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POLLACHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by **AICTE** and Affiliated to **Anna University**)

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Department of Mechanical Engineering

Regulation 2021

III Year – VI Semester

CME355 - MATERIAL HANDLING AND SOLID PROCESSING

CME355	MATERIAL HANDLING AND SOLID PROCESSING EQUIPMENT	L	T	P	C
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COURSE OBJECTIVES

1. To provide knowledge on materials handling equipment.
2. To provide knowledge on Industrial Vehicles
3. To provide knowledge on conveyor equipment.
4. To provide knowledge on Auxiliary Equipment and Hoisting Equipment.
5. To provide knowledge on Bulk Handling Equipment and Systems

UNIT – I INTRODUCTION TO MATERIALS HANDLING 9

Basic principles &objectives in material handling and its benefits - Classification of material handling equipment - selection of material handling equipments - guidelines for effective utilisation of material handling equipments -unit load concept

UNIT – II INDUSTRIAL VEHICLES 9

Introduction and types - Hand trucks - Two wheel Hand Trucks - Multiple wheel Hand Trucks - Hand Lift Trucks - Power Trucks - Fixed Platform Truck - Platform Lift Truck - Pallet Lift Truck - Walkie Truck - Straddle Carrier - Fork Lift Trucks - Specifications of FLT - FLT Attachments - Tractors - Industrial Tractor-Trailer-Self-propelled trucks and fork trucks - Automated guided vehicles Theory

UNIT – III CONVEYORS 9

Classification of conveyors- Definition - Description - General Characteristics - types and uses of belt Conveyors - Roller conveyors - Haulage Conveyors - Screw Conveyors - Bucket Conveyors - Chain Conveyors - Cable Conveyors - Pneumatic and Hydraulic conveyors - Computer controlled conveyor system.

UNIT – IV AUXILIARY EQUIPMENTAND HOISTING EQUIPMENT 9

Hoppers - Gates- Feeders- Chutes-positioners- Ball Table- Weighing and Control Equipment- Pallet loaders and unloaders -applications and advancements. - Hoisting Equipment - parts of hoisting equipment - Description and uses of hoists - Description and uses of ropes - description and purpose of crane hooks - Elevators - Cranes - Derricks - and its types

UNIT – V BULK HANDLING EQUIPMENT AND SYSTEMS 9

Storage of bulk solids - bulk handling equipment - Robotic handling - Materials handling at the workplace - Robots and their classification - Major components of a robot - classification of Robotic manipulators - Robotic handling applications

TOTAL:45 PERIODS

OUTCOMES: At the end of the course the students would be able to

1. Discuss the basic concepts of material handling equipment.
2. Explain the basic working principles of various industrial Vehicles.
3. Develop the basic working principles of various conveyors.
4. Elabrate the basic working principles of various Auxiliary Equipment and Hoisting Equipment.
5. Explain the basic working principles of various Bulk Handling Equipment and Systems.

TEXT BOOKS:

1. Allegri (Sr.), T.H., Material Handling – Principles and Practices, CBS Publishers and Distributors,Delhi, 1987.
2. Siddharta Ray, Introduction to Materials Handling, New Age International Publishers

REFERENCES:

1. Bolz, H. A and Hagemann, G. E (ed.), "Materials Handling Handbook", Ronald Press
2. 8005:1976, Classification of Unit Loads, Bureau of Indian Standards.
3. Apple, J.A., "Material Handling System Design", John Wiley & Sons
4. Theodore H., Allegre Sr., Material Handling Principles and Practice, CBS Publishers and Distributors
5. Immer J. R., Material Handling, Tata McGraw Hill Publication.

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UNIT - I

Introduction to material handling:

Material handling is loading, moving and unloading of materials.

To do it safely and economically, different types of tackles, gadgets and equipment are used when the material handling is referred to as mechanical handling of materials.

Basic Principles:

Materials handling is the moving of materials Mechanically.

* Material handling such is not a production process and hence does not add to the value of the product.

* It also cost money; therefore it should be eliminated or at least reduced as much as possible.

* It important point in favour of material handling is that its help production.

Objective of material handling:

* Minimise cost of material handling
* Safety in material handling through improvement in working condition.
* Maximum utilisation of material handling equipment.

- Prevent & damages to material
- Lower investment in Process inventory.

PRINCIPLES OF MATERIALS:

1) Planning
2) System
3) Space utilisation
4) unit load
5) Gravity
6) Material flow
7) Simplification
8) Safety principles
9) Mechanisation principle
10) Standardisation principle.

SELECTION OF MATERIAL HANDLING EQUIPMENTS:

- Properties of material
- Layout and Characteristic of the buildi
- Production flow
- Cost consideration
- Nature of Operation.
- Engineering factor
- Equipment Reliability.

Guidelines for effective utilisation of material handling equipment:

- As material handling adds no value but increases the production cycle time, eliminate handling wherever possible.
- Sequence the operation in logical manner so that handling is unidirectional & smooth.
- Use gravity wherever possible as it result in conservation of power and fuel.
- Install & regular preventive maintenance programme for material handling equipment so that downtime is minimum.
- In selection of handling equipment, criteria of versatility and adaptability must be the governing factor
- Weight - of unit load must be maximum so that each handling trip is productive.
- Work study aspects, such as elimination of unnecessary movement and combination of process should be considered while installing a material handling system.

Material handling equipments:

Material handling equipments can classified in two categories.

a) Fixed path equipments.

b) Variable path equipment.

a) which move in a fixed path. conveyn monorail devices, chutes nd palley drive equipments belong to this catogory.

b) It have no restriction in the direction of movement although their size factor to be given due consideration truck, fort lift, mobil Cranes nd industrial tractor belong to this catogory.

- ✗ Conveyors.
- ✗ Industrial truck
- ✗ Cranes and hoist
- ✗ containers
- ✗ Robots etc.
- ✗ trucks
- ✗ fork lift
- ✗ chutes etc.

Characteristics and classification of material

The different material are used and need to be handled in Industries.

They are classified based on specific characteristic relevants to their handling.

Basic classification of material is made on the basis of forms: which are.

- Gases
- Liquid
- Semi liquid
- Solids.

* Gases it is primarily pressure high or low Chemical properties are also important.

* Liquid the relevant characteristic are density viscosity, freezing and boiling point, temp etc.

* Semi - liquid are slurry, sewage, sludge. mud, pulp, paste etc.

* Gases are generally handled in tight and where required pressure resisting containers

* The method of handling of large volume of gas is through pipes by the help of Compressor, blower etc.

The classification are based on.

a) Shape of unit load.

b) position of C.G

c) mass of unit load in 10 steps from 0-2.5 kg to more than 5000 kg.

d) Volume per unit in 10 steps from 0-10 cm^3 to more than $10 m^3$.

e) Geometrical Shape.

f) Specific physical and chemical properties. unit load like abrasive, corrosive, dust emitting, damp, greasy/oily, hot, acid, toxic radioactive etc.

h) Load sensitive to pressure, shock, vibration, tarning/tilting acceleration/deceleration, cold heat, light, radiation, damp etc.

Major characteristic of bulk material so, that as their handling is concured, are lumpsize bulk weight, specific, moisture content, flowability, angle of repose, abrasiveness temperature, stickness, foaming or density.

etc

- Un safe workplace
- Product damage
- High packaging cost
- Reduced handling efficiency
- Wasted natural resources
- Reduction of environmental quality

System-based design:

It is a proven process of unit load components con optimization based on an understanding of how the pallet, packaging and material handling equipment interact during product distribution and storage & design the unit load components pairs

- Standards - compliant design

Standard permit a unit load to be designed and tested to meet a written specification (or) test method.

