CHAPTER-3

NUMERICAL CONTROL

SYLLABUS

- Define Numerical Control
- Explain the NC system with block diagram
- Describe the types of NC co-ordinate: Point – to – point, Straight Cut, and Contouring.
- NC part programming: G code and M-code. Reference Point (Machine Zero, Work zero, Tool zero & Tool offset). Simple part program for lathe.
- Explain the Extension of NC with the block diagram: (i) DNC (Direct numerical Control) (ii) CNC (Computer numerical Control) (iii) Adaptive Control

ASSIGNMENT

SHORT TYPE QUESTIONS

1. What is NC system?
2. What is adaptive control?
3. Define work zero.
4. What is CNC?
5. What is DNC?

LONG TYPE QUESTIONS

1. Explain CNC with block diagram.
2. Explain various component of NC system.
3. Explain preparatory function and G code along with miscellaneous function and M code.
4. Write down the components of DNC system.
5. Explain with a neat sketch point to point & straight cut NC co-ordinate system.
6. Differentiate between NC, CNC & DNC systems.

CHAPTER-3

Numerical Control of M/c tools

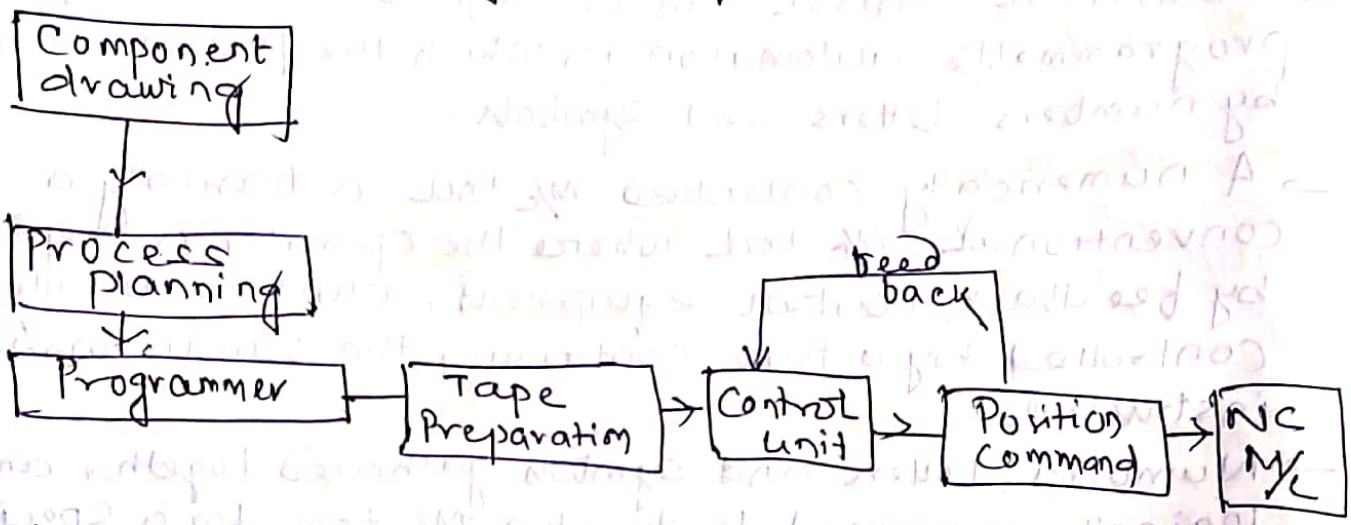
→ The word numerical is defined as the expression of something by numbers.
→ The word control is defined as the exercise of directing, guiding power over something.
→ Numerical control of M/c tools refers to the operation of M/c tools using numerical data stored on paper or magnetic tape, computer storage or direct information.
→ Numerical control can be defined as a form of programmable automation in which the process is controlled by numbers, letters and symbols.
→ A numerically controlled M/c tool is basically a conventional M/c tool where the operator is replaced by feedback control equipment, which is usually controlled by a tape containing the various machining instructions.
→ Numbers, letters and symbols gathered together and logically organized to direct a M/c tool for a specific task are called an NC program.

Difference between conventional and N/C M/c tools

→ In a conventional M/c tool, the component drawing and the initially planned/decided values of speed, feed, depth of cut etc. are given to the operator.
→ The operator reads the component drawing and the information in drawing is fed into M/c tool via handwheels, levers, switches etc. The operator monitors the cutter position during machining and makes any necessary corrections to ensure suitable output.
→ In a N/C machine tool, the otherwise human controlled operating functions of a conventional M/c tool, are replaced by numerically controlled operating functions.
→ In a N/C machine tool, the operator is replaced by the data processing part of the system and the control unit.

Block Diagram of NC System.

Numerical control is a technique of automatically operating a productive facility, based on code of letters, numbers and special characters. The complete set of coded instructions, responsible for executing an operation or set of operations is called a part program. This program is translated into electrical signals to drive various motors to operate the machine to carry out required operations.



Main components of a NC system.

An operational numerical control system consists of following basic components.

1. Program of instructions
2. Controller unit / Machine control unit (MCU)
3. M/c tool
4. Servomechanism and drive unit
5. Control panel

1. Program of Instructions

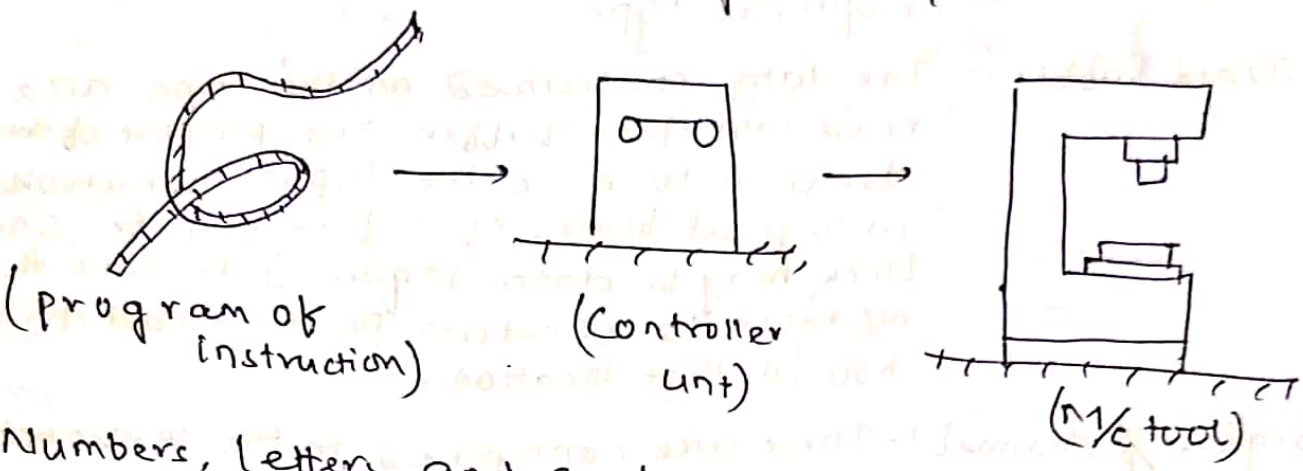
→ The program of instructions is prepared by someone called as part programmer.

→ The program of instructions is the detailed step by step set of directions which tell the M/c tool what to do.

→ It is coded in numerical or symbolic form on some type of input medium that can be interpreted

by the controller unit.

