Activity of Robot's moving forward and backward is called SURGING.

operating method of robot control unit: Continuous-path, Point-to-point, pick-and-place

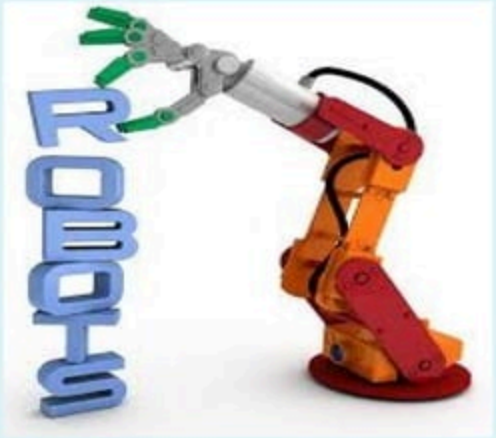
major components of a robot: Manipulator, Vehicle, Controller

Robotic grip: electromagnet, hook, scoop

Passive sensor: PIR sensor

Active sensor: blood pressure sensor, temperature sensor, ultrasonic sensor

INTRODUCTION TO ROBOTICS



INTRODUCTION TO ROBOTICS

WHAT IS A ROBOT ?

A robot can be defined as a programmable , self controlled device consisting of electronic , electrical or mechanical units.

Or

A robot is a mechanical apparatus designed to do the work of a man. Its components are usually electromechanical and are guided by a computer program or electronic circuitry.

Essential Characteristics of robots

- **Sensing:** The robot should be able to sense its surroundings and that is only possible with the help of sensors.

  Types of sensors:

  light sensors (eye) , touch sensors(hands) , hearing sensors(ears) or chemical sensors(nose)

- **Movement:** A robot needs to be able to move around its environment whether by rolling on wheels , walking , snaking or skating.
- **Energy:** A robot needs to be able to power itself which depends upon its power resources e.g. batteries , power generators or fuel.
- **Intelligence:** A robot needs to be intelligent and smart which is only possible by the programmer person.

TYPES OF ROBOTS

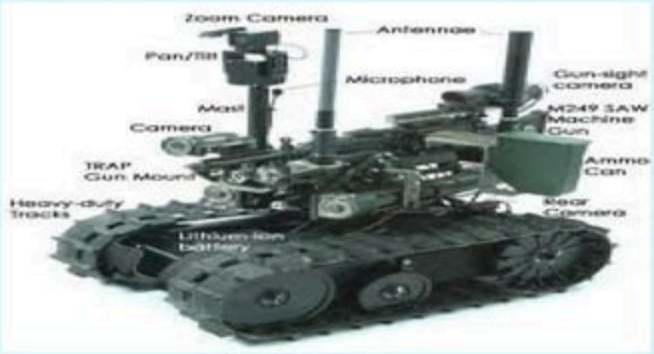
- Mobile Robots: They are able to move around in their environment and not fixed to one physical location.
- Industrial Robots: They are used in industrial manufacturing environment e.g. welding , material handling , painting and others.
- Domestic Or Household Robots: Robots used at home such as robotic vacuum cleaner , robotic pool cleaner and sweeper.
- Medical Robots: Robots used in medicine and medical institutions e.g. surgery robots
- Service Robots: Robots that don't fall into other types by usage e.g. robots used for research.
- Military Robots: they are used in military e.g. bomb disposal robot , different transportation robots and reconnaissance drones

Pictures Of Robots

INDUSTRIAL ROBOTS:

Pictures Of Robots

- Military Robots:



Entertaining Robots

Uses and Advantages of Robots

- ✓ Used in vehicles and car factories
- ✓ Mounting circuits on electronic devise e.g. mobile phones
- ✓ Working where there might be danger e.g. nuclear leaks and bomb disposal
- ✓ Surgeons are performing robotic surgeries to avoid jiggles and movement in microscopically aided surgery or brain surgery
- ✓ Mail delivery to various mail stations throughout the building in large corporations
- ✓ Toy robots are a good source of entertaining for the kids e.g. dancing and talking robots
- ✓ Robots do not get bored or tired and they can work 24/7 without salary and food

Disadvantages Of Robots

- It needs a high supply of power
- People can lose jobs in factories
- It needs maintenance to keep it running
- It cost a lot of money to make or buy a robot as they are very expensive
- A robot can not respond in time of danger as human can

Robotics

- Not a pure Computer Engineering subject
  - Combination e.g. Mechanical, Electrical and Computers
  - Mechatronics = Mechanical + Electronics.

Industrial Robots

- "a robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions, for the performance of a variety of tasks".

What is a Robot?

- The Study of Robots

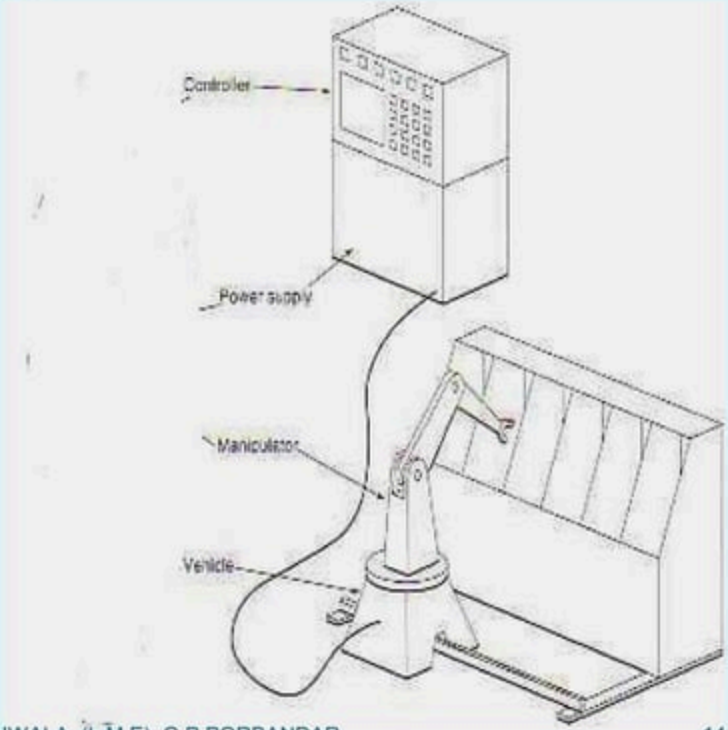
- A machine that looks and acts like a human being.
- An efficient but insensitive person
- An automatic apparatus.
- Something guided by automatic controls.
  - E.g. remote control
- a computer whose main function is to produce motion.

Characteristic of a Robot

- Repeatability
- Manual control
- Automatic control
- Speed of operation

Components

- Manipulator
- Controller
- Power supply
- Vehicle



General Components

- Manipulator
  - Configurations
    - Cartesian Coordinates
    - Cylindrical Coordinates
    - SCARA
    - Polar Coordinates
    - Jointed Arm
  - Wrist
  - Gripper

General Components

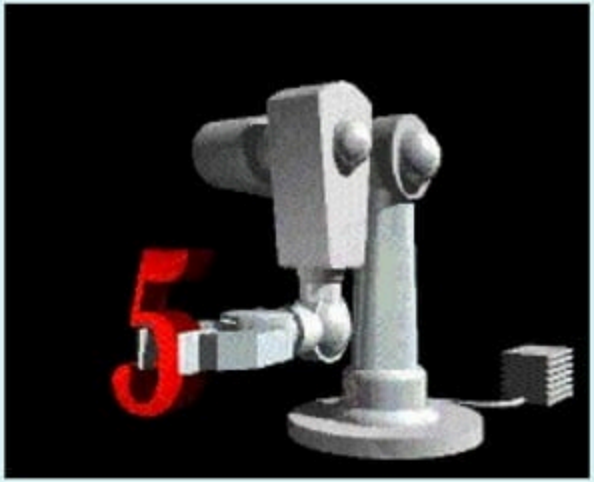
- Power supply
  - Pneumatic
  - Electrical
  - Hydraulic

General Components

- Controller
  - Servo Systems
    - Open Loop
    - Closed Loop
  - Operating Methods
    - Pick and Place
    - Point-to-point
    - Continuous path
- Vehicle
  - Stationary
  - Mobile

What are the parts of a robot?

- Manipulator
- Pedestal
- Controller
- End Effectors
- Power Source



Manipulator

(Mimics the human arm)

- **Base**
- **Appendage**
  - Shoulder
  - Arm
  - Grippers

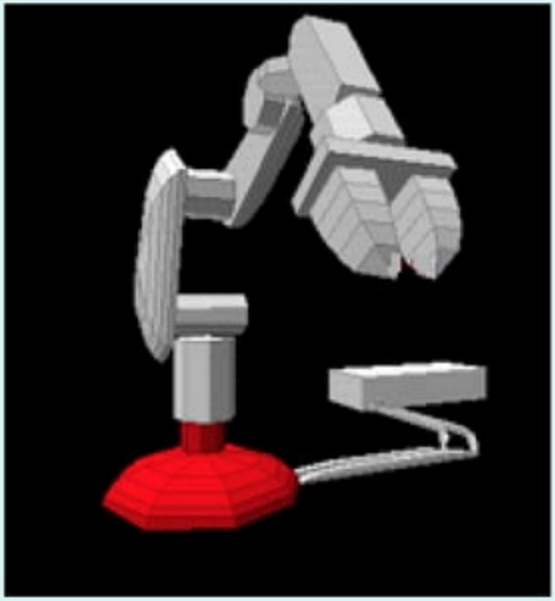
Here robot is considered as **industrial robot** called as **robotic manipulator or robotic arm.**

This arm is roughly **similar to human arm.**

It is modeled as **chain of rigid links interconnected by flexible joints**.