It comply with a standard and validated to determined that unit load is indeed effective.

Unit load concepts

The term unit load refers to the size of an assemblage into which a number of individual items are combined for ease of storage and handling.

Function:

Most consumer and industrial product move through the supply chain in unitized or unit load form for at least part of their distribution cycle.

Unit load make handling, storage and distribution more efficient

They help reduce handling cost and damage by reducing individual handling

* Component - based design.
  1) packaging and labeling
  2) pallet
  3) Handling / Storage equipment
  4) The distribution environment.

The consequences of independent components based design in the supply chain can include:

UNIT - II

Industrial vehicles:

Industrial vehicles/trucks is one of the most common group of material handling equipment used in industry.

The entire range of industrial vehicles/trucks are generally sub-classified into two groups.

- Non-powered truck (hand trucks)
- powered trucks

The powered truck can be further classified into three sub group

(a) Power truck
b) fork lift Truck.
c) Tractor

Hand trucks:

It have no source of motive power, these in generally moved manually or are attached to other powered moving equipment/units

(i) 2-wheel hand
(ii) multiple-wheel hand truck
(iii) Hand lift truck.

Hydraulic lifting mechanism:

x This consist of a hydraulic ram an oil storage vessel and a plunger pump.

x The handle of the truck connected to the plunger of the pump through suitable mechanism such as when the handle moved up and down.

x The pump forces a certain quantity of oil in the ram which through suitable linkage mechanism raises the platform with load

Capacity range hand lift truck vary bet 1/2 ton to 10 ton.

Mechanical lifting mechanism.

The mechanism is operated by a system levers. The plat. form is raised by actuating a handle, which in turn, raises a paul that falls into slot or groove.

x Capacity of mechanical hand truck is generally limited to 1 ton.

(a) Pallet

b) Platform

c) Special types.

a) Hand pallet trucks:

It is used for handling pallet.

It consist of two strongly build metallic tines called forks, connected at one end to give a U-fork a wheel is provided. which acts in accordance with the listing system.

(b) Platform lift trucks

∝ It is similar to a pallet truck expecting that instead of two fork it has a platform, which can be raised

∝ the platform may be solid or of open frame structure.

* The capacity of nominal size of Hd trucks of this kind vary within range 1/2 ton to 3tons 450mm to 680mm width, 750 to 1800mm length and lift height from 150 to higher values.

c) lifting feature has been utilized in designing various type of lifting trucks for handling varias specialized load in industries.

Power trucks:

When a vehicle / truck contain its own source of motive power it is called power truck.

The Six groups of BIS specification number.

1) mode of action
2) Power source
3) type of wheel
4) mode of control
5) height of lift
6) mode of travel.

Fixed Platform truck:

x These are powered industrial truck having a fixed level, non-elevating platform for carrying load.

x Material to be moved have to be loaded and unloaded to and from the platform by hand, hoist or crane.

Platform lift truck (Powered)

These equipment are a particular type of powered platform truck, whose platform can be raised or lowered to handle load or grid.

Range — upto 300mm to high-lift over 300mm.

Pallet lift truck (powered)

x These are similar to platform lift truck in which the platform is replaced by fork to work also with load on pallet.

x Low-lift model are used for movement of material only while the high lift model are

are used for stacking or pallet / skids one over another or in storage racks.

(a) Reach truck

(b) Slide loader truck.

Walkie Trucks:

This implies different type of powered truck described above.

x when the operator walks with the truck and operate it by means of control avaiable on the truck handle.

x walkie truck are smaller, lighter and slower than rider-types, generally powered by battery.

Straddle carrier:

x This a self-loading powered truck for movement of lory & heavy load, including shipping containers.

x The truck consist of a inverted 'U' shaped frame having wheels mounted on outside of the frame.

x The move with load nd unload it very quickly at a desired location.

capacity - upto 40 tonnes is common.

Fork lift Trucks:

It is useful and widely used equipment in industrial lift truck called fork lift trucks.

(ii) The Source of Power is Petrol / diesel or LP gas engine or a battery driven.

(iii) The mast may be tilted forward or backward with in range for better stability during movement with load and also to facilitate loading & unloading.

(iii) The operation of the mast and movement of the forks are through a hydraulic power pack.

(iv) The body of the truck is purposely build heavy which act as counter load when lifting load on forks.

(v) Solid rubber tyre are provided for operation in different floor conditions.

FLT Attachments

A pair of fork is used for working with Skids / pallets, containers and box shaped load resting on legs / packers.

- Boom
- Clamp
- Drum grab
- Crane
- Dge handle
- Grip - bottom
- load inverter cum pusher
- Load pusher
- Ram.
- Shovel
- Special fork
- Vaccum
- Side - shifter
- Rotator.

Specification of FLT:

There are different operating parameter or specification based on which suitable FLT is determined.

- Rated capacity (1000kg, 2000kg)
- power source (gas, diesel, battery etc)
- Turning radius
- physical dimension
- Mast height.
- Lift height.
- Mast specification.
- Travel speed
- Floor clearance.
- Free lift.
- Retractable fork
- Fork size
- Attachment provided.

other important specification

- motive power (ii) Power transmission (disc clutch, fluid coupling etc) (iii) tyre specification (iv) battery and charger specification etc.

Tractor:

Tractor is a vehicle having its own source of motive power, used to provide power to haulier, to give motion to another or a group of other vehicle which do not have their own motive power, such as trailers, semi trailer, transfer car etc.

Industrial tractor:

(i) Wheel type which are primarily used for movement of one to more trailer for inter plant or intra plant transportation.

(ii) Crawler type which are mostly used in out door and storage yard service at slow speed and for short hauls.

They are classified as small (100 kg normal to 500 kg)

Medium (250 kg normal to 750 kg)

Large (1.0 ton to 5 ton max)

Other specification are physical dimension, weight horse power, number of wheel drive, front or rear wheel steer, walkie or rider type etc.

- An electronically guided type require no operator which follow a white line painted or a wire embedded in the floor.
- These may be programmed for automatic decoupling of trailer and give signal of arrival at two ends.
- A two wheel tractor depend coming on conjuction with the attachment or load carrier for a balance steering of the tractor is done by pivoting about one of the two wheel, thereby resulting in very small turning radius i high maneuverability of the tractor.

Trailers.

Trailer all load bearing wheels vehicle or car without any motive, power, designed to be drawn by a tractor or truck.

* A semi trailer is a truck - trailer having one or more axles and constructed that a part of its weight is carried by the truck / tractor.
* A full trailer constructed to carry almost all its weight on its own wheels.
* more than one trailer may be pulled at time by a tractor is called a tractor trailer train.
* Trailer can be different shape & sizes.

UNIT-3

Conveyors:

Belt Conveyors:

A belt conveyor consist of an endless flat and flexible belt of sufficient strength, made of fabric, rubber, plastic or metal.

Characteristics:

1. Belt conveyor operate in one vertical plane horizontally or with an inclination (up or down) depending on the frictional property of the load conveyed.
2. Conveying capacity of a conveyor can be controlled by changing a belt speed.
3. Belt conveyor are generally employed for continuous flow of material.
4. metal/ special belts can carry hot, abrasive or reactive materials.

Conveyor.

a) Belt Conveyer
   1) flat
   2) trough
   3) closed
   4) metallic
   5) portable

b) Chain Conveyor
   1) apron
   2) Slat
   3) Cross-bars.
   4) Car type
   5) Power and free

c) Haulage conveyor

1) drag chain

2) flight

3) tow — over head, flush, under

d) Cable Conveyor.

e) Bucket Conveyor.