→ The most common input medium today is 25mm wide punched tape. Other forms of input media have been used including punched cards, magnetic tape etc.



→ Numbers, letters and symbols gathered together and logically organised to direct a M/c tool for a specific task are called an NC program.

→ NC program is interpreted by the controller unit and accordingly instructions are fed to M/c tool to perform all the required movements that produce a finished part.

→ The instructional data may be fed to the controller unit by manual entry. This method is called manual data input (MDI) and is appropriate only for relatively simple jobs where the order will not be repeated.

→ The second method of input is by mean of a direct link with a computer and this is called direct numerical control (DNC).

2. Controller Unit / Machine Control Unit (MCU)

The controller unit consists of the electronics and hardware that read and interpret the program of instructions (NC program) and convert it into mechanical actions of the M/c tool.

typical elements of NC controller unit include

1. tape reader
2. data buffer
3. signal O/p channels to the M/c tool
4. feedback channels to the M/c tool
5. sequence controls to co-ordinate overall op^n.

1. Tape Reader :- It is a device for winding and reading the punched tape containing the program of instructions. The tape reader may be of electromechanical, electronic, pneumatic or optical type.

2. Data buffer :- The data contained on the tape are read into data buffer. The purpose of this device is to store the input instructions in logical blocks of information, Ex. One block may be data required to move the M/c table to a certain position and drills hole at that location.

3 Signal O/p Channel :- These are connected to the servomotors and other controls in the M/c tool. Through these channels the instructions are sent to M/c tool from controller unit.

4. Feedback Channels :- In order to make certain that the instruction have been properly executed by the M/c tool, feedback are sent back to the controller unit via feedback channels. The most important function of this return loop is to assure that the table and workpart have been properly located with respect to tool.

5. Sequence Control :- It co-ordinates the activities of the other elements of controller unit. The tape reader is actuated to read data into the buffer from the tape, signals are sent to and from the M/c tool and so on. These types of operation must be synchronised and this is the function of the sequence controls.

3. Machine tool

M/c tool is that part of NC system which performs useful work of converting raw materials into finished component. M/c tool is designed to perform machining operations. It consists of work table, spindle, cutting tools, work fixtures and other auxillary equipment needed in machining operation.

4. Servo Mechanism and drive unit

A servo mechanism is a group of elements which convert the NC input into precision mechanical displacements of m/c tool parts. These elements include motors (hydraulic / electric), gear trains and transducers (velocity or position).

In other words, a servo mechanism is a series of mechanical, electrical, hydraulic or pneumatic units which is used to control the position of a m/c slide and which employs some form of measuring unit to monitor slide position and provide feedback signal.

→ There are mainly two types of transducers are commonly used :—

a. Velocity transducer :- These are used to measure spindle speed and slide velocity

b. Position transducers :- These are used to measure slide displacement.

5. Control Panel

→ Control panel may be a part of controller unit or of m/c tools.

→ The control panel also known as control console contains dials and switches by which the m/c operator runs the NC system. It may also contain data displays to provide information to the operator.

Classification of NC machines

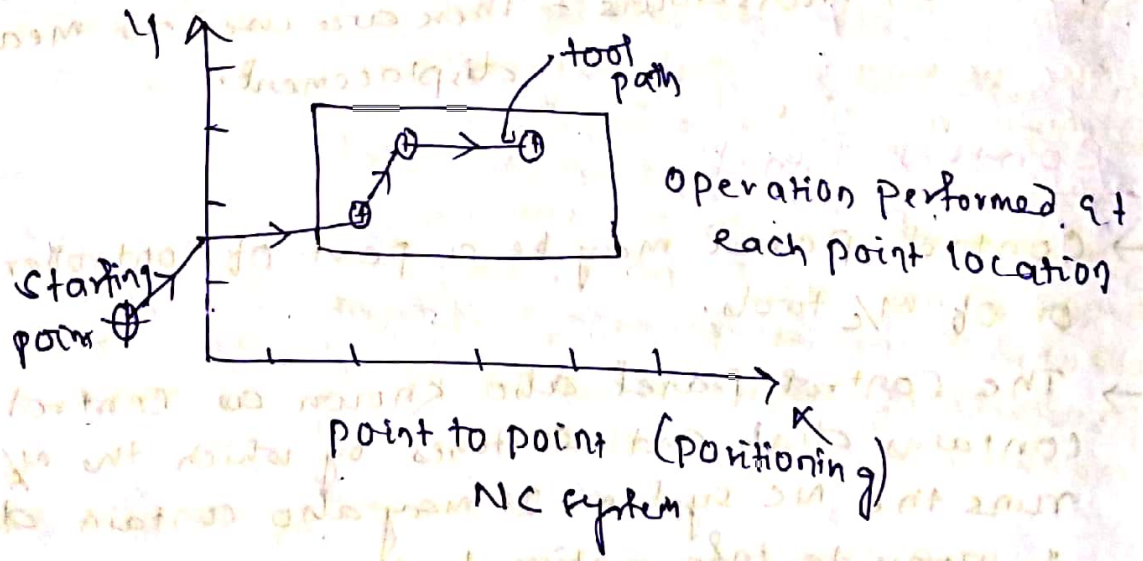
Based on control system characteristics

a. point to point system
b. Straight line system
c. contouring system

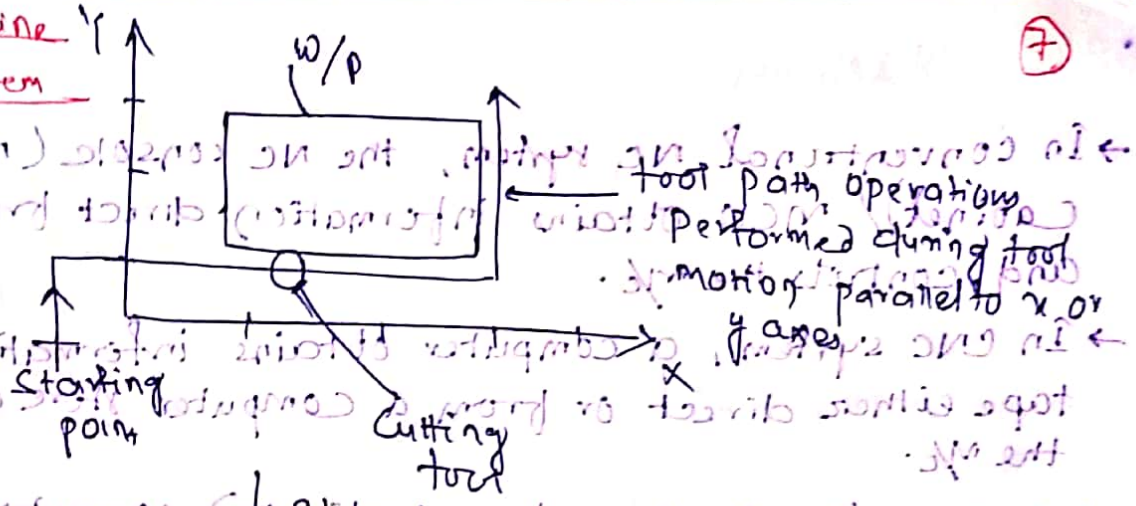
1. Point to point System (PTP)

→ A point to point NC system is basically a positioning system. Its primary purpose is to move the tool or w/p from one programmed point to another for an operation such as drilling a hole. The speed or path by which this movement from one point to another is accomplished is not important in point to point NC.