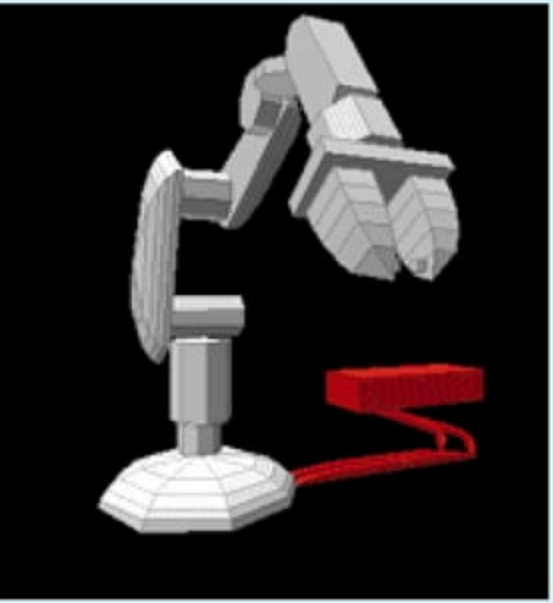
Links corresponds to :**chest, upper arm, fore arm**
Joints: **shoulder, elbow, and wrist.**
At end of arm is an **end effector (tool, gripper or hand).**
Tool has two or more fingers that open and closes.

Pedestal



- Supports the manipulator.
- Acts as a counterbalance.

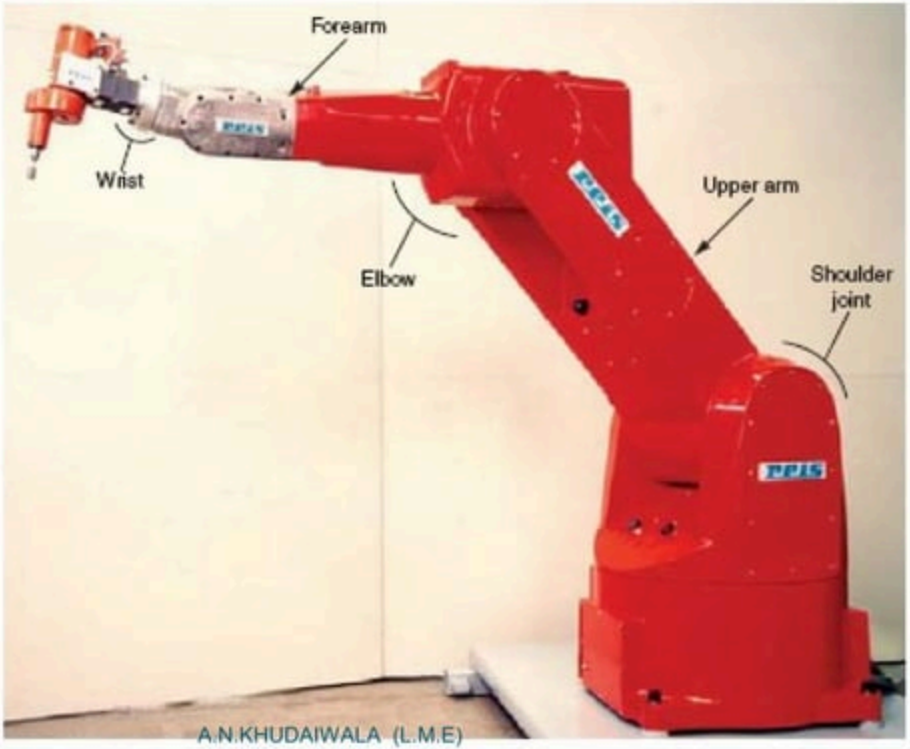
Controller



(The brain)

- Issues instructions to the robot.
- Controls peripheral devices.
- Interfaces with robot.
- Interfaces with humans.

Figure 2-1. This robot has been designed expressly for use in precise path-oriented tasks such as deburring, milling, sanding, gluing, bonding, cutting, and assembly. (Reis Machines, Inc.)

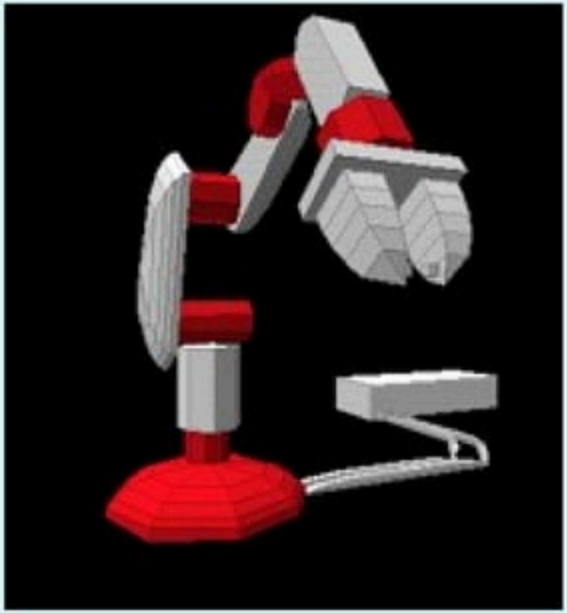


End Effectors

(The hand)

- Spray paint attachments
- Welding attachments
- Vacuum heads
- Hands
- Grippers

Power Source

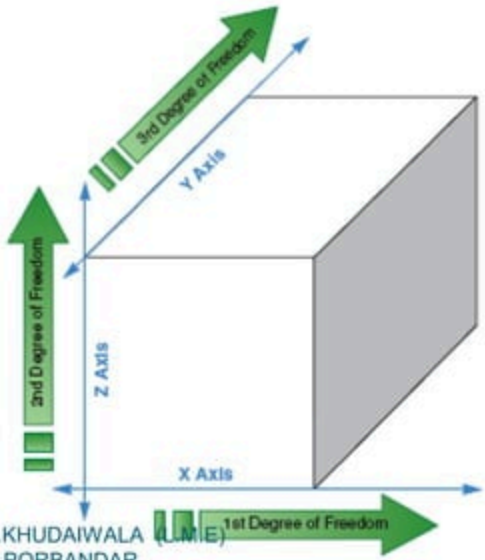


(The food)

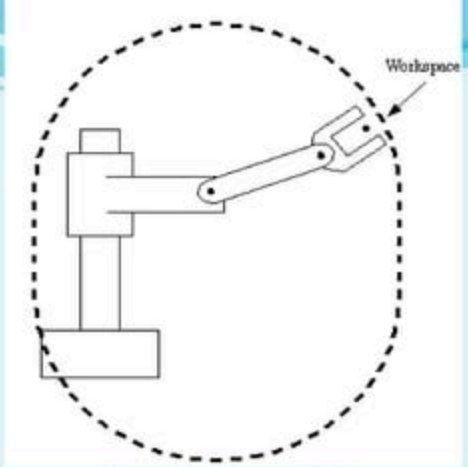
- Electric
- Pneumatic
- Hydraulic

The number of degrees of freedom defines the robot's configuration.
For example, many simple applications require movement along three axes: X, Y, and Z.
See **Figure 2-10. These tasks require three joints, or three** degrees of freedom

Figure 2-10. The three basic degrees of freedom are associated with movement along the X, Y, and Z axes of the Cartesian coordinate system.



Thus a **minimum of six axes** are required to achieve any desirable **position and orientation in the robot's work volume or work envelop or workspace.**



The **locus of the points in the three dimensional space that can be reached by the wrist by the various combinations of the movements of the robot joints from base up to wrist**, is called the **gross work envelop of the robot.**

The robot motions are accomplished by means of powered joints.

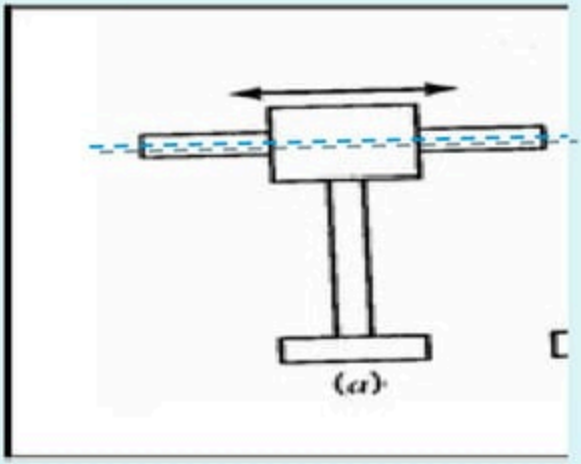
The **rigid members** connected at the joints of the robot are called **links.**

In the link-joint-link chain, the **link closest to the base** is referred to as the **input link** .

