish a specific task. The two categories of end effectors are (a) grippers and (b) tools

7. Define – Grippers

Grippers are end effectors used to grasp and manipulate objects during the work cycle.

Types of grippers:

1. Mechanical grippers
2. Vacuum grippers

3. Magnetic devices
4. Adhesive devices

8. Classify the sensors in robotics

Sensors used in industrial robotics can be classified into two categories:

1. *Internal sensors* are components of the robot and are used to control the position and velocities of the various joints of the robot. These sensors form a feedback control loop with the robot controller.

2. *External sensors* are used to coordinate the operation of the robot with the other equipment in the cell.

9. Name the various sensors used in industrial robotics

1. Tactile sensors
2. Proximity sensors
3. Optical sensors
4. Machine vision

10. Define – Control Resolution, Accuracy and Repeatability of Robot

Control resolution refers to the capability of the robot's positioning system to divide the range of the joint into closely spaced points, called addressable points, to which the joint can be moved by the controller.

$$Control\ resolution, CR = \frac{R}{2^B - 1}$$

Accuracy is the robot's ability to position the end of its wrist at a desired location in the work volume.

$$Accuracy = \frac{CR}{2} + 3\sigma$$

Repeatability is a measure of the robot's ability to position its end-of-wrist at a previously taught point in the work volume.

$$Repeatability = \pm 3\sigma$$

11. What is meant by pitch, yaw and roll?

Pitch is rotation around the X-axis, Yaw is around the Y-axis, and roll is around the Z-axis.

12. Write the applications of an industrial robot.

1. Repetitive work cycle
2. Material handling
    a. Material transfer
    b. Machine loading and unloading
3. Processing operations
    a. Spot welding
    b. Arc welding

c. Spray coating

4. Assembly and inspection

13. Define – Robot Programming

A robot programming can be defined as a path in space to be followed by the manipulator, combined with peripheral actions that support the work cycle.