→ NC drill presses are a good example of PTP systems. First the m/c is set at the starting point and the datum is recorded (0,0). Now X and Y information is supplied for the first hole to the m/c tool, the m/c table moves so as to position the w/p under the spindle to drill the first hole. When this is completed, the drill moves up and then the information is read for the next hole and similarly it is drilled. It should be noted that other informations like depth, speed and feed rate have also to be supplied.



2. Straight line (cut) system



(Straight line system)

→ Unlike point to point system, the cutting motion in this system is along a line such as milling of slots or grooves.

→ The feed rate of tool or w/p is usually controlled by command from the NC program.

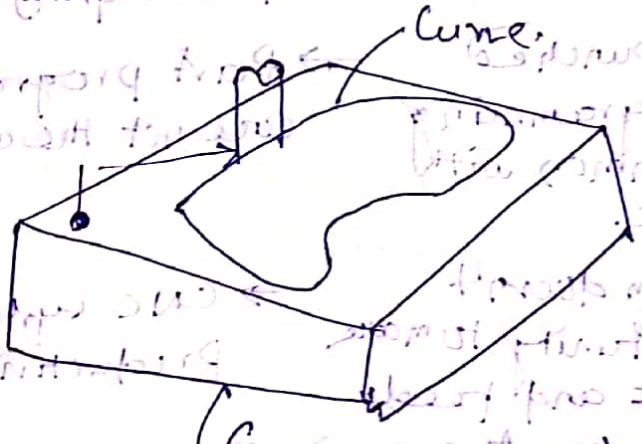
→ Straight line cuts parallel to either the X or Y axis may be programmed. With this type of NC system, it is not possible to combine movements in more than a single axis direction. Therefore angular cuts on the w/p would not be possible.

→ An NC machine capable of straight cut movements is also capable of PTP movement.

3. Contouring system

→ Contouring is the most complex, the most flexible and the most expensive type of M/c tool control.

→ Contouring NC systems are capable of directing the tool or w/p to move at any angle and also along curved paths.



(Contouring system)

CNC Machines

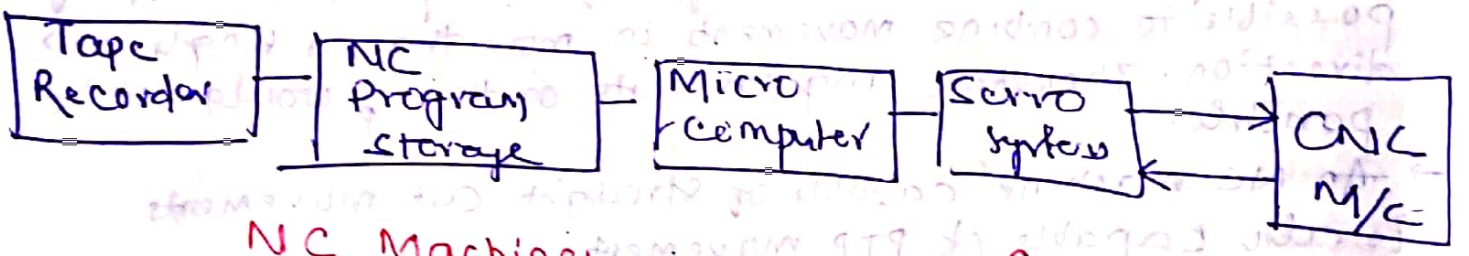
→ In conventional NC system, the NC console (NC control cabinet)/ MCU obtain information direct from a tape and controls the M/c.

→ In CNC system, a computer obtains information from a tape either direct or from a computer store and controls the M/c.

→ CNC implies the use of a dedicated computer within a NC unit to perform some or all the basic numerical control functions and hence the name CNC.

→ The Primary function of CNC system is to control of M/c tool.

→ This involves conversion of part program instructions into M/c tool motions through computer interface and servosystem.



NC Machines	CNC Machines
1. Purely hardware based NC.	→ A software based system. One of the objective of CNC system is to replace as much of the conventional NC hardware with software as possible and to simplify remaining hardware
2. In preparing punched tape, part programming mistakes are common with conventional NC.	→ Part programming mistakes are not there.
3. The control system doesn't provide the opportunity to make changes in speeds and feeds during cutting process. As a consequence the programmer must set the speeds	→ CNC system gives high productivity

and feeds for worst case condition. The result is lower than optimum productivity.

→ Since conventional NC controller unit is hard wired, the control features can't be easily altered to incorporate improvements in the unit.

→ Use of computer as the control device provide flexibility to make improvement in such features as circular interpolation when better software becomes available.

→ During the production of each part, the tape is read again. This increases the chances of in accuracy in machining due to increase use of tape reader.

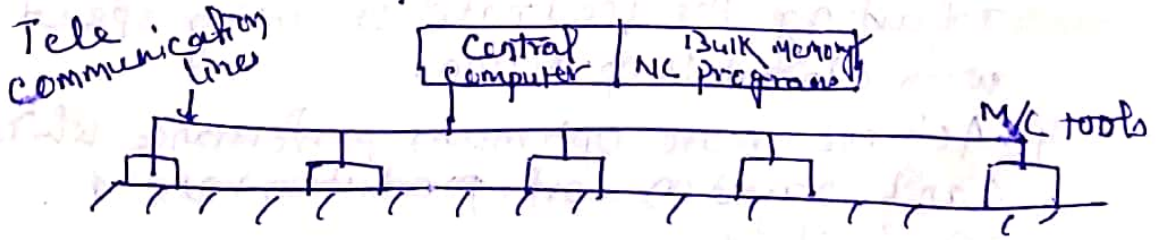
→ The part program tape and tape reader are used only once to enter the program into computer memory. This results improved reliability.

Direct Numerical Control

→ Whereas CNC is a self contained NC system for a single M/c tool, with DNC several M/c tools are directly controlled by a central computer. Punched tape is no longer used in DNC system. Instead, all information flow is provided by a computer that interfaces with M/c control unit. In operation, the DNC computer receives the equivalent of punched tape information from a compiling facility and directs storage of that information in disc or magnetic tape data storage unit.

→ DNC system consists of four basic components

1. Central computer
2. Bulk memory which stores NC part program
3. Telecommunication lines
4. M/c tools.



→ The computer calls the part program instructions from bulk storage and sends them to the individual M/c tools as the need arises. It also receives data back from the machines.

Adaptive control Machining Systems

→ In CNC one computer is used to control one M/c tool.

→ DNC involves the use of a large computer to control a number of separate NC machine tools.

→ Adaptive control machining denotes a control system that measures one or more process variables (such as cutting force, temp., noise power etc) and manipulates feed or speed in order to compensate for undesirable changes in the process variables.