1) gravity discharge

2) pivoted bucket

3) bucket elevator.

f) Roller Convey

a) gravity

Types of belt Conveyor:

Flat belt Conveyor:

x The active side of belt remain flat supported by cylindrical rollers or flat slider bed.

The conveyor is generally short in length and suitable for conveying unit load like crates, boxes packages, bundles length and suitable for Conveying unit load like crates, boxes, packages, bundles etc.

Throughed belt Conveyor:

In this conveyor, comparatively wide flat belt is supported on throughed carrying roller or shaped supporting surface.

x The conveyor are used in handling bulk materials of different classes.

x The return side of the belt is generally kept flat supported on cylindrical rolles.

x The troughed conveyor are used within a plant for moving bulk material from one point to another.

x These are comparatively of shorter length and path of movement in straight line in a horizontal or an inclined plane.

x The stresses in the belt within limit of cotton fabric belts.

x Throughed belt conveyor are used for transportation of bulk material over long distance, by means of a series of conveyor, ~~her~~ path that are combination of inclines, declines and horizontal sections.

x They are generally termed as long centre conveyor.

Long - centre:

(i) transportation of the output of mine to the processing plants

(ii) material from shipping port to the storage / transport loading slots

(iii) movement of material between planes etc.

Closed belt conveyor:

(i) It can can fragile material safely. And without breaking by reducing into particle collision.

(ii) Ability to handle corrosive and reactive material without contamination.

x Metallic belt conveyor
x portable conveyor
x Chain or rope driven belt conveyor.
x Submerged belt conveyor

Parts of belt Conveyor.

a) conveyor belt
x belt construction
x Belt cover
x Belt width
x belt splicing

b) Idler

Chain conveyors:

Chain conveyor means a group of different type of conveyor used in diverse application, Characterized by one or multiple Strand of endless chain to travel entire conveyor path, driven by one or a set of sprocket at one end and supported by one or a set of sprocket at another end.

Haulage conveyors:

It is a special group of chain conveyor. It implies the material is dragged, pushed or towed by means of a chain (or) chain making use of flight or surface which are part to the chain themselves.

conveyor run at low speed (15 to 60 rpm)

Type of haulage conveyors:

a) Drag chain conveyor.

It is a conveyor having one or more endless chain which slide in a track or trough resting at the bottom of a through and material resting directly on the chain are carried by the chain links

(i) Multiple Strand drag
(ii) Pusher - bar
(iii) Wide - chain drag

b) flight conveyor.

c) Tow conveyor.

(a) overhead
b) flush - floor.
c) under floor tow Conveyor.

These are widely used in applicating moving automobile / work racks, in manufacturing assembly line ware houses, freight handling terminals etc.

Types of Chain conveyor:

a) Apron or pan conveyor
b) Apron / pan design
   1) Flat, Spaced apron
   2) Corrugated apron
   3) Special types.
c) Cross-Bar (or) Arm conveyor
d) Car-type conveyor.
e) Carrier chain & flat top chain conveyor.

Flat-Top chain conveyor.

It is provide of carrier chain conveyors may be rolling or sliding type, which specially designed chain link or with flat plate attached to the chain link to provide a continous, smooth like bottle, cans etc.

Trolley conveyor:

(i) Load-carrying trolley.
(ii) Load-propelling trolley
(iii) Load towing trolley conveyor.
(iv) Suspended tray conveyor.

Components of Chain conveyors:

a) Pulling chain
b) Sprocket to drive and support the chain
c) Take up arrangement
d) Drive arrangement.
e) Various other components specific to various chain conveyor

(i) Compression type which operate on toggle principle
(ii) Screw type
(iii) Weight operated type.
(iv) End dump bucket for discharging load from one to other end.

Roller conveyors:

A roller convey supports unit type of load on a series of roller mounted on bearing resting at fixed spacing on two side frames which are fixed to stand or trestle placed on floor at certain interval.

1) unpowered
2) powered.

unpowered are not driven or powered from an external source.

The load rolls over the series of roller either by manual push or push from endless moving chain or rope fitted with pusher dogs, rod or clamps.

Types of roller of Conveyor:

a) unpowered roller

parts of unpowered roller

* Rollers.

Cable conveyors:

These conveyr form a distinct group of material handling equipment to transport people and bulk material for load carrying bucket, using overhead moving cable or wire ropes and are composed of one or more span from the loading point to the discharge point covering long distance is known as rope ways.

(i) As load are moved at a substantial height from the ground, shortest route between the terminals can be followed.

(ii) Cost of operation is comparatively less than other transporatim.

(iii) material are moved bet distantly located points without the need of re-handling.

classification:

- bicable
- monocable.

Component of Cable Conveyr:

- one or more cable one of which is driven which pull the load
- A number of load carrying bucket or carriers which are hung through hanger from wheeled
- Loading & discharge
- drive arrangement.

The rigid hanger are connected with traction rope through grips.

a) Cylindrical
b) double tapered
c) coneel.

Roller parameter	Type of roller		
	Medium heavy	heavy	Extra heavy
Roller dia (mm	73	105	155
Max load per roller kg	200	600	1200
Axle dia at the journal mm	20	30	45

Frame is that part of the conveyor on which the roller axes at rest and fixed to.

x The axles are flat machined at the ends so that the axles do not rotate in slots.

x for heavy rollers, the axles may be fixed on the frame by clamps.

Pneumatic Conveyor:

It is process of conveying granular/powdered material floating the material in a gas, primarily air and then allowing it to flow to designed through a closed pipe.

- α pipe line conveyor.
- α Air activated gravity
- α Tube conveyor.

Advantage :-

1) High capacity of material can be conveyed over a considerable length
2) Comparatively simple.
3) Flexibility in selection.
4) The Conveying process is generally in nature its easily.

UNIT - IV

Auxillary Equipment and hoisting equipment

Gates:

Gates are used in conjuction with various bulk material storage hoppers to close or open the outlet and adjust discharge of material in batches from the hoppers.

1) Slide gates
2) Trough gates
3) Pivoted gates

Feeders.

* Powered feeder are used for continous and controlled flow of bulk material from a storage to a MH equipment

* Bulk material feeder are generally installed near the outlet of a material hopper and serve to unload the hopper a controlled rate.

* Desired flow is achieved by varying in finiety the rate of operation of the loading elements.

(i) Belt feeders
2) Apron feeders
3) Screw feeder
4) Oscillating feeder.
5) vibrating feeder.

x rotary disk feeders.

Chutes:

Chutes are inclined connection bet two system of MH equipment or production equipment in the form of through of definite geometrical cross section pipes, which convey unit or bulk load by gravity.

Throughs:

For bulk material, rectangular. or round Shaped troughs are used

x These may be lined by cast iron or hard plat or glass tiles for abrasive material.

pipes are used for dusty or liquidous material

x Ladder and spiral chutes

x Transfer Slides.

positioners:

x It is defined to be task of orienting material into the workplace.

x It is a component of MH at the workplace

x It conventionally a manual operation performed by the operator by processing equipment

x The purpose of positioner is to perform the positioning OPN. independent of the operator as well as better.

x If Increase production, higher safety less fatigue of the operator.

Hoisting equipments:

It is usually powered equipment is used for lifting and lowering unit and varying load intermittently.

A variety of equipment fall under the heading of hoisting equipment starting from hoist different type of elevator and cranes

Expecting for elevator, these equipment generally utilize a drum, wire rope, pulley and load lifting attachment for performing the lifting and lowering.

parts of hoisting equipment.