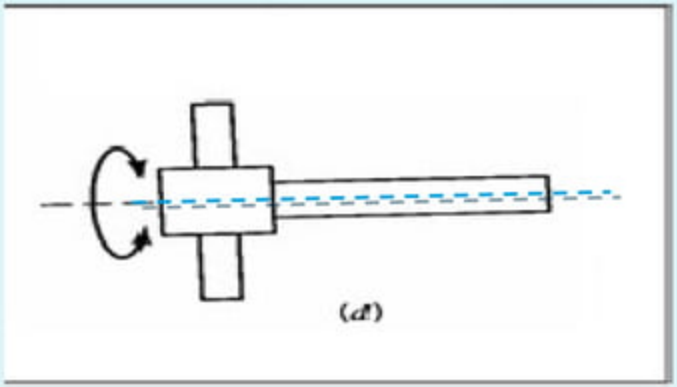
The **output link** is the one which **moves with respect to the input link.**

There are basically two types of joints commonly used in industrial robots, which are:

(i) prismatic or linear joints,(p) which have sliding or linear (translational) **motion along an axis.**



(ii)Revolute ,(R) : which exhibits the rotary **motion about an axis.**



the links are aligned perpendicular to one another at this kind of joint. The rotation involves revolution of one link about another.

Based on the physical configuration or the **combination of the revolute or prismatic joints for the three major axes**, a particular **geometry of the work envelop is achieved**.

The table shows the some of the most common robot work envelops based on the major axes:

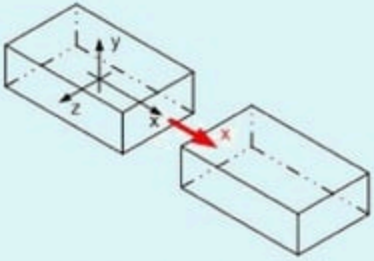
P:Prismatic -- R:Revolution

robot	Axis 1	Axis 2	Axis 3	Total revolute
cartesian	P	P	P	0
Cylindrical	R	P	P	1
Spherical	R	R	P	2
SCARA	R	R	P	2
Articulated	R	R	R	3

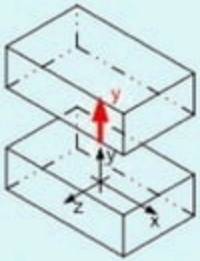
Cartesian Gantry Robot Arm

Robot Classification:

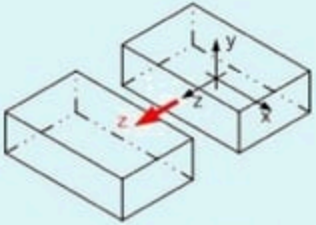
Degrees of Freedom



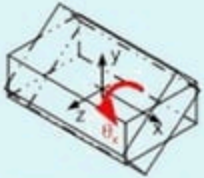
Linear in x-direction



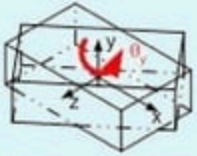
Linear in y-direction



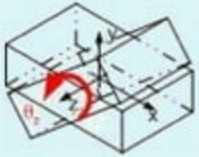
Linear in z-direction



Rotation around x-axis



Rotation around y-axis



Rotation around z-axis

Diagrams courtesy Dr. Eberhard Bamberg Assistant Professor of Mechanical Engineering University of Utah

Degrees of Freedom

Each plane in which a robot can maneuver.

- ROTATE BASE OF ARM
- PIVOT BASE OF ARM
- BEND ELBOW
- WRIST UP AND DOWN
- WRIST LEFT AND RIGHT
- ROTATE WRIST

Robot Classification:

The six degrees of a rigid body are often described using nautical terms:

Moving up and down (heaving);

Moving left and right (swaying);

Robot Classification:

Moving forward and backward (surging);
Tilting forward and backward (pitching);
Turning left and right (yawing);
Tilting side to side (rolling).

Robot Components

- 1. **Manipulator or Rover**: Main body of robot
  (Links, Joints, other structural element of the robot)
- 2. **End Effecter**: The part that is connected to the last joint hand) of a manipulator.
- 3. **Actuators**: Muscles of the manipulators (servomotor, stepper motor, pneumatic and hydraulic cylinder).
- 4. **Sensors**: To collect information about the internal state of the robot or To communicate with the outside environment.

Robot Components...

- 5. **Controller**: Similar to cerebellum. It controls and coordinates the motion of the actuators.
- 6. **Processor**: The brain of the robot. It calculates the motions and the velocity of the robot's joints, etc.
- 7. **Software**: Operating system, robotic software and the collection of routines.

Robot specification

But in addition to classification, there are several additional characteristics :

(i)Number of axes

(ii)Load carrying capacity (kg)

(iii)Maximum speed (mm/sec)

(iv)Reach and stroke (mm)

(v)Tool orientation (deg)

(vi)Precision, accuracy and Repeatability of movement (mm)

(viii) Operating environment

Load Carrying Capacity:

The load carrying capacity is mainly determined by various factors : **robot's size, configuration, type of drive system and the type of application for which it is designed**.

A very wide range: **from few grams to several thousand of kilograms**.

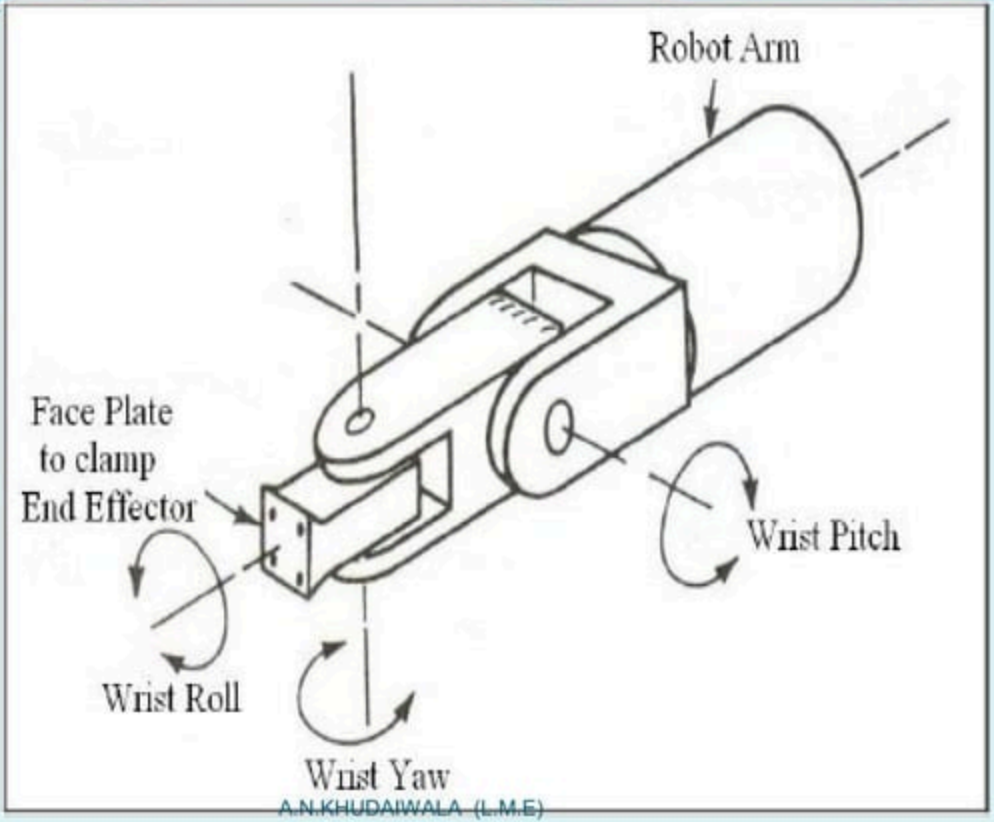
The maximum load carrying capacity should be specified for the **condition that it is** in its **weakest position.**

It is the position when the robots arm is at **maximum horizontal extension.**

The specification provided by manipulator **manufacturers** is actually the **gross weight capacity that can be put at the robotic wrist.**

Thus to use this specification the user **must know weight of the end effector.**

E.g., if the gross load carrying capacity of a robot is 10.0 kg and it's end effector weigh 3.0 kg, then the net load carrying capacity of the robot would be only 7.0 kg.