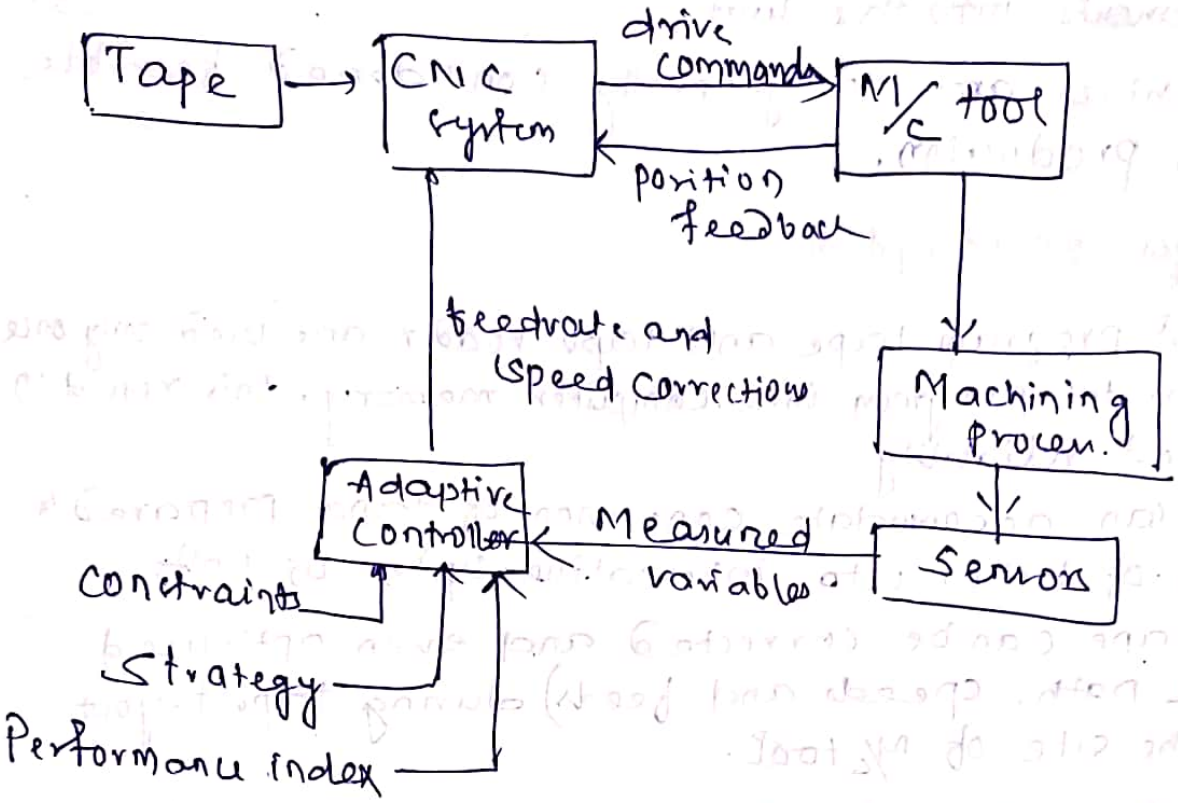
→ In other words AC uses information about a machining process to improve the efficiency of that process while it is taking place.

→ Adaptive control determines the proper speeds or feeds during machining as a function of variations in such factors as work material hardness, depth of cut etc. AC has the capability to respond to and compensate for these variations during the process.

→ NC doesn't have this capability.

→ Adaptive control is a system that

1. automatically and continuously identifies online performance by measuring some process variables such as torque, force, deflection, vibration, tool temp.
2. Monitors the performance by comparing these measurements with established limits.
3. Modifies the process by automatically adjusting the feedrate or cutting speed with closed loop action.
4. Achieve more optimum performance which can be based on cost, production rate & w/p quality.



Advantages of AC Machining

1. Increased production rate compared to conventional or NC machining.
2. Increase tool life due to more efficient and uniform use of cutter. Cutter is never severely loaded.
3. Less operator intervention.

Advantages of Conventional NC system.

1. Simpler to understand.
2. Acquisition cost of standard hard wired NC is lower.
3. Personal training is simpler. It is prefered for first time NC user.

Limitations of Conventional NC System

1. Part programming mistakes are common.
2. Non-optional speeds and feeds.
3. Use of tape reader again and again limits reliability of the system.
4. The conventional NC controller unit is hard wired. This means that its control features can't be easily altered to incorporate

improvements into the unit.

5) NC machines are not generally considered feasible for high production.

Advantages of CNC system.

1. The part program tape and tape reader are used only once to enter the program into computer memory. This result in improved reliability.
2. CNC can accomodate conversion of tapes prepared in units of inches into internation system of units.
3. NC tape can be corrected and even optimized (tool path, speeds and feeds) during tape tryout at the site of m/c tool.
4. A reduction in hardware circuits and simplification of the remaining hardware.
5. Greater flexibility. To latter conventional system, it needs rewiring whereas a modification in a CNC system mean reprogramming.

Disadvantages of CNC m/c

1. The capital cost for buying the m/c is high.
2. There is a loss in machine flexibility.
3. Control system is costly.
4. CNC machines are much more complex than conventional m/c.

NC Part Programming

→ A part program is a list of coded instructions which describes how the designed component or part will be manufactured.

→ These coded instructions are called data. A series of letters and numbers.

→ The part program includes all the geometrical and technological data to perform the required M/c functions and movements to manufacture the part.

→ The part program can be further broken down into separate lines of data, each line describing a particular shape of machining operations. These lines which run in sequence are called as blocks.

→ A block of data contains words sometime called as codes. Each word refers to a specific operation or movement.

→ The programming language recognised by CNC. The M/c controller is an ISO code which includes G and M code groups.

→ Each program word is composed from a letter called the address along with a number.

Types of NC codes

1 Preparatory Code (G-code)

→ The term preparatory in NC means that it prepares the control system to be ready for implementing the information. A preparatory function is designated in a program by the word address 'G' followed by 2 digits.

G 00

Address 2 digit number.

2. Miscellaneous Codes (M-Code)

→ Miscellaneous function use the address letter M followed by two digits.

→ They perform a group of instructions such as coolant ON/OFF, tool change, spindle ON/OFF, program stop or program end.

CHAPTER-4

ROBOT TECHNOLOGY

SYLLABUS

Defining a robot (ISO)
Fields of application of robots
Explain Robot anatomy.
Describe Robot Configuration

ROBOT

Robot can be defined as a programmable multifunction manipulator designed to move materials, parts, tools or specialised devices through variable programmed motions for performance of variety of tasks.

REASONS FOR USING ROBOT

1. It relieves man from hazardous or fatigue tasks
2. It brings improvements in product quality
3. Robots will lead the way into areas of technology where man has not entered so far
4. Mobile robots with moving arms and wide sensing power will find more applications
5. In countries of short of labour, it brings in savings from labour reductions

OBJECTIVES OF INDUSTRIAL ROBOT

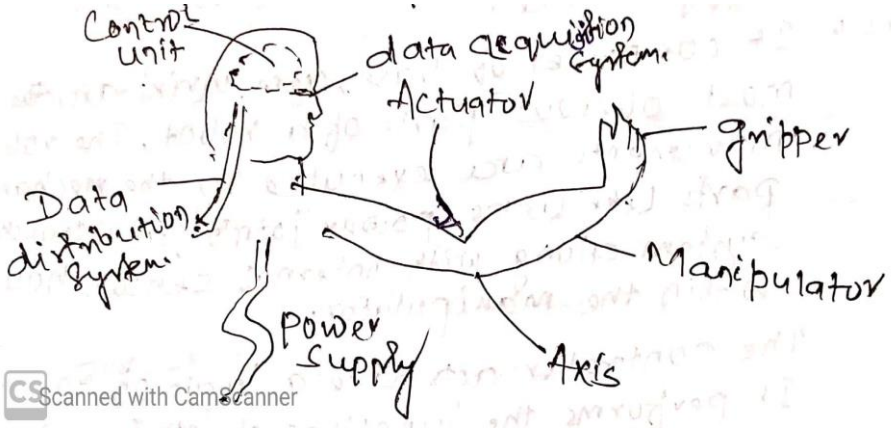
1. To increase productivity
2. To reduce production time
3. To minimise labour requirements
4. To enable the life of production machines
5. To improve existing manufacturing processes