14. Write the types of robot programming methods.

1. Leadthrough programming
2. Computer-like robot programming languages
3. Off-line programming

Industrial Robotics

Sections:
1.Robot Anatomy and Related Attributes

2.Robot Control Systems

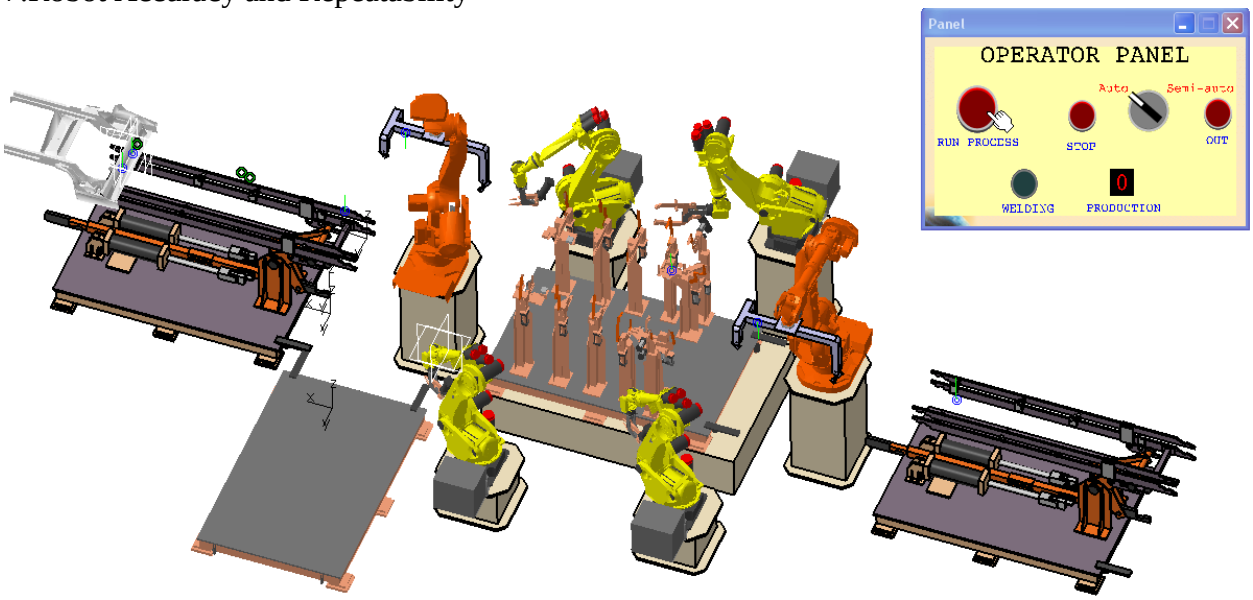
3.End Effectors

4.Sensors in Robotics

5.Industrial Robot Applications

6.Robot Programming

7.Robot Accuracy and Repeatability



Industrial Robot Defined

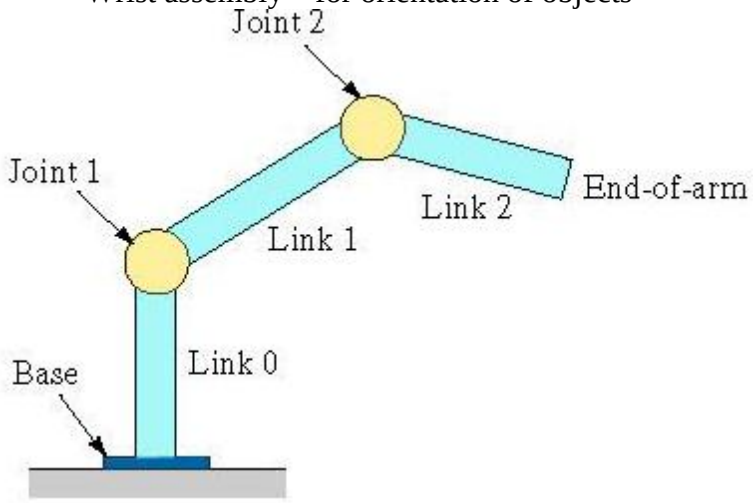
A general-purpose, programmable machine possessing certain anthropomorphic characteristics
Why industrial robots are important:

- Robots can substitute for humans in hazardous work environments
- Consistency and accuracy not attainable by humans
- Can be reprogrammed
- Most robots are controlled by computers and can therefore be interfaced to other computer systems

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



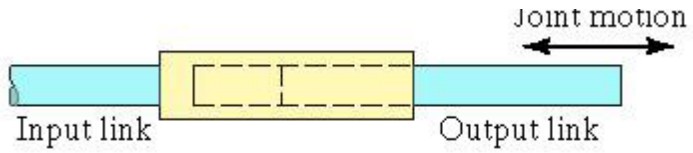
Robot manipulator - a series of joint-link combinations

Types of Manipulator Joints

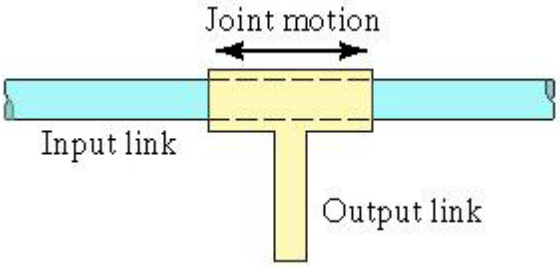
Translational motion

- Linear joint (type L)
- Orthogonal joint (type O)
- Rotary motion
- Rotational joint (type R)
- Twisting joint (type T)
- Revolving joint (type V)

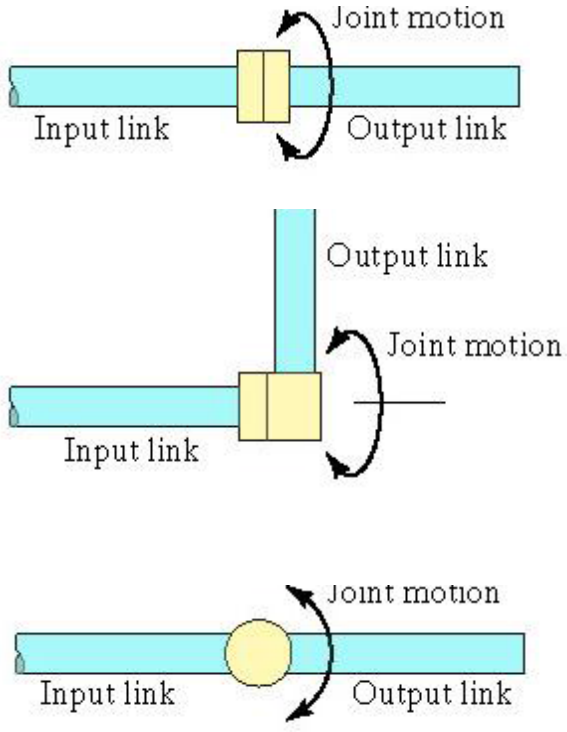
Translational Motion Joints



Linear joint (type L)



Orthogonal joint (type O)



Rotational joint (type R)
Twisting joint (type T)
Revolving joint (type V)