Robot Arm
Face Plate
to clamp
End Effector
Wrist Pitch
Wrist Roll
Wrist Yaw

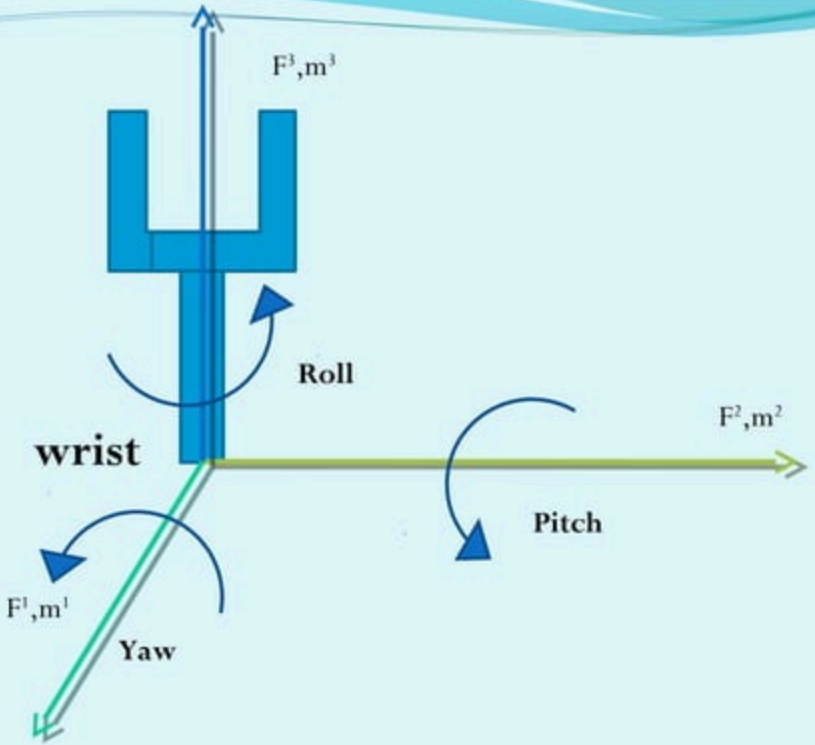
1.Wrist roll: it involves the rotation of the wrist mechanism about the arm axis. Wrist roll is also referred to as wrist swivel.

2. Wrist pitch: if the wrist roll is in its center position, the wrist pitch is the up or down rotation of the wrist. also called wrist bend.

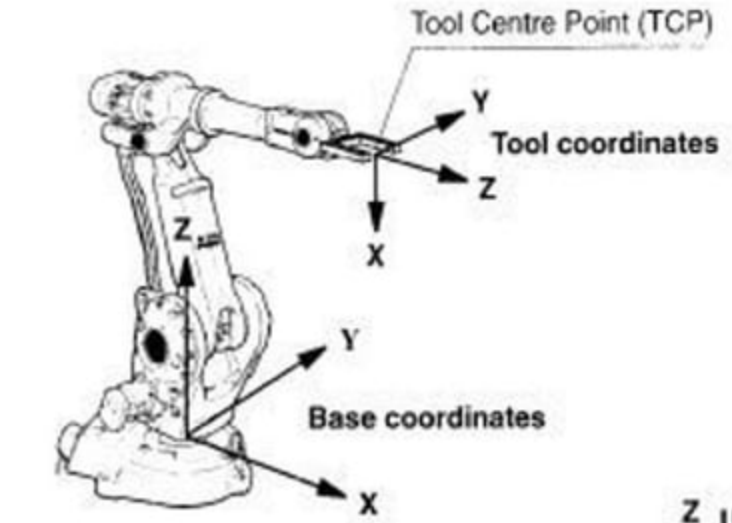
3.Wrist yaw: if the wrist roll is in center position of its range, wrist yaw is the right or the left rotation of the wrist.

The wrist yaw and pitch definitions are specified w.r.t.the central position of the wrist roll,
the rotation of the wrist about the arm axis will change the orientation of the pitch and yaw movements.

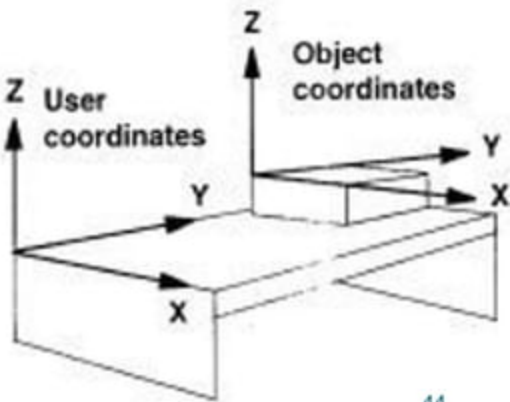
The robot would have a spherical wrist if the axes used to orient the tool intersect at a common point.

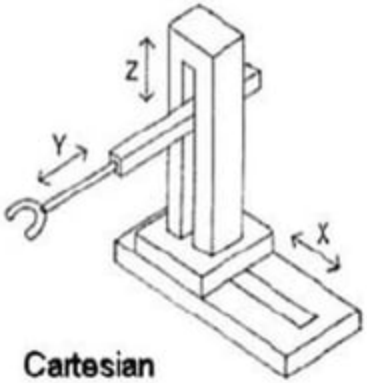

F³,m³
Roll
wrist
F²,m²
Pitch
F¹,m¹
Yaw

Coordinate systems

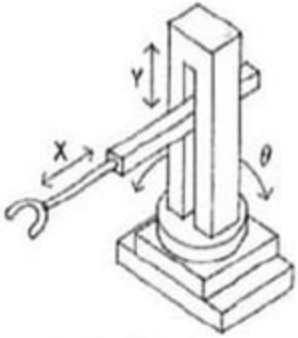


World coordinates

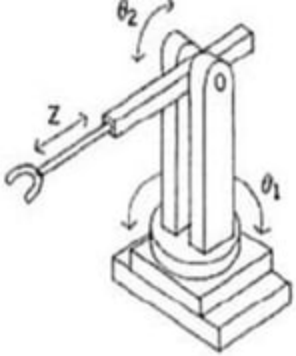




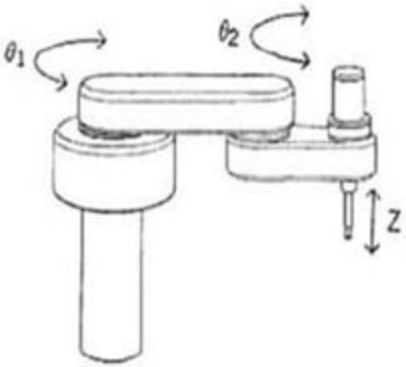
Cartesian



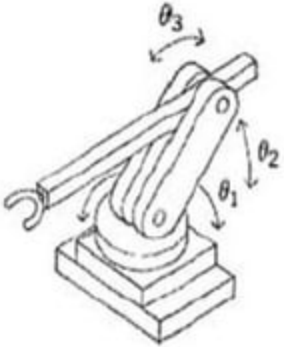
Cylindrical



Polar



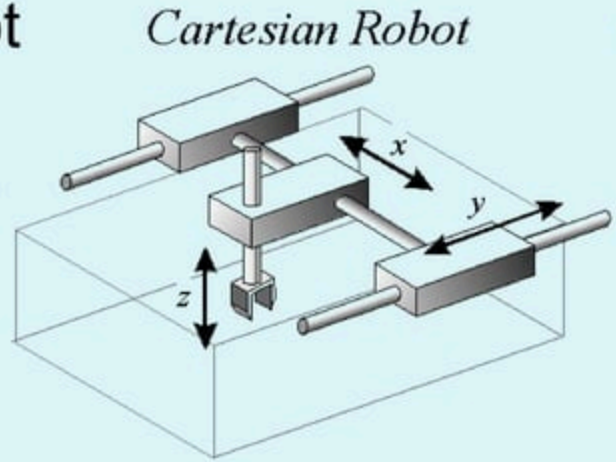
SCARA



Revolution

Cartesian Robot

The first type of robot is called the cartesian robot. This type of robot uses the X, Y, Z three dimensional coordinate system to control movement and location.



The major advantages :

1.Ability to do straight line insertions into furnaces.

2.Easy computation and programming.

3.Most rigid structure for given length.

Disadvantages :

1.Requires large operating volume.

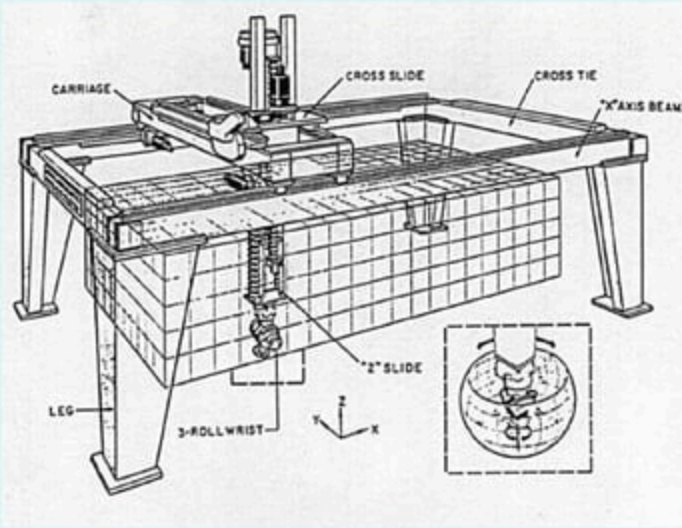
2.Exposed guiding surfaces require covering in corrosive or dusty environments

3.Can only manipulate the objects in front of it.