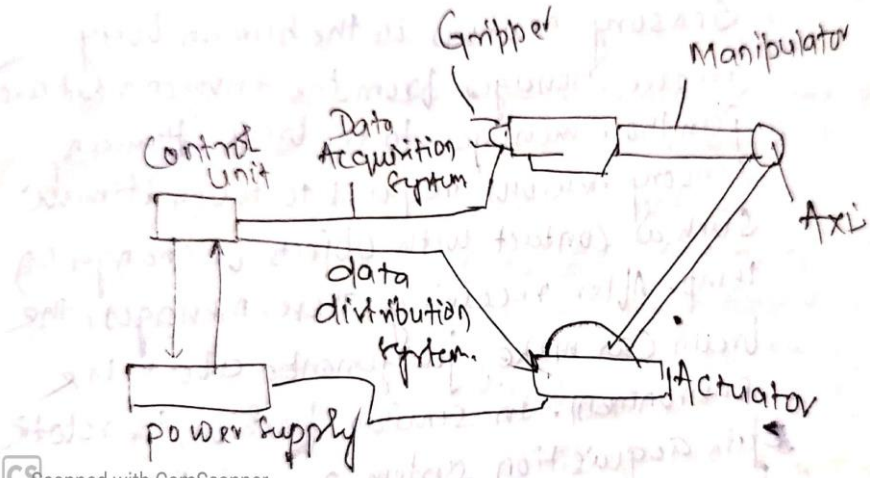
BASIC ELEMENTS OF ROBOT / ROBOT ANATOMY

The basic elements of industrial robots are manipulator, controller, end effector, sensors and energy source:-

1. **Manipulators: -** It comprises of base, arm, wrist are the most obvious parts of a robot. The robot movements are executed by the mechanical parts like links, power joints and transmission system along with internal sensors housed within the manipulator.
2. **Controller: -** The controller acts like a brain of robot. It performs the functions of storing and sequencing data in memory, initiating and stopping the motions of manipulators and interacting with environment.

3. **End effectors: -** End effector is the tool, a sort of gripper which directly interacts with the job. Grippers are being designed to handle a wide range of part configurations. The gripper is similar to human hand. Just the hand grasps the tool to perform the work; the gripper secures the robot's work piece while the operation is being performed. The shape of the gripper is determined by the task it has to perform. These include tools designed to weld, paint or perform machining operations such as milling and grinding.





4. **Actuators: -** Just as the human body requires muscles the robot arm requires actuators to move the manipulators. The actuators are devices that exert force to drive the manipulator into a predetermined position or series of positions and hold the joint rigidly once the position is reached. There are two types of actuators. Angular and linear. Angular actuators rotate their loads. Linear actuators extend their loads. The classification of actuators is related to the type of power they use. Electrical actuators use electrical power, hydraulic actuators use hydraulic power and pneumatic actuators use pneumatic power.
5. **Axes/Joints/ Degree of freedom: -** While the manipulator provides the support needed there must be flexible joints in the system to follow for movement in different directions. The axes are flexible joints in the system to allow for movement in different direction. The axes are flexible pivots in the mechanical skeleton that allow the bending of structure at that point.

6. **Power supplies: -** Just as human digestive system converts food into usable energy the robot power supply provides the actuators and control unit with the energy that they need to function. The energy must be in the form that a robot system can use. If the actuators are hydraulic and the workplace only has electrical power available, then the power supply must convert this electrical energy into hydraulic energy.
7. **Data distribution system: -** In the human body neurons receive messages from the brain and passage those messages to the muscles. In the same way the data distribution system receive messages from control unit and passes them on to the actuators.
8. **Data acquisition system: -** Sensory neurons in the human body receive messages from the environment and pass those messages to the brain. Human sensory neurons respond to touch stimuli such as contact with objects or change in temperature. After receiving these messages, the brain can make judgements about the environment. In similar fashion, the robotic data acquisition system receives messages from environment and passes those messages into control unit.

WORK VOLUME

- Work volume or work envelope refers to the space within which the robot can manipulate its wrist end.
- The work volume is determined by the following physical characteristics:
    1. Robot's physical configuration.
    2. Sizes of the body, arm and wrist components.
    3. Limits of robot's joint movements.

CLASSIFICATION OF ROBOT

Based on Robot Arm Configuration

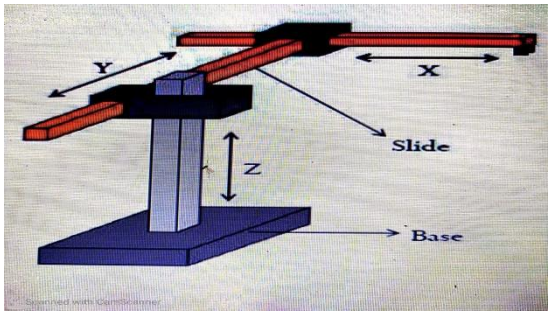
- Cartesian coordinate
- Cylindrical coordinate
- Polar coordinate
- Jointed arm configuration

Based on power source

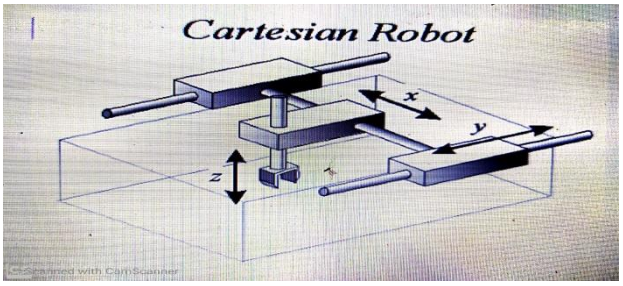
- Pneumatic
- Hydraulic
- Electric

CARTESIAN COORDINATE SYSTEM

- In this there are three orthogonal directions X, Y and Z.
- X-coordinate axis may represent left and right motion.
- Y-coordinate axis may represent forward and backward motion.
- Z-coordinate axis may represent up and down motions.
- Example of Cartesian System is Overhead Crane Movement



WORKING ENVELOPE OF CARTESIAN CONFIGURATION ROBOT

- The working envelope of the Cartesian configuration is a rectangular prism.
- 

ADVANTAGES:

- Work envelope can be increased by travelling along the x axis.
- Linear movement and hence simpler control.
- High degree of accuracy and repeatability due to their structure.

DISADVANTAGES:

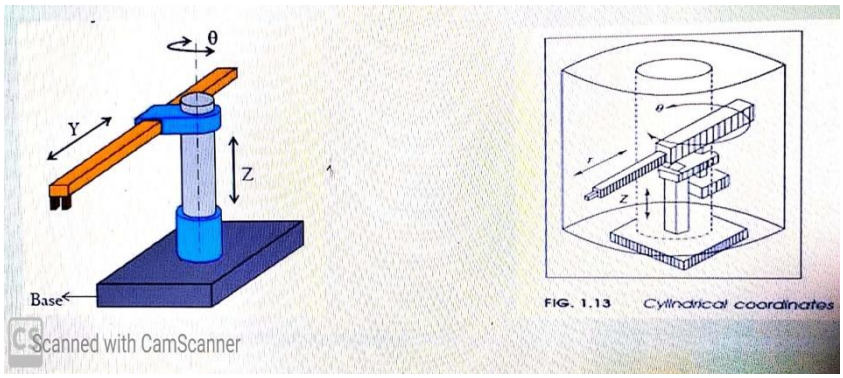
- Movement is limited to only one direction at a time.