Robot Body-and-Arm Configurations

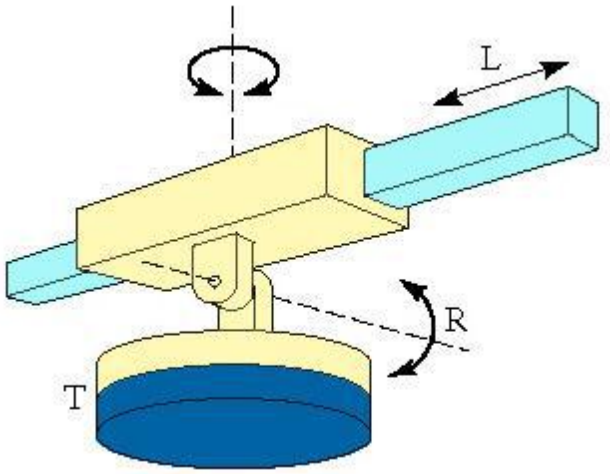
Five common body-and-arm configurations for industrial robots:
1.Polar coordinate body-and-arm assembly

2.Cylindrical body-and-arm assembly

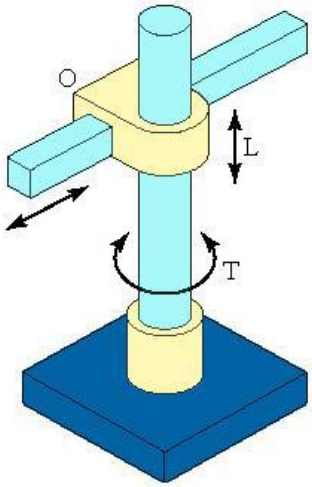
3.Cartesian coordinate body-and-arm assembly

4.Jointed-arm body-and-arm assembly

5.Selective Compliance Assembly Robot Arm (SCARA)
Function of body-and-arm assembly is to position an end effector (e.g., gripper, tool) in space
Polar Coordinate Body-and-Arm Assembly