4.Axes of robot are hard to seal

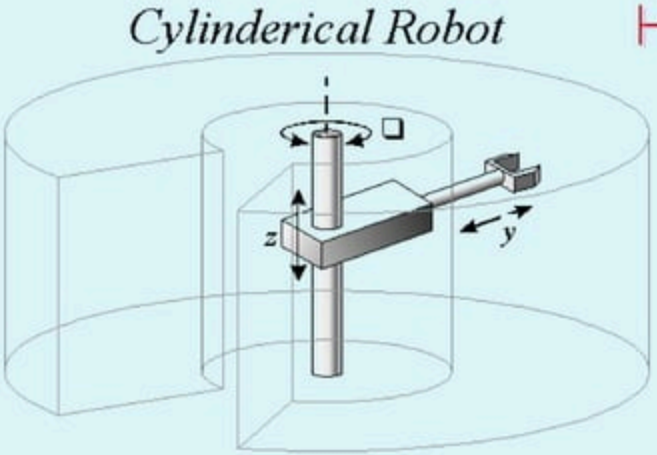
Gantry Robots

Gantry robots are cartesian robots that have been super-sized! This structure minimizes deflection along each axis.

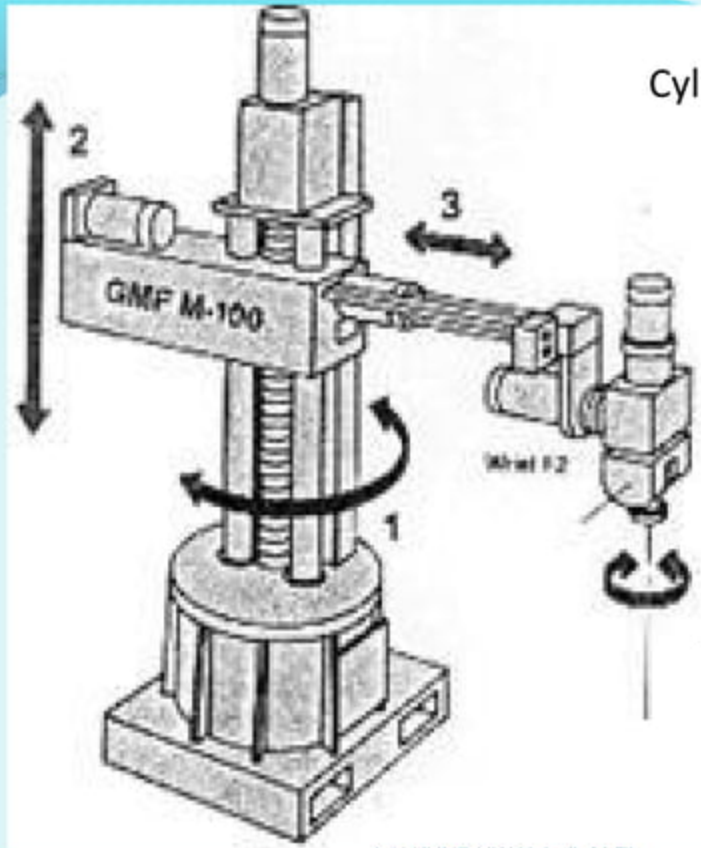


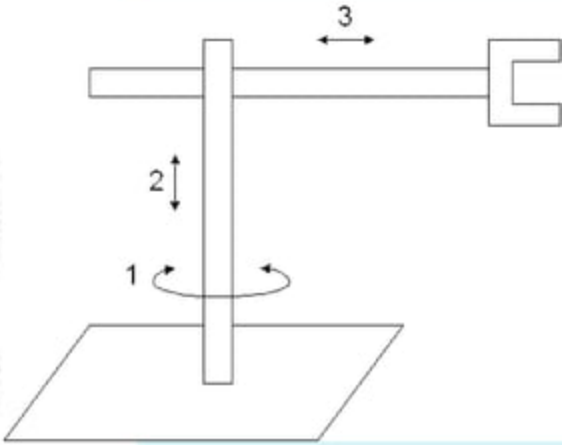
Cylindrical Robots

Cylindrical robots have a main axis that is in the center of the operating envelope. It can reach into tight areas without sacrificing speed or repeatability.



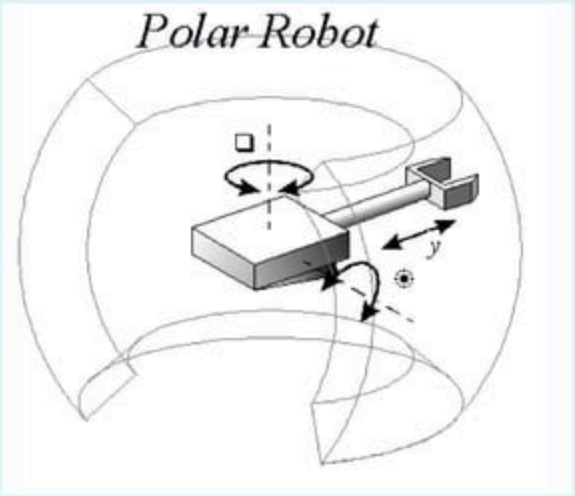
Cylindrical Robot Arm





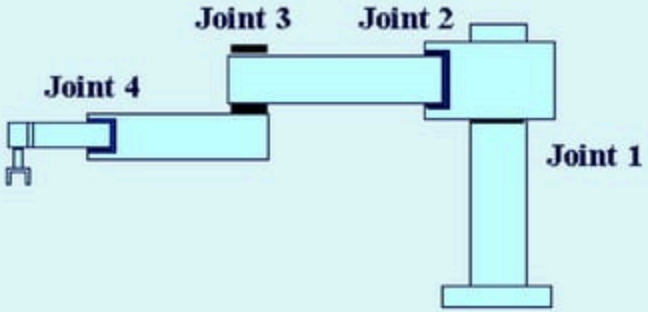
Spherical Robots

Spherical or polar robots are similar to a cylindrical robot, but form a spherical range of motion using a polar coordinate system.



SCARA Robots

SCARA robots, or Selective Compliance Assembly Robot Arm, are quite popular. It is a combination of the articulated arm and the cylindrical robot.

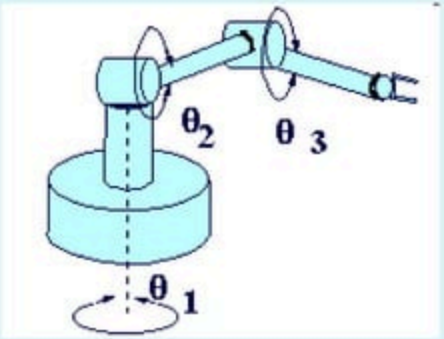


SCARA Robot Arm

Adept's SCARA robots

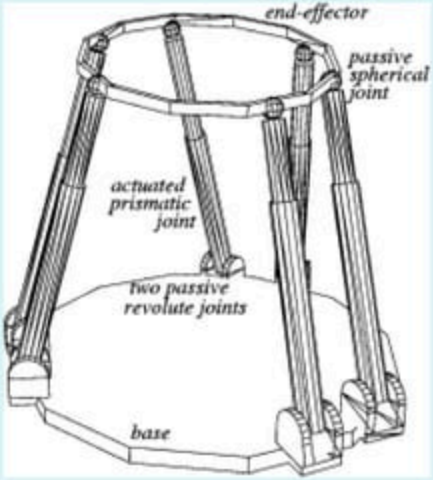
Articulated Arm Robot

Articulated arm robots have at least three rotary joints. They are frequently called an anthropomorphic arm because they closely resemble a human arm.



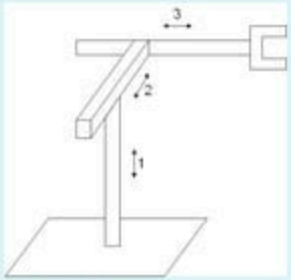
Parallel Robots

Parallel Robots consist of a fixed base to a platform by means of a number of legs. This type of robot is used to create realistic flight simulators or rides in amusement parks.