APPLICATIONS:

- Pick and place operation.
- Assembly
- Nuclear material handling
- Welding

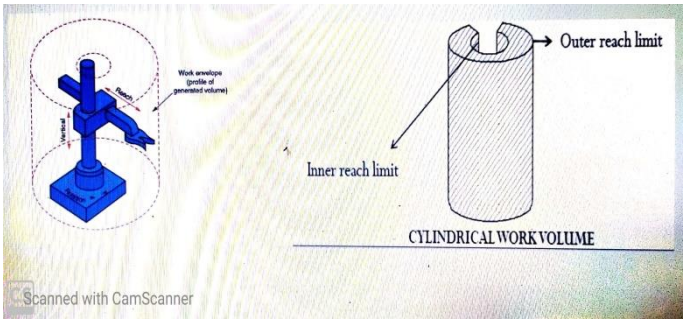
CYLINDRICAL CONFIGURATION ROBOT

- It uses a vertical column and a slide that can be moved up or down along the column.
- The robot arm is attached to the slide so that it can be moved radially with respect to the column.
- By rotating the column, the robot is capable of achieving a work space that approximates a cylinder.
- It contains two linear motions and one rotational motion.
- Angular Motion, θ along vertical axis; Translation Motion, z along z - direction that corresponds to up and down motion; radial, r in or out translation.



WORKING ENVELOPE OF CYLINDRICAL CONFIGURATION ROBOT

- The working envelope of this configuration is as its name suggests a cylinder.



ADVANTAGES

- Results in larger work volume than a rectangular manipulator.

DISADVANTAGES

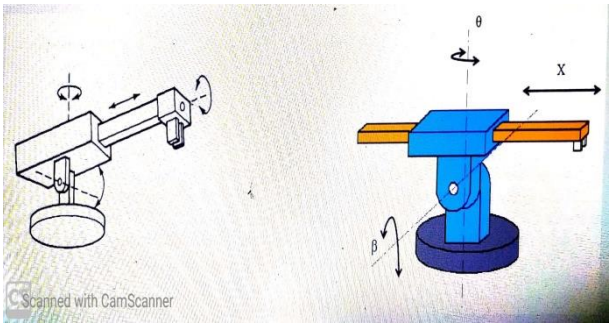
- Repeatability and accuracy are lower in the direction of rotary motion.

APPLICATIONS

- Assembly.
- Coating application
- Die casting.
- Foundry and forging application
- Machine loading and unloading.

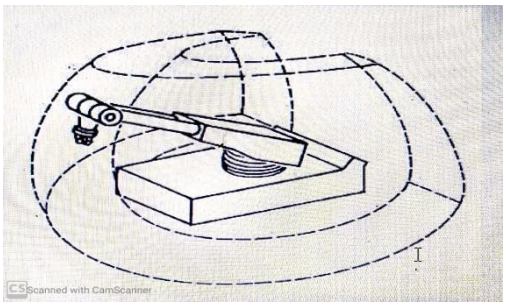
POLAR CONFIGURATION ROBOT

- It uses a arm that can be raised or lowered about a horizontal pivot.
- The pivot is mounted on a rotating base.
- The various joints provide the robot with capability to move its arm within a spherical space, and hence it is also called as "Spherical Coordinate Robot."
- It has one linear and two rotary motions.
- The UNIMATE2000 series is an example of spherical robot.



WORK VOLUME OF A POLAR CONFIGURATION ROBOT

- The work volume of a polar configuration robot is in the form of a sphere.
- It consists of one linear and two angular motions.
- The linear motion, r, corresponds to a radial in or out translation.
- The angular motion corresponds to a base rotation, θ , about a vertical axis.
- Another angular motion, β , about an axis which is perpendicular to the vertical through the base and sometimes is termed as elbow rotation.



ADVANTAGES

- Larger work envelope than the rectilinear or cylindrical configuration.

DISADVANTAGES

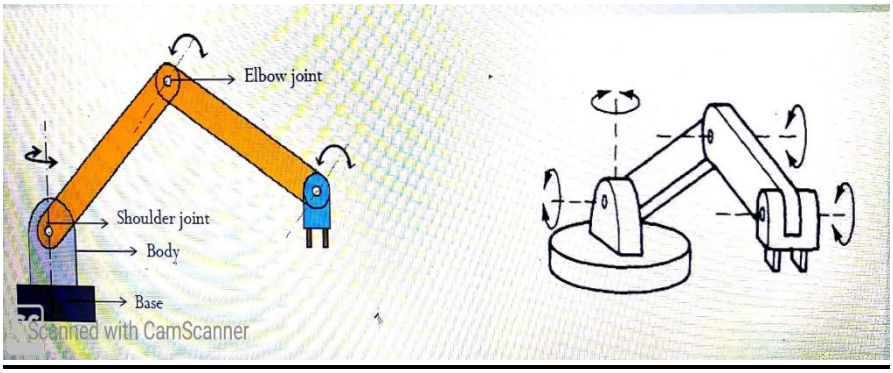
- Repeatability and accuracy are also lower in the direction of rotary motion.

APPLICATIONS

- Die casting.
- Forging.
- Injection molding.

JOINTED ARM CONFIGURATION

- Its configuration is similar to that of a human arm.
- These components are connected by two rotary joints corresponding to shoulder and elbow.
- A wrist is attached to the end of forearm, thus providing several additional joints.
- Cincinnati MilacronT3(Model776)robot is a commercially available.

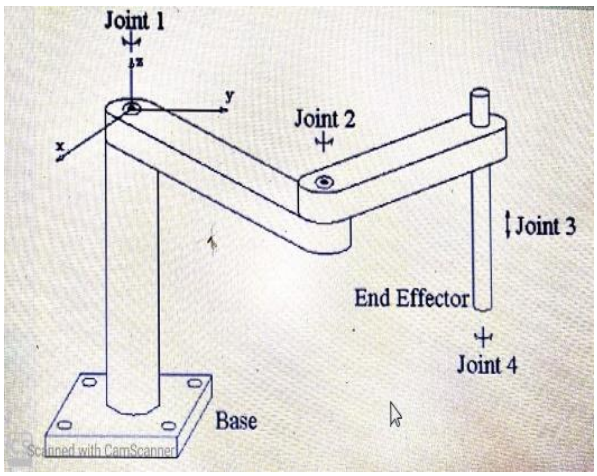


WORK ENVELOPE OF JOINTED - ARM CONFIGURATION

- It is similar to the configuration of a human arm.
- It consists of a vertical column that swivels (rotate) about the base using a T-joint.
- Shoulder joint (R-joint) is located at the top of the column.
- The output link is an elbow joint (another R joint).