(i) Welded load chain

2) roller chain

Welded chain are manufactured by joining one or of individual chain links by hammer hot forging or by resistance welding of two butt links.

- heavy weight
- Susceptibility of jerks
- heavy wear
- Low safe speed of movement
- Sudden failure.

Manipulator and Charges.

Forging manipulator furnace charge, Cake pusher in coke oven, roller table deflector and manipulators.

Tables, lift, bridge and ramps.

(i) positioning table are essentially table whose height can be adjusted to job at the level at which it can be manipulated easily.

(ii) Hydraulic lift are common positioning for lifting and lowering a heavy object. The operator can easily control this.

(iii) Bridge are erpically designed platform to bridge gap or height difference bet the dock edge or surface to the carrier floor. and allow use of hand trolley or powered truck to load and unload material bet dock and carriers.

* Ramp is a portable for placing at the door g a carrier or building to bridge the vertical distance to the ground by a sloping runway.

* Elevating platform can also act as a positioner for a fall job like welding, Gilling fitting etc.

Pulley system:

Combination of movable and fixed pulley or sheaves intended to achieve a gain in force or gain in speed called pulley system.

* Multiple pulley system.

Arresting gear and brakes:

In hoisting equipment use of arresting gear or brake is of paramount importance to prevent the raised load from getting lowered of its own weight, when the raising effort is withdrawn.

(a) Pawl and ratchet.

Brakes:

It is used for dual purpose of holding the suspended load at rest and for controlling the speed of lowering of load

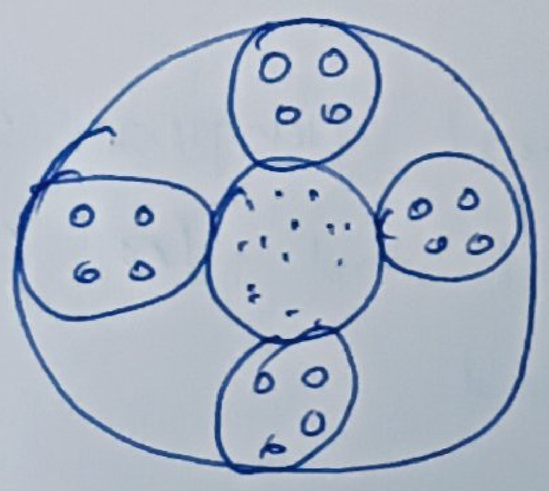
Some of this brakes are to be operated while some are automatic.

* Operated brake include
  * Shoe
  * band
  * Cone.
  * disk brake etc.

Roller Chain

It superior to welded chain in many ways.

- The friction in the joints are also hence more efficient
- Roller chain have high flexibility in the plane of rotation and hence sprocket of smaller diameter may be used.
- It is used for both hand operated and electrically driven equipment like hoist or winches for lifting heavy load at slow speed. and in guideways.
- Sprocket for welded chain
- Sprocket for roller chain
- Steel wire rope and drums.



Regular lay

$$D > e_1 e_2 d$$

D - drum / pulley

d - rope diameter

e_1 = factor depending on the type of hoisting

e_2 = factor depending on rope construction.

Grabs: For quick suspension and release of typical types of loads.

- Conformation to the shape and properties of the load.
- quick grabbing
- Adequate strength & reliability
- Safety to men
- Convenience of use
- loco weight.

Grabbing attachments

a) Tubs
b) Grab bucket
c) Ladles
d) Electro magnet.

Hoists

Hoist is an apparatus for raising or lowering a load suspended from a hook on the end of a chain

A hoist be fixed based mounted or supported from overhead by clevis or hooks.

It may be travelling type mounted on a track.

They are used for relatively lighter load (2 to 3 tonnes)

They are relatively slow speed limited travel distance and fixed direction.

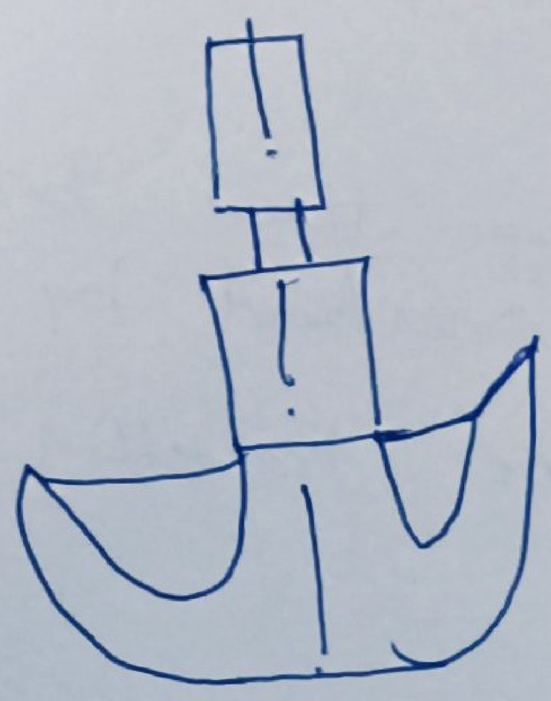
The common attachment used with various hoisting equipment.

a) hooks
b) grabs
c) grab bucket
d) Ladles
e) Electro magnets etc.

Hooks:

The method of lifting unit load by hoisting equipment is to sling the load by chain or rope and suspended it from the hook of the hoisting.

- Standard hooks
- Ram shorn hooks
- Solid triangle eye hook
- Hinged triangle hooks.
- Suspension of hooks



The cylindrical shank portion is generally fitted to a crosspiece provided with machined fastened at the ends.

Constructional features:

a) Hand operated hoist
b) Electric hoist.

Freight Elevator / Lifts:

It consist of a box type cage or car which moves vertically up and down through the designed opening kept in the floor called shaft of the elevator.

∝ The car is suspended from and moved up and down by a hoisting mechanism located at the top of the shaft

(i) drum winch type.
(ii) traction type.

Cars of a freight elevator may be designed to suit type of material.

1) fork lift truck
2) tow truck
3) trolley
4) overhead monorail conveyor

Robot :

Defined by robotics Industry Association (RIA) as

- A re-programmable, multifunctimal manipulter designed to move materials, parts, tools or specialized devices through variable programmed motion for a variety of tasks

- Robot is a reprogrammable, multi functional, electro-mechanical device designed to do desired task through programming.

- Possess certain anthropomorphic characteristics
  - Mechanical arm
  - Sensors to respond to input
  - Intelligence to make decisions
  - Actuators to do task

- The branch of technology and art and Science that deals with the design, Construction, operation, and application of robots.

— Robotics is an interdisciplinary research area at the interface of Computer science and Engineering.

— Robotics involves design, Construction, operation, and use of robots.

The goal of robotics is to design intelligent machines that can help and assist human in their day-to-day lives and keep everyone safe.

Brief history :

- In 700s human sized Mechanical clocks that played music.

— 1800 - A programmable machine for weaving threads.

- 1830 - christoper Spencher design a cam operated lathe
- Designed a motorized crane with gripper to remove ingots from a furnace.
- Robot derived from the word robota from Czech language by karel capek in 1921.
- The czech coriters karel capek and josep capek introduces the robot through a drama.
- In 400 BC itself the robot were in discussion by Arkitics.
  - 1921 - word robot derived from a czech play-
  - 1940s - TeleOperator developed at Oak ridge national labs.
  - 1954 - George Devol, programmed articulor transfer device.
  - 1956 - Joe Engelberg, Unimation (first robotics company)
  - 1961 - First robot installed on assembly line in Gm.
  - 1968 - Japan, Kawasaki makes robots.
  - 1969 - GE makes first walking robots.
  - 1974 - First hydraulic drive robot, cincinati milacron.
  - 1978 - First puma robot (Programmable univers-l sel machine for assembly.