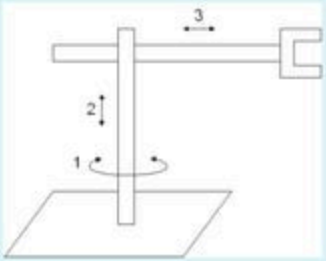


Manipulators

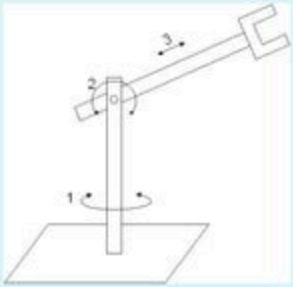
- Robot Configuration:



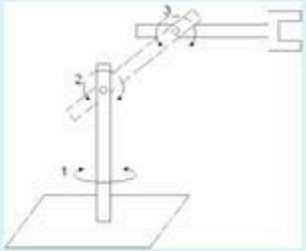
Cartesian: PPP



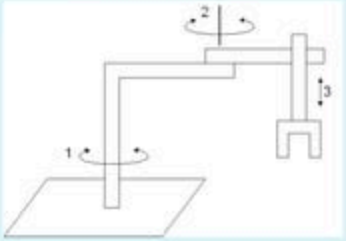
Cylindrical: RPP



Spherical: RRP

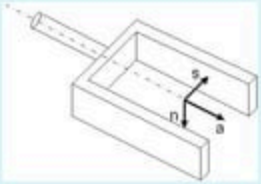


Articulated: RRR



SCARA: RRP

(Selective Compliance Assembly



Hand coordinate:

n: normal vector; **s**: sliding vector;

a: approach vector, normal to the tool mounting plate

Classification based on motion control methods:

It is based on method used to control the movement of end effecto

There are two types of motions:

1.Point to point motion:

- **Tool moves to sequence of discrete points in a workspace.**
- The path between points is **not explicitly controlled by user.**
- It is useful **for operation** which is **discrete in nature.**

e.g. Spot welding , pick and place , loading and unloading

Continuous motion:

- End effector **follows a prescribed path in three dimensional space.**
- The speed of motion may vary along the path.

e.g. arc welding , spray painting

Grippers
(End-of-Arm Tooling)

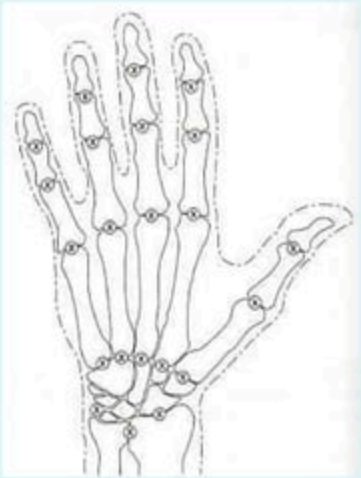
Can make or break the robotic project

End-of-Arm-Tooling

- This general class of devices is also called end-of-arm tooling (EOAT).
- Robot end-of-arm tooling is not limited to various kinds of gripping devices.
- Grippers not available by default in general-purpose robots
- In some situations, a robot must change its gripper during its task. If so, the robot's wrist must be fitted with a quick-disconnect device.

The First Gripper Designed

- The first gripper which was designed resembles more to the human hand.
- Later it was realized to design grippers along to the requirement.



Robotic Hands versus Human Hands

- Robot end effectors
  - heavy objects, corrosive substances, hot objects, or sharp and dangerous objects.
  - not good at handling complex shapes and fragile items.
  - do not have good tactile sensing capability,

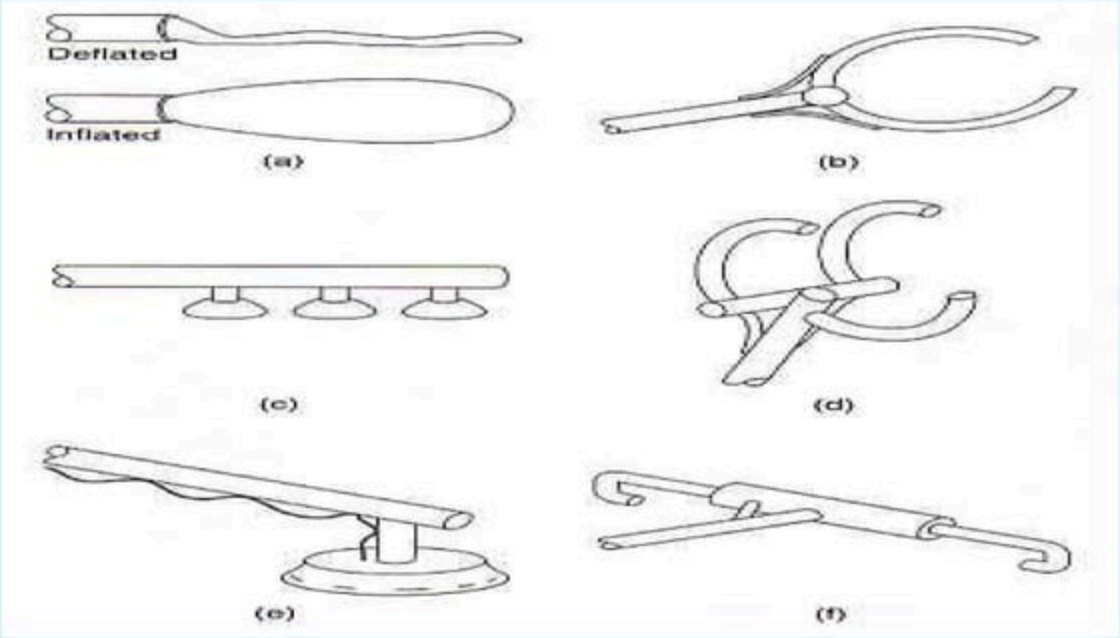
How Grippers work?

- Seven different methods to grip a part:
  - grasp it
  - hook it
  - scoop it
  - inflate around it
  - attract it magnetically
  - attract it by a vacuum
  - stick to it

Types of Robotic Grippers

- Vacuum cups
- Electromagnets
- Clamps or mechanical grippers
- Scoops, ladles, or cups
- Hooks
- Hands with three or more fingers
- Adhesives or strips of sticky tape

Types of Robotic Grippers



Types of Robotic Grippers

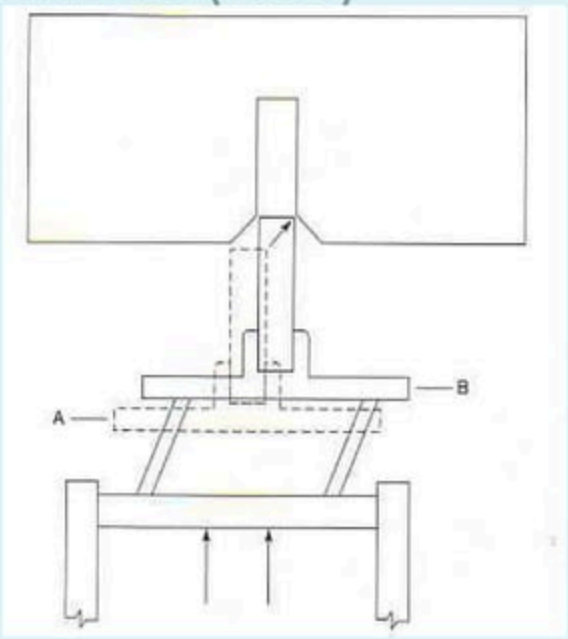
a. Inflatable bladder
b. Two-finger clamp
c. Vaccum cups
d. Three-fingers clamp
e. Magnet head
f. Tubing pickup device

REQUIREMENTS FOR AN EFFECTIVE GRIPPER

1. Parts or items must be grasped and held without damage
2. Parts must be positioned firmly or rigidly while being operated on.
3. Hands or grippers must accommodate parts of differing sizes or even of varying sizes
4. Self-aligning jaws are required to ensure that the load stays centered in the jaws
5. Grippers or end effectors must not damage the part being handled.
6. Jaws or grippers must make contact at a minimum of two points to ensure that the part doesn't rotate while being positioned.

Remote Center Compliance (RCC)

- Useful for accurate positioning of objects.
- Robots contains a built-in multiaxis floating joint to adjust for the misalignments.



Power for Grippers

- Independent power supply required
- Four types of power are used for grippers:
  - pneumatic
  - electrical
  - hydraulic
  - springs

Control Unit

Control Units

- The brain of a robot
- Servo Systems
  - Open Loop
  - Closed Loop

OPERATING METHODS OF ROBOT CONTROL UNIT

- Pick-and-Place Control units
- Point-to-Point Control Units
- Continuous-path Control Units

PICK & PLACE CONTROL UNIT

- Generally small and pneumatic-powered, with no position information feedback.
- Open-loop servo-controlled robots.
- Sometimes referred to as low-technology control units.

PICK & PLACE CONTROL UNIT

- Typical sequence of operations
  - Move robot to starting position.
  - Grasp a part.
  - Remove the part from a machine.
  - Move to second position
  - Deposit part.
  - Prepare to start another cycle.

POINT TO POINT CONTROL UNIT

- Can reach any point within its work envelope
- Can have as many points in its work sequence
- **Medium-technology** control units.
- Can be programmed by a person moving the robot through the sequence of points that the robot will be required to repeat in performing the task.