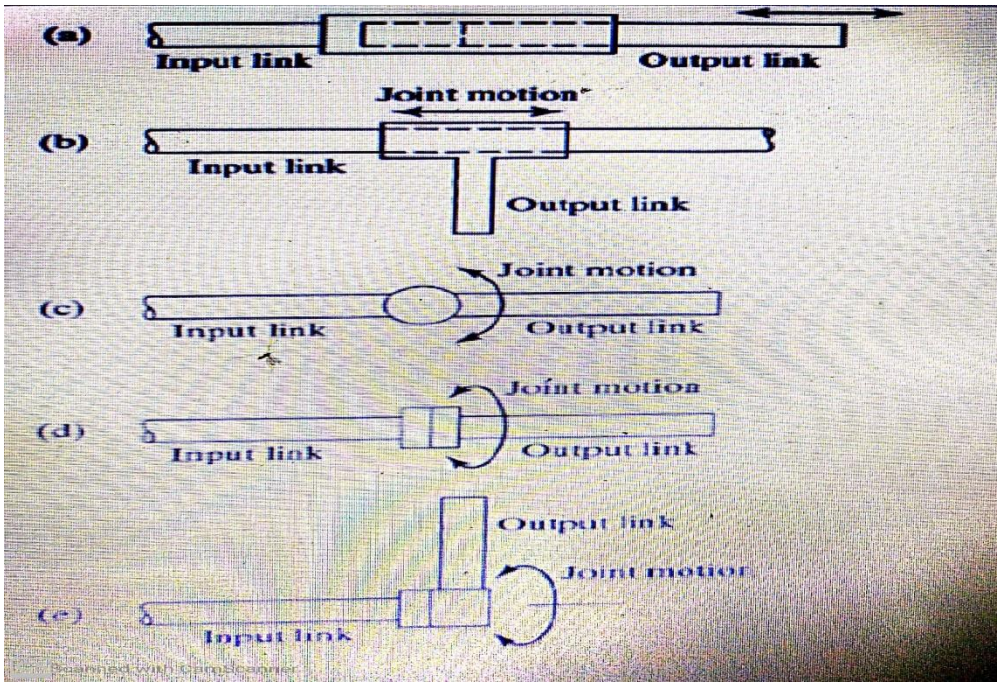
SCARA ROBOT

- SCARA is a special type of jointed arm configuration.
- It stands for Selective Compliance Automated Robot Arm (or) Selective Compliance Articulated Robot Arm.
- It is similar to jointed-arm except that the vertical axes are used for shoulder and elbow joints to be compliant in horizontal direction vertical insertion tasks.



JOINTS

1. Linear joint (type L):- Translational motion
   Axes of input and output link are parallel
2. Orthogonal joint (type O):- Translational motion
   Input & output links are perpendicular
3. Rotational joint (type R):- Rotary motion
   Axis of rotation is perpendicular to input and output link axis
4. Twisting joint (type T):- Rotary motion
   Axis of rotation parallel to axis of links
5. Revolving joint (type V):- Rotary motion
   Axis of rotation parallel to input but perpendicular to output



TYPES OF ROBOT SENSORS

1. **LIGHT SENSORS:-** A Light sensor is used to detect light and create a voltage difference. The two main light sensors generally used in robots are Photoresistor and Photovoltaic cells.
2. **SOUND SENSORS: -** As the name suggests, this sensor (generally a microphone) detects sound and returns a voltage proportional to the sound level. A simple robot can be designed to navigate based on the sound it receives.
3. **TEMPERATURE SENSOR: -** Temperature sensors are used to detect the surrounding temperature change.
4. **PROXIMITY SENSOR: -** This is a type of sensor which can detect the presence of a nearby object within a given distance, without any physical contact.

5. **CONTACT SENSOR: -** Contact sensors are those which require physical contact against other objects to trigger.
6. **PRESSURE SENSOR:-**As the name suggests pressure sensor measures pressure.
7. **POSITIONING SENSORS: -** Positioning sensors are used to approximate the position of a robot, some for indoor positioning and few others for outdoor positioning.

END EFFECTOR

A robotic end-effector is any object attached to the robot flange (wrist) that serves a function. In robotics, an end effector is the device at the end of a robotic arm, designed to interact with the environment. Device that attaches to the wrist of the robot arm and enables the general- purpose robot to perform a specific task.

BASIC TYPES

- Grippers – to grasp and manipulate objects (e.g., parts) during work cycle
- Tools – to perform a process, e.g., spot welding, spray painting

TOOLS AS END EFFECTOR

- A tool is equipped in the robot for carrying out several operations on the work parts instead of grasping it. A tool acts as an end effector when it is attached directly to the robot's wrist.
- In robot applications, the most commonly used three tools as end effectors are listed below:

  1. Spot welding tools
  2. Spray painting nozzle
  3. Arc welding torch

GRIPPERS

Grippers are the end effectors used for holding the parts or objects. Grippers are devices which can be used for holding or gripping an object. Applications of grippers: - Machine Loading and unloading, picking and placing of parts on conveyor, material handling, bottle handling, arranging parts onto pallets, etc.

TYPES OF GRIPPER

- Mechanical Grippers
- Hooks
- Vacuum Grippers
- Adhesive Grippers

REPEATABILITY & ACCURACY

The repeatability of a robot might be defined as its ability to achieve repetition of the same task. On the other hand, accuracy is the difference (i.e. the error) between the requested task and the obtained task (i.e. the task actually achieved by the robot).

ASSIGNMENT

SHORT TYPE

1. Define robot.
2. State the fields of applications of robots.
3. What is the use of sensors?

LONG TYPE

1. Describe the main components of Robot.
2. Describe the different configuration of Robotics with neat sketch.
3. Explain the different sensors used in robot.
4. Explain the accuracy and repeatability of a robot.
5. Discuss various types of end effectors.

CHAPTER-6
CAD / CAM AND CIM

SYLLABUS

- Define CAD, CAM and CIM
- Explain the benefits of CAD. CAD software and hardware
- Explain the benefits of CAM, differentiate between CAD and CAM
- Explain the concept, background. Software and hardware of CIM

COMPUTER AIDED DESIGN (CAD)

- The use of a computer to interact with a designer in developing and testing product ideas without actually building prototype. The evolution of a design typically involves the creation of geometric models of product, which can be manipulated, analysed and refined. In CAD, computer graphics replace the sketches and engineering drawings traditionally used to visualize products and communicate design information.
- The various design related tasks performed by a modern CAD system can be grouped into four functional areas:-
    1. Geometric modelling
    2. Engineering analysis
    3. Design review & evaluation
    4. Automated drafting
- Computer-Aided Design (CAD) is the technology concerned with the use of computer systems to assist in the creation, modification, analysis, and optimization of a design. Computer-aided design (CAD) is a computer technology that designs a product and documents the design's process. CAD may facilitate the manufacturing process by transferring detailed diagrams of a product's materials, processes, tolerances and dimensions with specific conventions for the product.
- It can be used to produce either two-dimensional or three-dimensional diagrams, which can then when rotated to be viewed from any angle, even from the inside looking out. CAD is also known as computer-aided design and drafting (CADD).
- **Computer-aided design** (**CAD**) is the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing.

CAD is used: -

- To produce detailed engineering designs through 3-D and 2-D drawings of the physical components of manufactured products.
- To create conceptual design, product layout, strength and dynamic analysis of assembly and the manufacturing processes themselves.

CAD SOFTWARE

- It describes the main functions of a CAD programme such as drawing, editing, data output, system control, data storage, management and other special features.
- Falls into two broad categories 2-D and 3-D based on number of dimensions.
- 3-D software permits the parts to be viewed with the 3-D planes, height, width, and depth visible.
- Such representation approximates the actual shape and appearance of the object to be produced, therefore they are easier to read and understand.
- CAD software describes the main functions of a CAD program, such as Draw, Edit, Data Output, Data Storage and Management, System Control.