Main Components of industrial robot:

* Arm or manipulter
* End Effectors
* Drive Mechanism
* Controller
* Custom features : eg Sensor and transducers.

Arm or manipulator:

- Robots arm can vary in size and Shape.
- The robot arm is the part that permits that the robot can be freely.

→ It consist of robot arm, the shoulder, elbow and wrist move and twist to the exact position.

→ A simple robot with three degree of freedom can move in three ways

* up & down
* Left & right
* forward & backward.

End Effector:

- The End part connects to the robot's arm and function as a fingers of a hand.
- This parts comes indirect contact with the material the robot is manipulating.
- Some variations of an effector are a gripper a vacuum pump, magnets, and welding torches.

* Spary paint attachment
* welding attachment
* vacuum heads
* hands
* Grippers.

Drive Mechanism:

- The drive is the engine that moves the articulations into their designed positions.
- The joints are the sections between the parts of the robot.
- The following types of units are.

hydraulic, electric or Pneumatics.

* Hydraulic drive system give a robot great speed and strength
* Electric system provide a robot with less speed & strength.

* Pneumatic drive system are used for smaller robots that have fewer axes of movement.

Controller: (The brain)

The controller is the "brain" of the robot and allows the part of the robot to operate together.

The Controller gives instructions written in code called a program.

* Issue instruction to the robot
* Controls Pharipheral devices.
* Interfaces with robot
* Interfaces with human.

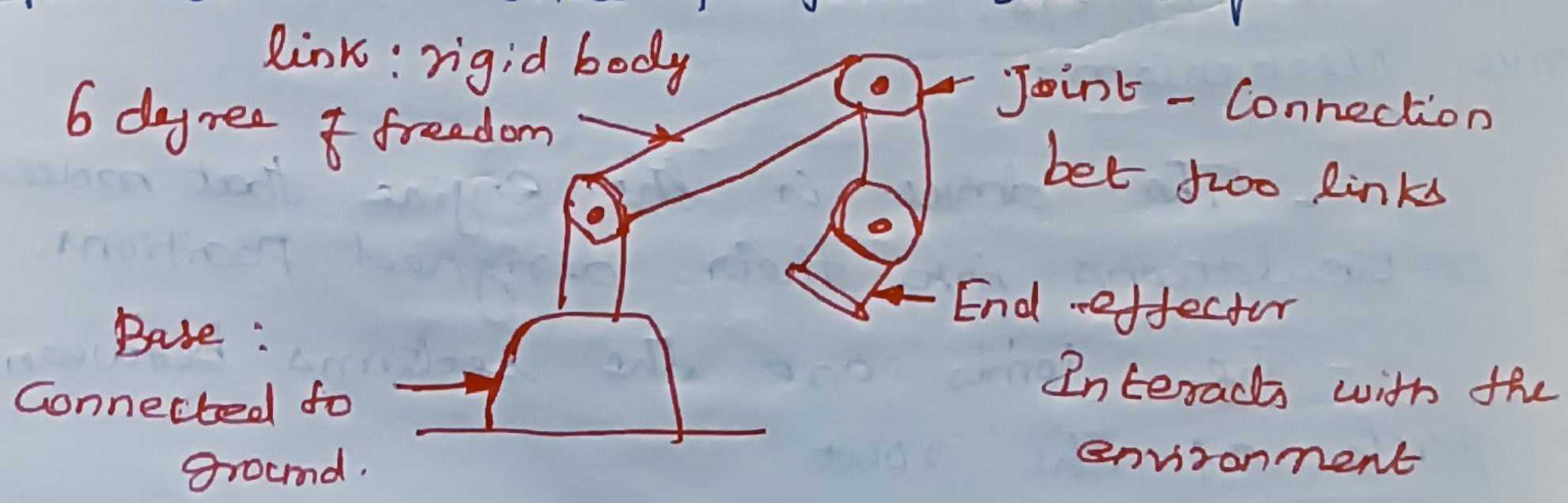
Pedestal:

Robot risers also known as robot pedestals, are heightened platforms that can be attached to the base of an industrial robot in order to elevate it.

Robot - Mechanical Structure:

The mechanical structure of manipulator that consist of rigid body connected by means of joints is segmented into arm that ensure mobility and reachability.

- A wrist that confers orientation and an end effectors that perform the required task.



Asimov's three laws of robots:

The three laws of robotics Asimov also proposed his three "claw of robotics", and he later added a "Zeroth law"

"Zeroth law": A robot may not injury humanity or through inaction, allow humanity to come to harm.

`First law': A robot may not injury a human being or through inaction, allow a human being to come to harm, unless this would violate a higher order law.

Second law: A robot must obey orders given it by human beings, except where such orders would conflict with a higher order law.

Third law: A robot must protect its own existence as long as such protection does not conflict with a higher order law.

Robot classification:

* Robot on Configuration — Cartesian, Cylindrical polar, articulated

* Based on degree of freedom - 3, 4, 5, 6, 7

* Based on work volume - Rectangle, Cube Cylinder and Semi-sphere, Sphere.

* Based on applications - Industry, personal assistance, entertainment, assembly, space, mobile, Soft robots.

* Based on drive system: Electric, hydraulic Pneumatics, harmonic

* Based on Payload: Based on kilogram (5kg, 10kg

* Based on End effector: Gripper, Vacuum cup Magnetic etc.

Robot classification:

The following is the classification of robot according to the robotics Institute of america (RIA)

- Variable-Sequence robot : A device that performs the successive steps of a task according to a predetermined method easy to modify

- Play back robot : A human operator perform the tasks manually by leading the robot.

- Numerical Control robot : The operator supplies the movement program rather than teaching it the task manually

- Intelligent robot : A robot with the means to understand its environment and the ability to successfully complete a task despite changes to the environment

Robot types — Stationary :

* Puma 560 × ABB arm × Msu microbot.

Mobile robots : Sony's QRIO × MSU Micro crawler × MSU mobile manipulter research Platform (R2-D2) × Stanford's Stanley (first winner of DARPA Grand Challenge)

Space robot : × Canada Arm on International Space Station × JPL's pioneer Space probe × ISRO's Chandray

Robot Accessories:

A robot is a system, consist of the following elements, which are integrated to form a whole.

→ Manipulator / Rover : This is the main body of the robot and consist of link, joint and structural elements of the robot.

→ End Effector : This is the main part that generally handles object, make connection to other machines, or perform the required task.

It can vary in size and Complexity from a end effector on the Space Shuttle to a small gripper.

Accessories:

Actuator: Converting hydraulic energy (or) electrical energy on to mechanical energy.

Actuator are the muscles of the manipulators. Common types of actuator are servomotors, stepper motor, Pneumatic cylinder etc.

Sensor: Sensor are used to collect information about the internal state of the robot or to communicate with the outside environment.

Robots are often equipped with external sensory devices such as vision system, touch and tactile sensor etc with help to communicate with the environment.

Controller: The Controller recieve data from the computer control the motion of actuator and coordinates those motion with the sensory feedback information.

Robot Specification:

* Joint variable (Joint):
  → Relative displacement between adjacent links.
Can be revolute or prismatic.
* End effector: Gripper or tool used to perform the robot task.
* Degree of freedom:
  Number of joint (DOF > 6 implies redundant robot)
* Configuration:
  Determined the location of every point on the manipulator (not just the end effector)
* workspace (work envelop)
  Total volume spread out by the endeffector as manipulator executes all possible motions.
* Accuracy, Repeatability and resolution: Repeatability is how accurately the same position can be reached if the motion is repeated many times.