POINT TO POINT CONTROL UNIT

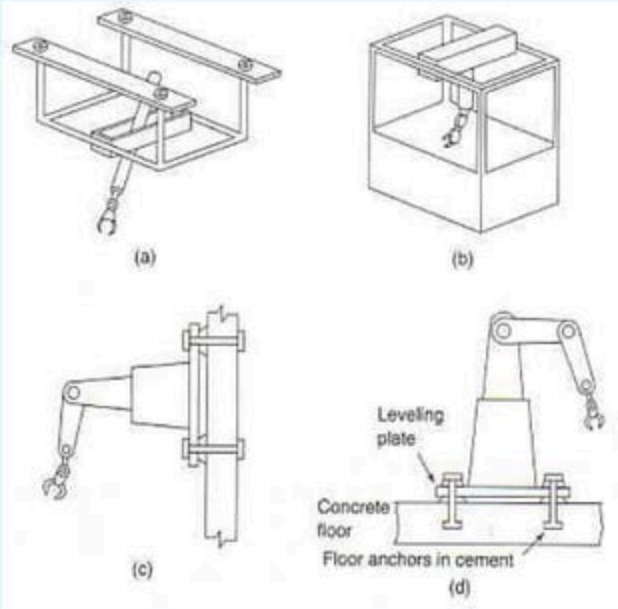
- The path between the points
  - Not predictable
- Uses Stepper Motor

CONTINOUS PATH CONTROL UNIT

- Can reach any point within its work envelope
- Can have as many points in its sequence as a particular task may require
- Most expensive of all control units.
- High-technology control unit
- Large memory capacity required

The Vehicle and the Robot's Base

- Many industrial robots have fixed-position bases and thus do not have a vehicle.
- Even with a fixed-base robot, stable mounting is essential.
- Fixed-base robots could be used: a) overhead mounting, b a gantry mount, c) a wall mount, or d) a floor mount.



Mobile Robots

- Wheel configuration
- Center of Gravity
  - Should be Low

ROBOTIC SENSORS

WHAT IS A SENSOR ?

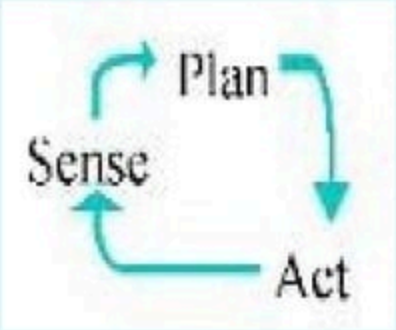
- A sensor is a converter that measures a physical quantity and converts it into a signal that can be read by an observer.

Eg.

NEED OF A SENSOR

- NEED OF SENSORS FOR ROBOTS

1) LOCALIZATION
2) OBSTACLE DETECTION
3) INTERNAL INFORMATION



Sensors

- Sensors changes a robot from dumb to intelligent.
  - The ability to adapt to particular surroundings is one definition of intelligence.

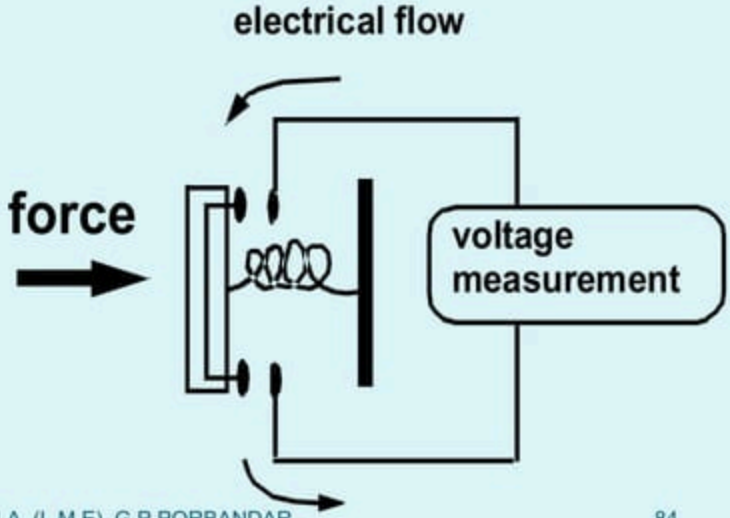
TYPES OF SENSORS

1. EXTEROCEPTORS (EXTERNAL SENSORS)
2. PRORIOCEPTORS(INTERNAL SENSORS)

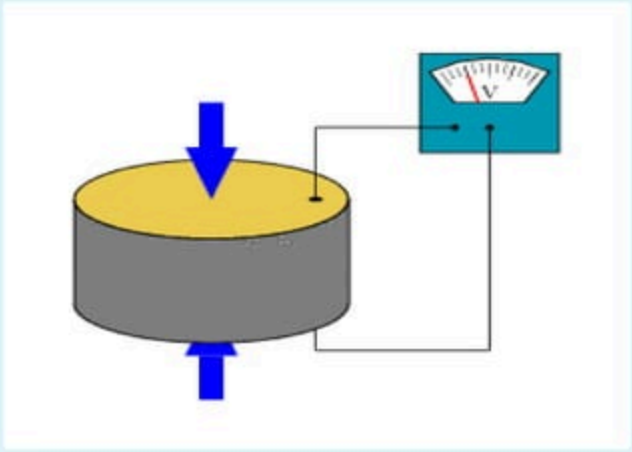
CLASSIFICATION OF EXTERIOCEPTORS

1)CONTACT SENSORS- Sensors that determine shape,size ,weight etc by touching.

a) Touch sensors



b) force/stress sensors-To measure robotic system forces .(PIEZO ELECTRIC SENSOR)



2) NON CONTACT SENSORS

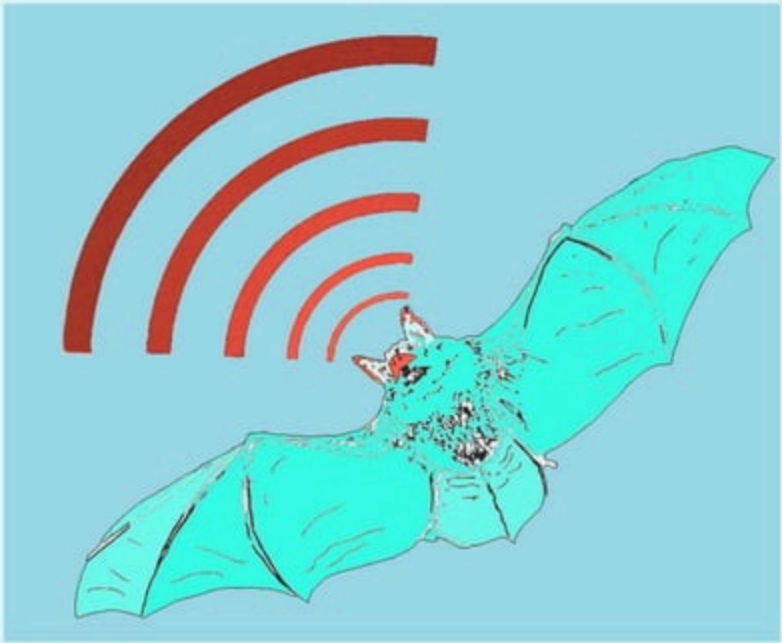
a) proximity sensors- they sense and indicate presence and sometimes position also without physical contact.

Types

1) Optical proximity sensors

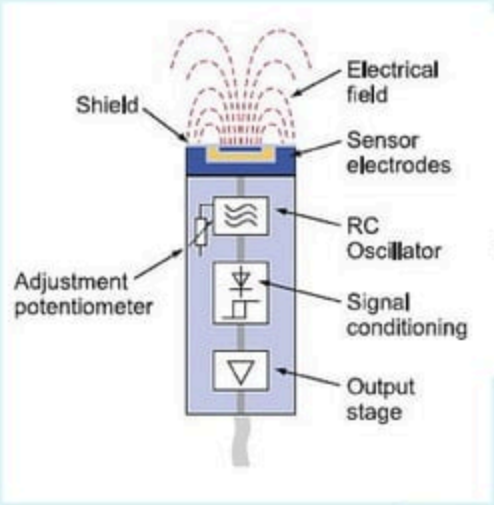
2)Photoelectric proximity sensor

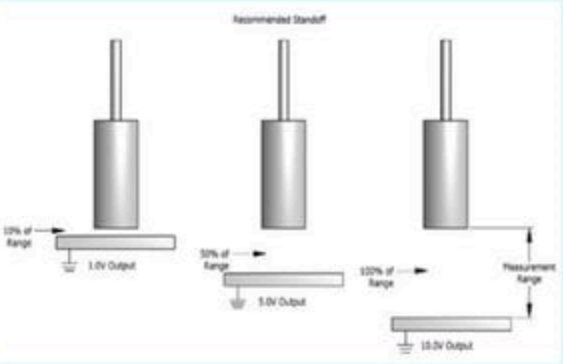
3) Acoutic proximity sensor



4) Capacitive proximity sensors

It works on the principle of change in capacitance with environment.





RANGE SENSORS

- IT PROVIDES PRECISE MEASUREMENT OF THE DISTANCE FROM A SENSOR TO AN OBJECT.