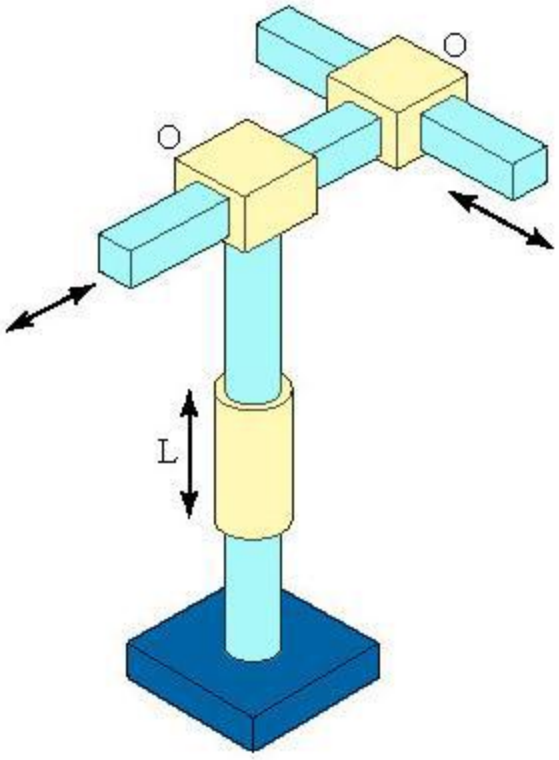


Cylindrical Body-and-Arm Assembly

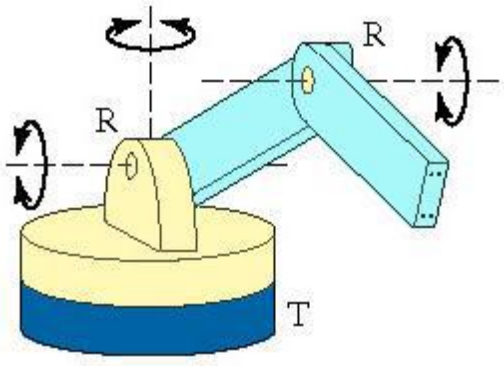


Cartesian Coordinate Assembly

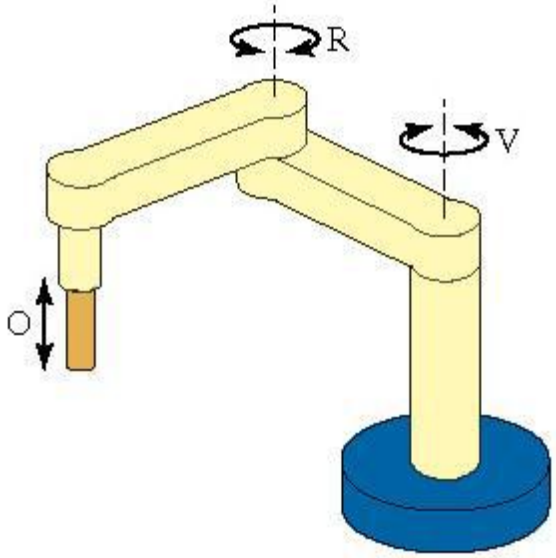
Body-and-Arm



Jointed-Arm Robot



SCARA Robot

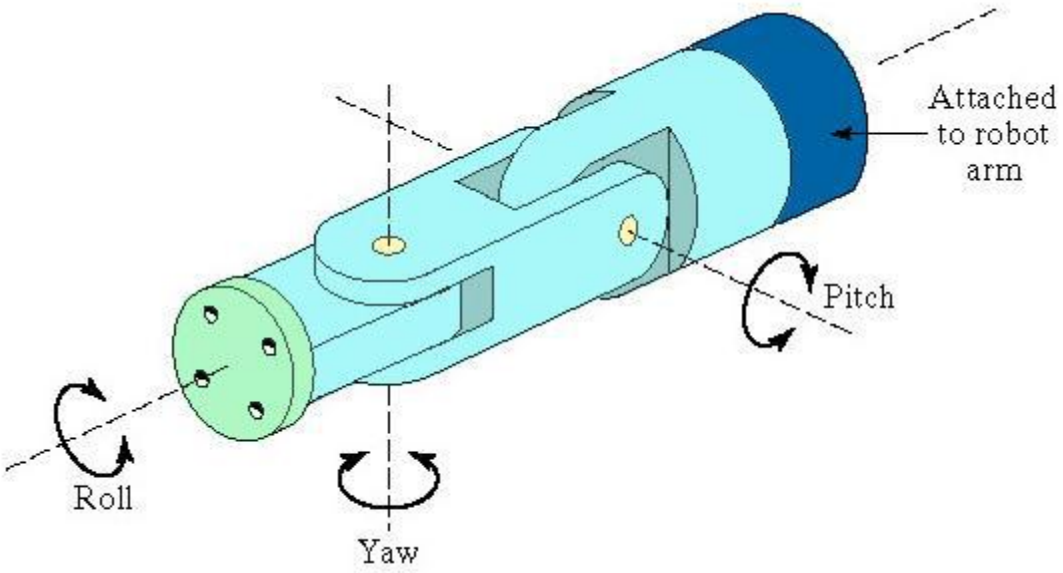


Wrist Configurations

- Wrist assembly is attached to end-of-arm
- End effector is attached to wrist assembly
- Function of wrist assembly is to orient end effector
- Body-and-arm determines global position of end effector

Two or three degrees of freedom:

- Roll
- Pitch
- Yaw
- Wrist Configuration



Industrial Robot Applications

1.Material handling applications

- Material transfer – pick-and-place, palletizing
- Machine loading and/or unloading

2.Processing operations

- Spot welding and continuous arc welding
- Spray coating
- Other – waterjet cutting, laser cutting, grinding

3.Assembly and inspection

Robot Programming

Leadthrough programming - work cycle is taught to robot by moving the manipulator through the required motion cycle and simultaneously entering the program into controller memory for later playback

Robot programming languages - uses textual programming language to enter commands into robot controller

Simulation and off-line programming – program is prepared at a remote computer terminal and downloaded to robot controller for execution without need for leadthrough methods

Leadthrough Programming

Two types:
1.Powered leadthrough
Common for point-to-point robots

Uses teach pendant to move joints to desired position and record that position into memory
2.Manual leadthrough
Convenient for continuous path control robots

Human programmer physical moves manipulator through motion cycle and records cycle into memory

Leadthrough Programming Advantages

Advantages:
Can readily be learned by shop personnel

A logical way to teach a robot

Does not required knowledge of computer programming
Disadvantages:
Downtime - Regular production must be interrupted to program the robot

Limited programming logic capability

Not readily compatible with modern computer-based technologies

Robot Programming Languages

Textural programming languages provide the opportunity to perform the following functions that leadthrough programming cannot readily accomplish:
Enhanced sensor capabilities

Improved output capabilities to control external equipment

Program logic not provided by leadthrough methods

Computations and data processing similar to computer programming languages

Communications with other computer systems
Robot Accuracy and Repeatability

Three terms used to define precision in robotics, similar to numerical control precision:
1.Control resolution - capability of robot's positioning system to divide the motion range of each joint into closely spaced points

2.Accuracy - capability to position the robot's wrist at a desired location in the work space, given the limits of the robot's control resolution

3.Repeatability - capability to position the wrist at a previously taught point in the work space