* Speed and accaleration (min and max)
* Payload capacity - payload is the weight of robot Can Carry.

Robot specifcatim:

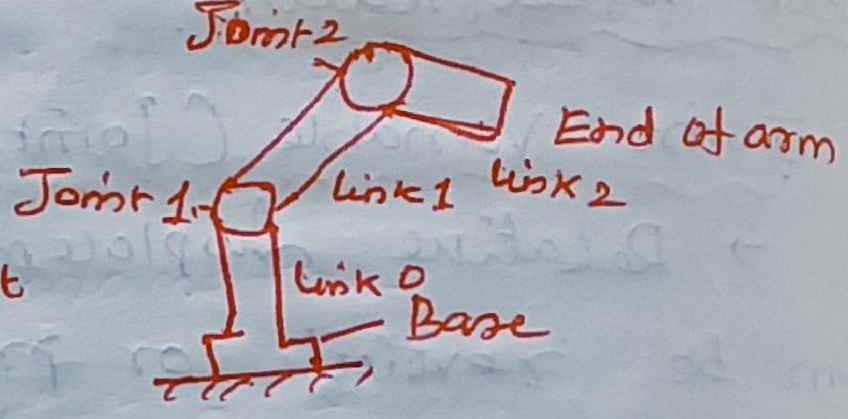
- link • Joint • No of axis • payload - Accuramy
- Precision • Repeadability • Resolutim • Speed • Robot size
- vertical reach • Horizonital reach.

Link and joint variable:

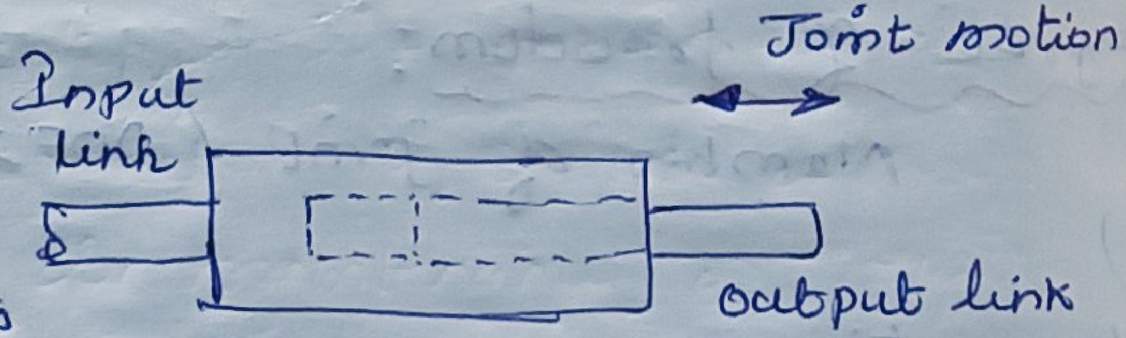
x Link are rigid Components of the robot manipulator
x Relatice displacement between adjecant links
x It can be revolute or prismatic
x Joint provide the robot of degree of freedom of motim
x In most cases, 1 DOF is associated with a joint
x Robot are often classified according to total number of DOF they posses.

Robot Specification:

* Linear joint / Prismatic joint
* Orthogonal joint
x Rotational / Rotary joint
x Twisting joint
x Revolving joint

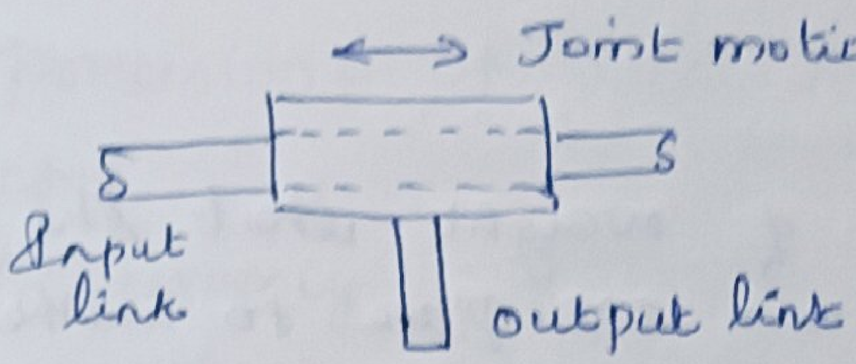


* Linear joint (L)



→ Prismatic joints are also known as linear joints. They are called as prismatic, because the cross section of the joint is considered as a generalized prism.
→ They permit link to move in a linear relationship
→ Adjoining link are perpendicular, but one link slide at the end of other link
→ The joint motion is defined by sliding or translation movement of the link.

* orthogonal joint (O Joint)



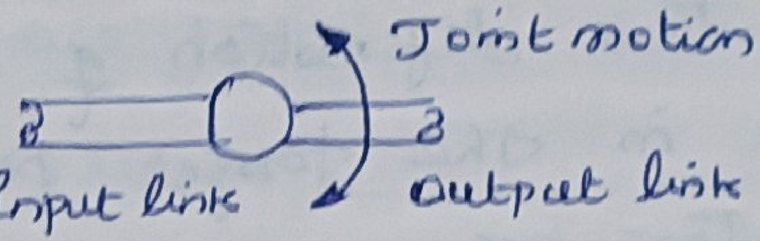
orthogonal cross joint extend across intervals bet by sternatic joints.

→ They feature a relative movement taken by the input link and output link.

→ This kind of motion involved in the orthogonal joints is a translational sliding motion.

→ The output link is perpendicular to the input lin

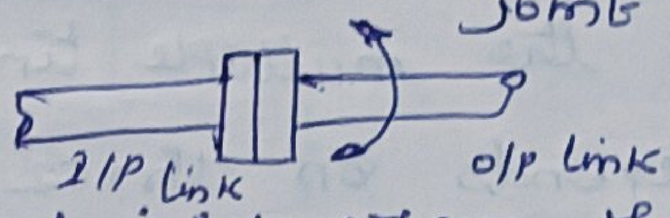
* Rotational / Rotary joint: (R)



→ It is defined by its motion rotation about an axis perperdicular to the adjoining links

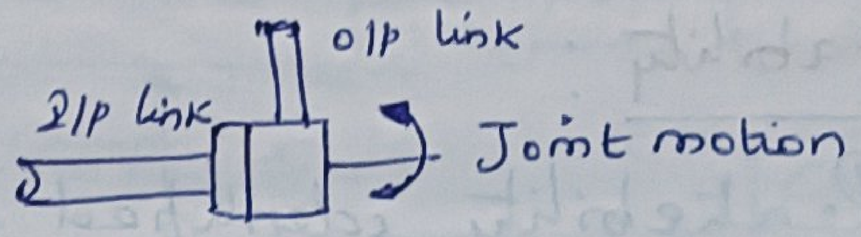
→ Here the length of adjoining link do no, but the relative portion of the link with respect to another as the rotation takeplace.

* Twisting joint (T)



It is also a rotational joint, where the rotation take place about an axis that is Parallel to both adjoining links

* Revolving joint (R)



→ It is another rotational joint, where the rotation take place about an axis that is parallel to one of the adjoining links

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

Robot specification:

Number of axis

- minimum 3 required for industrial robot

→ No of axis 1 to 3 – Major axis
→ No of axis 4 to 6 – minor axis
→ No of axis 7 to n – to reach obstacles.

Robot Specification

Pay load :

→ maximum amount of weight that the robot can be able to move from one place to another

→ Pay load is mentioned in kilogram (kg)

Accuracy :

→ The ability of the robot to position its wrist end at desired target point within its reach.