CATEGORIES

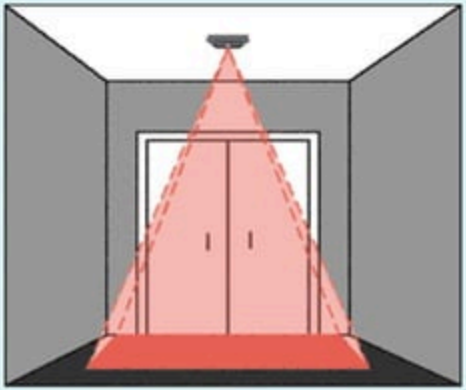
- Active
- send signal into environment and measure interaction of signal with environment

  e.g. radar, sonar

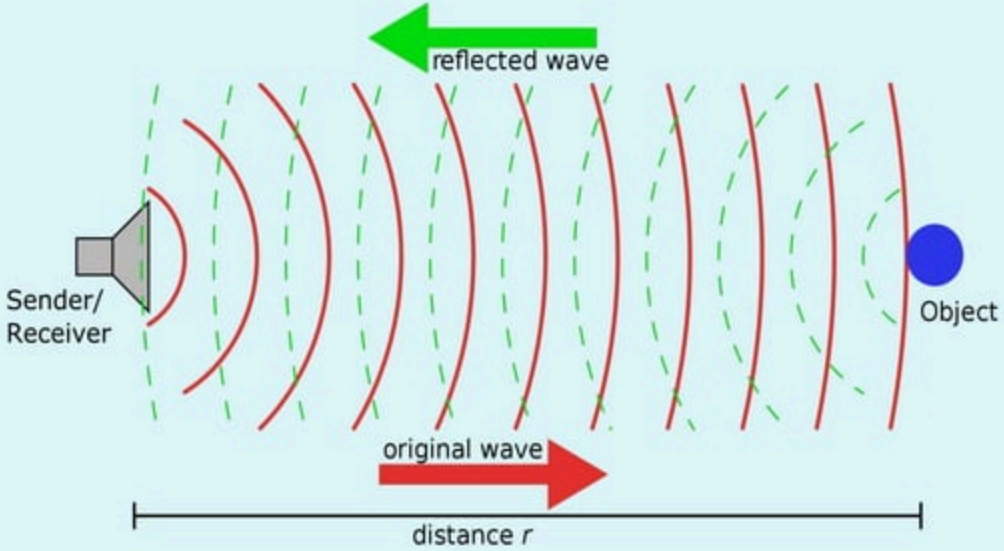
- Passive

  record signals already present in environment

  e.g. video cameras
- Sterioscopic vision system

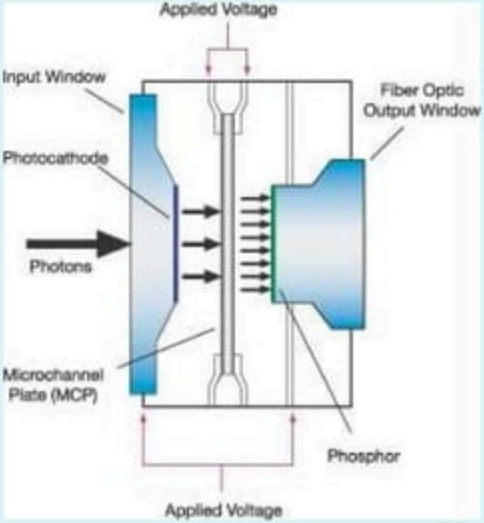


Ultrasonic ranging systems (active)



MACHINE VISION SENSORS

- ICCD



- Intensified CCD's are also cameras which can exploit gain to overcome the read noise limit but also have the added feature of being able to achieve very fast gate times. The gating and amplification occurs in the image intensifier tube. Image intensifiers were initially developed for night vision applications by the Military but increasingly their development is being driven by scientific applications. The Image intensifier tube is an evacuated tube which comprises the Photocathode, Microchannel plate (MCP) and a Phosphor screen, and the properties of these determine the performance of the device. The photocathode is coated on the inside surface of the input window and it captures the incident image: see the diagram on the right. When a photon of the image strikes the photocathode, a photoelectron is emitted, which is then drawn towards the MCP by an electric field. The MCP is a thin disc (about 1mm thick) which is a honeycomb of glass channels typically 6-10 μm, each with a resistive coating. A high potential is applied across the MCP, enabling the photoelectron to accelerate down one of the channels in the disc. When the photoelectron has sufficient energy, it dislodges secondary electrons from the channel walls. These electrons in turn undergo acceleration which results in a cloud of electrons exiting the MCP. Gains in excess of 10,000 can readily be achieved. The degree of electron multiplication depends on the gain voltage applied across the MCP which can be controlled in the camera.

. TUBE TYPE CAMERAS

Velocity sensors

DC TACHOMETER

PROPRIOCEPTORS

Encoder- a device, circuit, software program, algorithm or person that convert information from one format or code to another

What Can Robots Do?

Industrial Robots

- Material handling
- Material transfer
- Machine loading and/or unloading
- Spot welding
- Continuous arc welding
- Spray coating
- Assembly
- Inspection

Material Handling Manipulator

Assembly Manipulator

Spot Welding Manipulator

1.12.1 Loading/unloading parts to/from the machines

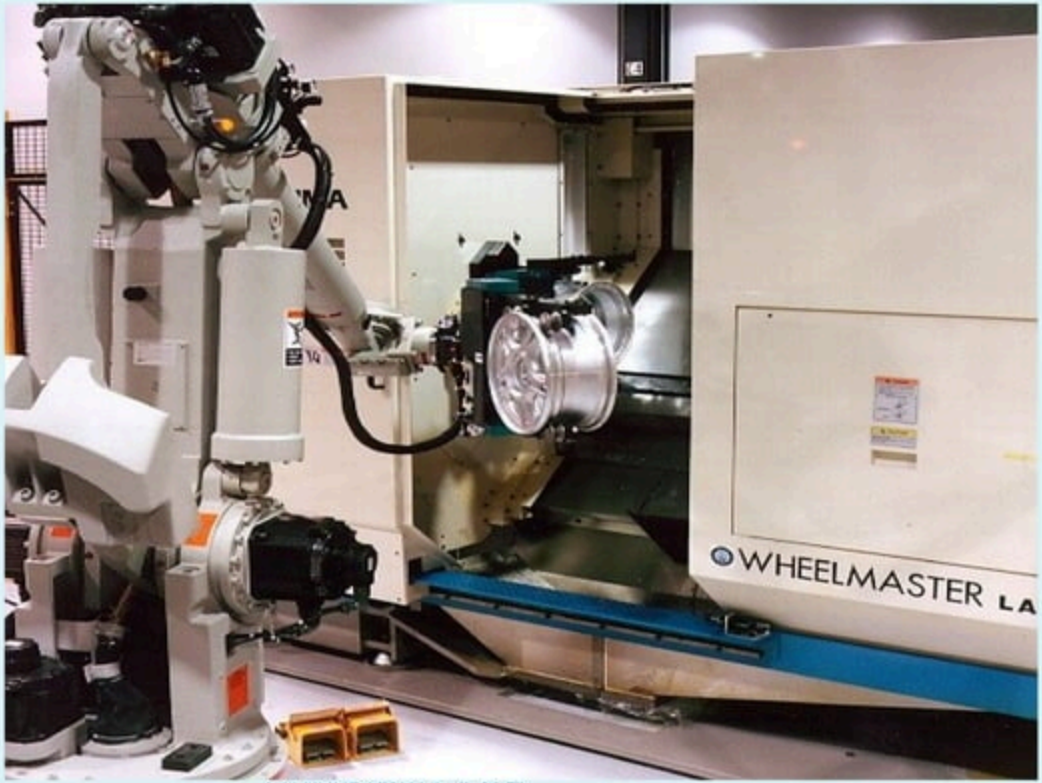
(i)Unloading parts from **die-casting machines**

(ii)Loading a raw hot billet into a die, holding it during forging and unloading it from the forging die

(iii)Loading **sheet blanks into automatic presses**

(iv)Unloading **molded parts formed in injection molding machines**

(v)Loading raw blanks into NC machine tools and unloading the finished parts from the machines


WHEELMASTER

Single machine robotic cell applications include:

(i)The incoming conveyor delivers the parts to the fixed position

(ii)The robot picks up a part from the conveyor and moves to the machine

(iii)The robot loads the part onto the machine

(iv)The part is processed on the machine

(v)The robot unloads the part from the machine

(vi)The robot puts the part on the outgoing conveyor

(vii)The robot moves from the output conveyor to the input conveyor

Multi-machine robotic cell application: Two or three CNC machines are served by a robot. The cell layout is normally circular.

Assembly Operations:

Electronic component assemblies and machine assemblies are two areas of application.

Inspection:

Industrial robots are used for inspection applications, in which the robot **end effector is special inspection probe**.

Palletizing and Depalletizing:

Many products are **packaged in boxes** of regular shape and **stacked on standard pallets for shipping.**

Robots are commonly used to **palletize and depalletize boxes** because they can be programmed to move through the array of box positions layer after layer.

Drilling

Hole drilling is a precision machining process.

Drilling robots **use special drilling end effectors** which locate and dock onto the work piece or a fixture.

FIGURE 14.21 Spot welding automobile bodies with industrial robots. *Source:* Courtesy of Ford Motor Co.

Spot welding is the most common welding application found in the manufacturing field.

Fastening

Robots are commonly used for applying **threaded fasteners** in the automobile industry for fastening wheels,

in the **electronics industry** for **screwing components to circuit boards and circuit boards into chassis**.

Paint and Compound Spraying

Robots provide a **consistency in paint quality** and widely used in **automobile industry** for medium batch production.

Painting booths are **hazardous** because the paint material is often toxic, and flammable.

Arc Welding

Ship building, aerospace, construction industries are among the many areas of application