→ How closely the robot arm is able to move to a specific coordinate in the workcell

→ This definition of accuracy applies in the worst case in the target point is between two control points

→ For example when the arm is fully stretched, the mechanical inaccuracies tend to larger.

Precision

— It is ability of the robot to attain its target position at the multiple time.

→ Its depends on three parameters.

* Accuracy * Spatial resolution * Repeability.

Repeatability :

Reliability identified the percentage of time that the robot is expected to operate without being taken out of service for maintenance or repair.

* It denoted by mm

Robot size

- The capacity of the robot can be denoted in kilogram (kg) is known as robot size.

Reach : The max distance that can be covered by

* It denote by mm

* ~~reach can be~~ reach can be categorized

* Vertical reach * Horizontal reach.

Precision of robot movement:

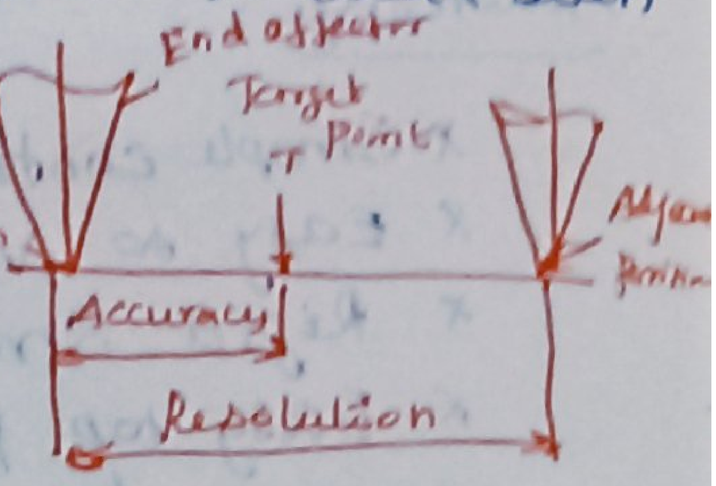
Precision of robot movement is depend on three factor

- Accuracy
- Spatial resolution (Ability of the robot to break down its movements into increments)

$\#$ increments $= 2^n$

N = Number of bits in Control memory

- Spatial resolution = Range $/ 2^n$



Ex: A robot controller has 12 bit storage capacity, the full range of the robot = 1.0 for one joint

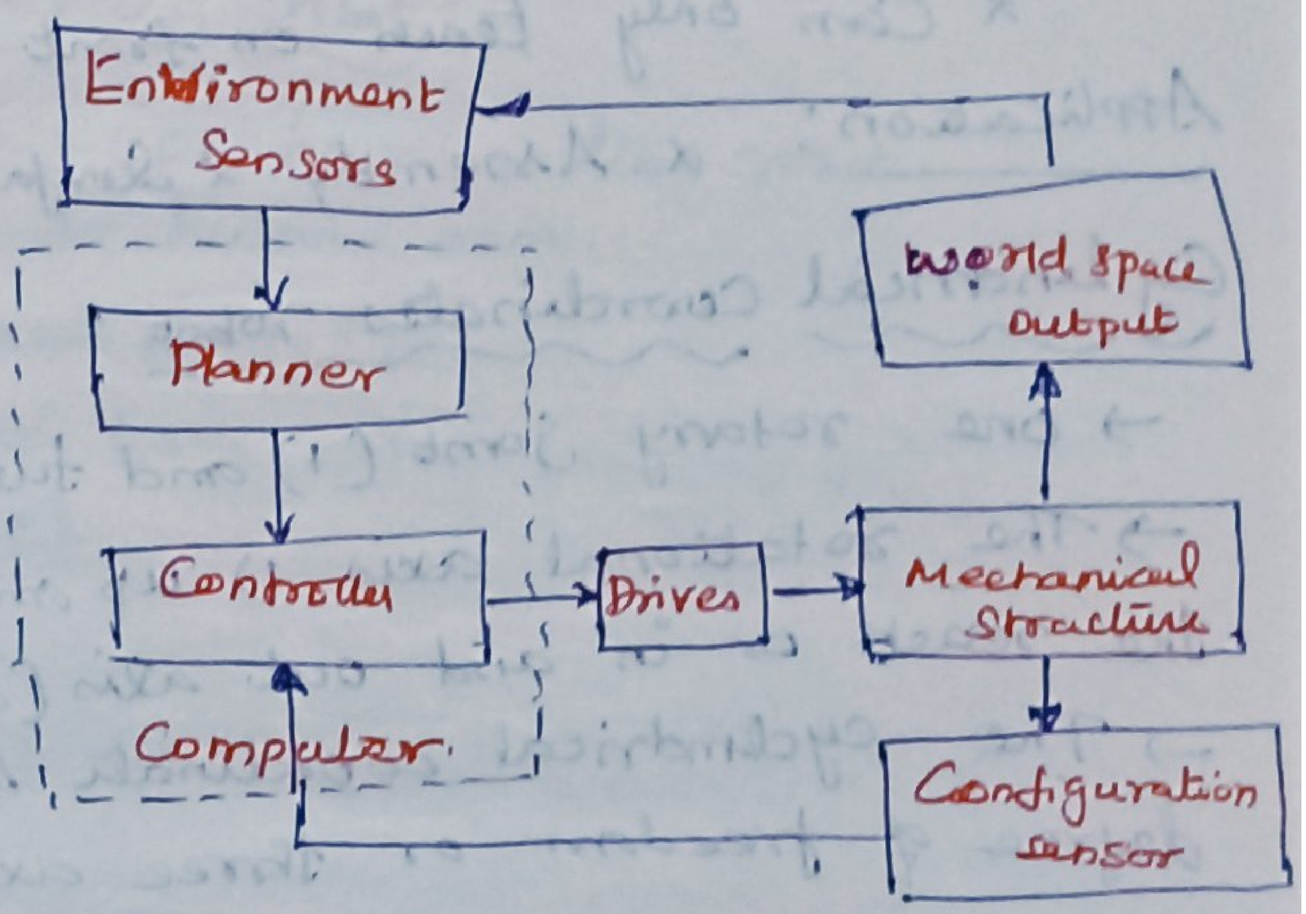
$= 1.0\,m / 4096 = 0.244\,mm$

- Repeability

Robotic System Architecture:

Components:

→ Mechanical Structure
→ Drives
→ Computing and control
→ Sensors
→ Communication



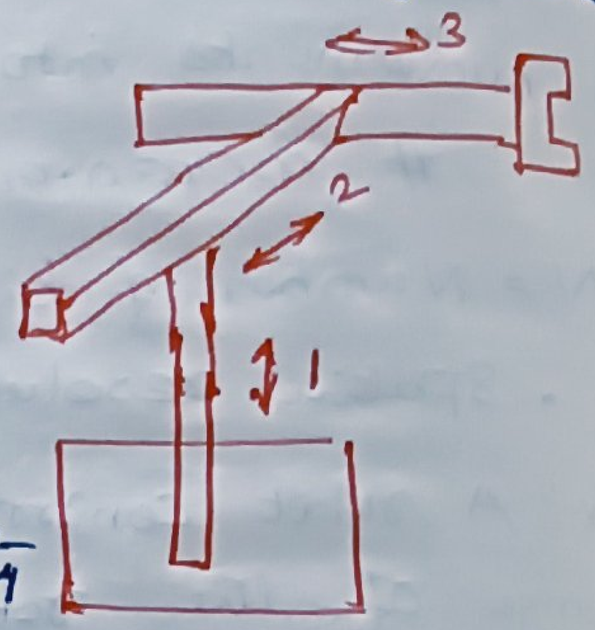
Robot Classification based on Configuration:

- Cartesian
- cylindrical
- Polar / Spherical robot
- Articulated / jointed arm
- SCARA

Cartesian robot / rectangular:

→ It is consist of three slide joints two of which are orthogonal.

→ The three slides are parallel to the 1, 2 and 3 of the cartesian coordinate system.
→ All arm joints are linear (1, 2, 3)
→ Movement along all three can occur simultaneo
→ These are also called rectilinear or Gantry robots



Advantage:

* Simple controls
* Easy to Visualize
* Rigid Structure
* Easy to program off-line
* High degree of mechanical rigidity
* Good accuracy and repeatability

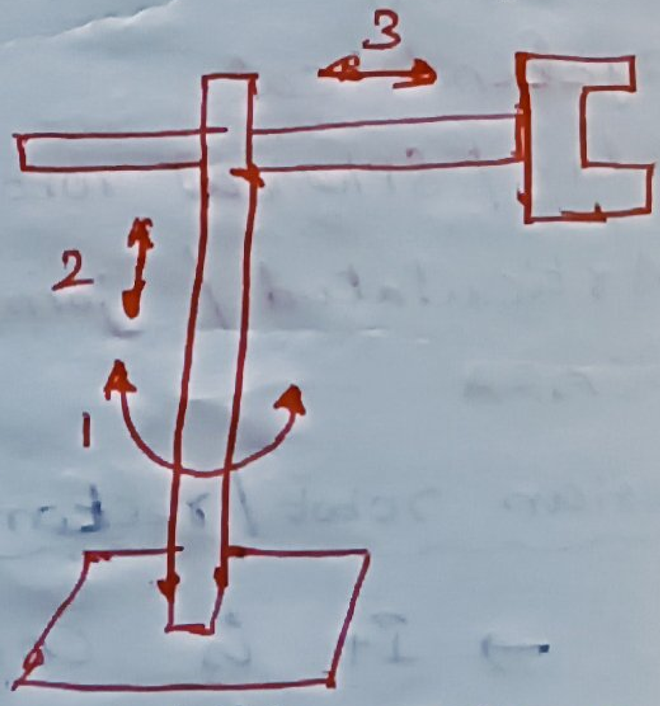
Dis-advantage:

* Limited in movement
* Required large floor space for the large structu
* Can only reach on front of itself

Application: * Assembly * Surface finish * Inspectio

Cylindrical Coordinates robot:

→ One rotary joint (1) and two linear joint (2 & 3)
→ The rotational axis 1) up and down axis (2) and the reach or in and out axis (3)
→ The cylindrical coordinate system incorporates thr degree of freedom or three axis
→ Work envelop is cylindrical
→ It is mostly in pick and place arm as parts feedi and assembly.



Advantage:

* Rigid Structure
* Easy to program off-line
* Good repeatability and accuracy
* Suitable for pick & place opn

Dis-advantage:

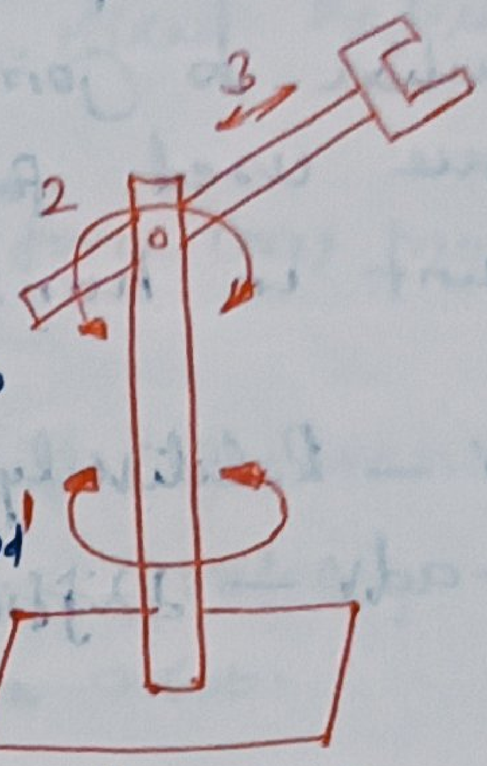
* Lower mechanical rigidity 2. Repeatability & accuracy lower in direction of rotary movement 3. More sophisticated syste
4. Horizontal motion is circular only.

Polar / Spherical robot :

→ It is three axes one linear joint (3) and two rotary joint (1, 2)

→ The rotational axes (1), the bent axis (2) and the reach axis (3)

→ It is called Spherical robots.



Advantage :

- Simple design
- High payload
- Easy to program.
- Light in weight
- Good precision

Dis-advantage

- Short vertical reach
- Less stability
- Can't reach around obstacles
- Repeatability & accuracy are lower due to rotary joints

Applications : Press loading, Die coating, part cleaning, Heat treatment, Forging.

Jointed-arm or articulated robot :

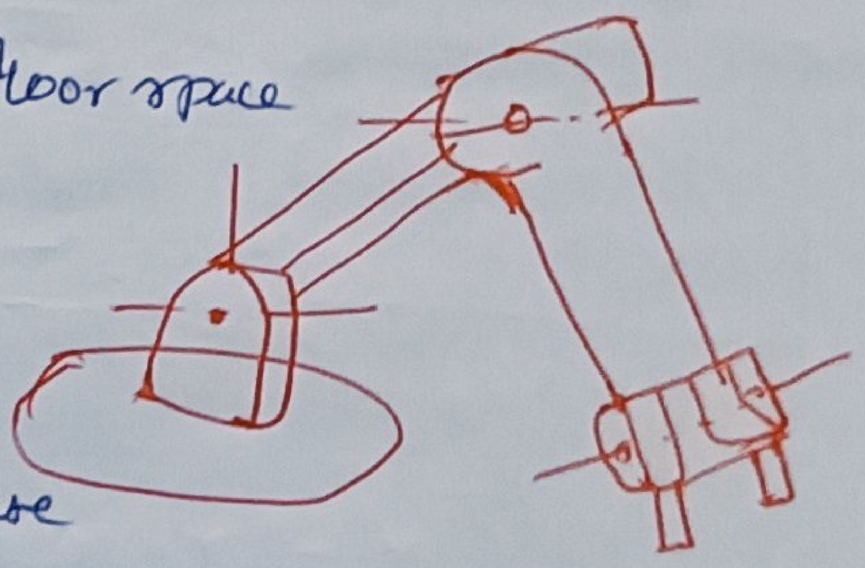
- Most anthromorphic or human like robot.
- → Design is similar to human arm.
- → Three rotational axis (1, 2, 3)
- → Rotation about axis base waist (vertical axis)
- → Shoulder (horizontal)
- → Elbow (horizontal)
- → work envelop is : Circular when viewed from top.

Advantage :

- Can reach around obstacles.
- → Larger work area for less floor space

Dis-advantage :

- → Less accuracy due to rotary joints
- → Sophisticated Controller because programming is complex
- → Less stable specially at maximum reach.



Application

- Pick and place
- Assembly robot
- Welding robot
- Spray painting robot etc

SCARA Configuration:

→ SCARA Stands for Selectively Compliant assembly Robot arm
→ Rotational axis (1 & 2) and linear (3)
→ Work envelop Similar to the Cylindrical one.
→ Similar to Jointed arm robot except that vertical axes are used for shoulder and elbow joint to be Compliant in horizontal direction for vertical insertion tasks.
→ Adv — Relatively inexpensive, Good Repeatability
→ Dis-adv — Difficult to program off-line.