CAD HARDWARE

- It describes the physical components of a CAD system such as system unit, memory and hard disk.
- It consists of one or more design workstations, digital computers and other output devices.
- Input devices are generally used to transfer information from a human or storage medium to computer where CAD functions are carried out.
- The main hardware components of CAD are system unit, central processing unit, memory, monitor, printers, key board, mouse etc.
- CAD Hardware describes the physical components of a CAD system such as system Unit, Central Processing Unit (CPU), Memory, Hard Disk, Floppy Disk, CD-ROM, External Storage Devices, The Monitor, Printers and Mouse.

BENEFITS OF CAD

- **Ease of document reproduction**
- **Visualization of complex technical elements**
- **Reduced manufacturing time**
- **Improved accuracy of design**
- **Customer modifications are easier to make**
- **Improved engineering productivity**
- **Reduced engineering personnel requirements**

APPLICATION OF CAD

- **Solid modelling**
- **Assembly**
- **Surface modelling**

CAM

- Computer Aided Manufacturing (CAM) can be defined as the use of computer systems to plan, manage and control the operations of a manufacturing plant through either direct or indirect computer interface with the plant's production resources. In other words, the use of computer system in non-design activities but in manufacturing process is called CAM.
- The geometric model developed during the CAD process forms the basis of CAM activities.
- Once parts are produced CAD software can be used to inspect them.
- After passing inspection, CAM software can be utilized to instruct to robot systems to assemble the parts to produce the final product.

BENEFIT OF CAM •

- Greater supervision of the production
- Fast response to changes in market demand
- Greater flexibility
- Product variety
- Reduced waste
- In large scale production, the results are consistent
- Enables very high accuracy levels in large scale production

APPLICATION OF CAM

- Turning
- 3-D Milling

DIFFERENTIATE BETWEEN CAD AND CAM

CAD	CAM
Stands for computer aided design	Stands for computer aided manufacturing
With the help of a computer to design some object	With the help of a computer to manufacture some object
A CAD user will typically bean engineer with training in CAD software	A CAM user will usually be a special trained machinist
Enables engineers and architects to design model of product	It is used to control the M/C tools and related machinery in the manufacturing process of the product
CAD software offers better visualisation of the design, improves accuracy and eliminates error during the manufacturing process	Optimises production process by reducing waste of raw materials and manufacturing errors
Basic: - CAD is the implementation of digital computers in engineering design and production.	Basic: - CAM is the implementation of computers in transforming engineering designs into end products.
Involved processes:- Definition of a geometric model, definition translator, geometric model, interface algorithm, design and analysis algorithms, drafting and detailing, documentation.	Involved processes:- Geometric model, process planning, interface algorithm, NC programs, inspection, assembly and packaging.
Requires :- Design conceptualization and analysis.	Requires :- Control and coordination of the necessary physical processes, equipment, materials, and labour.
Software :- AutoCAD, Autodesk Inventor, CATIA, SolidWorks	Software :- Siemens NX, Power MILL, WorkNC, SolidCAM

CIM

- "CIM is the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organizational and personnel efficiency."
- Computer-integrated manufacturing (CIM) is the manufacturing approach of using computers to control the entire production process. CIM is an example of the implementation of Information and Communication Technologies (ICTs) in manufacturing.
- Computer-integrated manufacturing (CIM) is the manufacturing approach of using computers to control entire production process. This integration allows individual processes to exchange information with each other and initiate actions.
- CIM is not a product that can be purchased and installed. It is a way of thinking and solving problems. This integration allows individual processes to exchange information with each other and initiate actions.
- The term CIM comprises three words – computer, integrated and manufacturing. CIM is the application of computers in manufacturing in an integrated way. CIM is an attempt to combine computer technologies in order to manage and control the entire business and manufacturing.
- CIM is the computerization of design, manufacturing, distribution and financial/business function into one coherent system.

WHY CIM

- To meet Competitive pressures.
- To coordinate and organize data.
- To eliminate paper and cost associated with its use.
- To automate communication within a factory

Benefits of CIM

- Improved customer service
- Improved quality
- Shorter time to market with new products
- Greater flexibility and responsiveness
- Improved competitiveness
- Lower total cost
- Increase in manufacturing productivity
- More productive and efficient
- Increase product reliability
- Decrease the cost of production and maintenance

Subsystems in computer integrated manufacturing

- CAD (Computer-Aided Design) involves the use of computers to create design drawings and product models.
- CAE (Computer-Aided Engineering) is the broad usage of computer software to aid in engineering tasks.
- CAM (Computer-Aided Manufacturing) is the use of computer software to control machine tools and related machinery in the manufacturing of work pieces.
- CAPP (Computer-Aided Process Planning) is the use of computer technology to aid in the process planning of a part or product, in manufacturing.
- CAQ(Computer-Aided Quality Assurance) is the engineering application of computers and computer controlled machines for the inspection of the quality of products.
- PPC (Production Planning and Control) A production (or manufacturing) planning and control (MPC) system is concerned with planning and controlling all aspects of manufacturing, including materials, scheduling machines and people, and coordinating suppliers and customers.
- ERP (Enterprise Resource Planning) systems integrate internal and external management information across an entire organization, embracing finance/accounting, manufacturing, and sales and services.

CIM Hardware

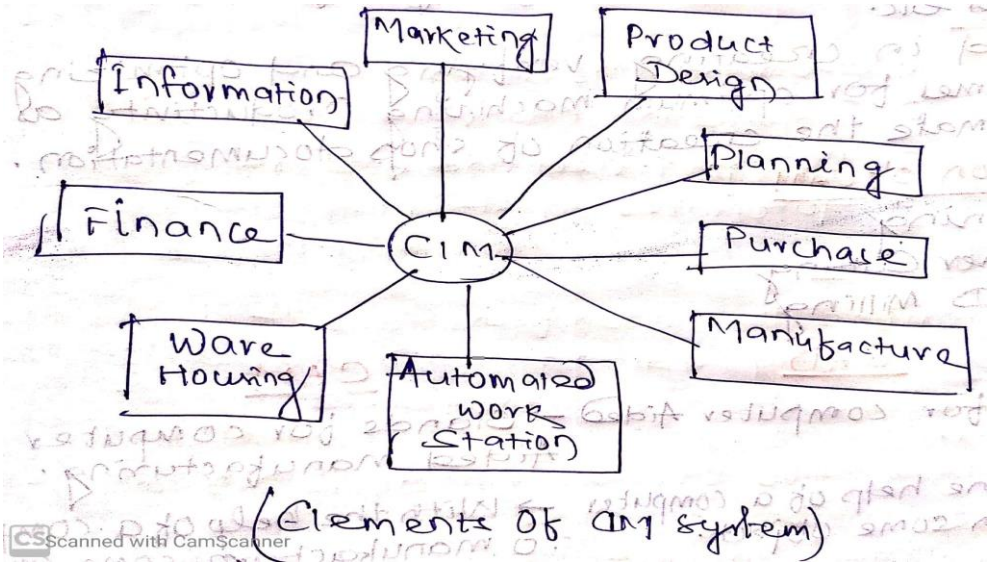
CIM hardware comprises the following:-

- Manufacturing equipment such as CNC machines or computerized work centres, robotic work cells, work handling and tool handling devices, storage devices, sensors, inspection machine etc.
- Computers, controllers, CAD/CAM systems, workstations, data entry terminals, printers, cables, connectors etc.

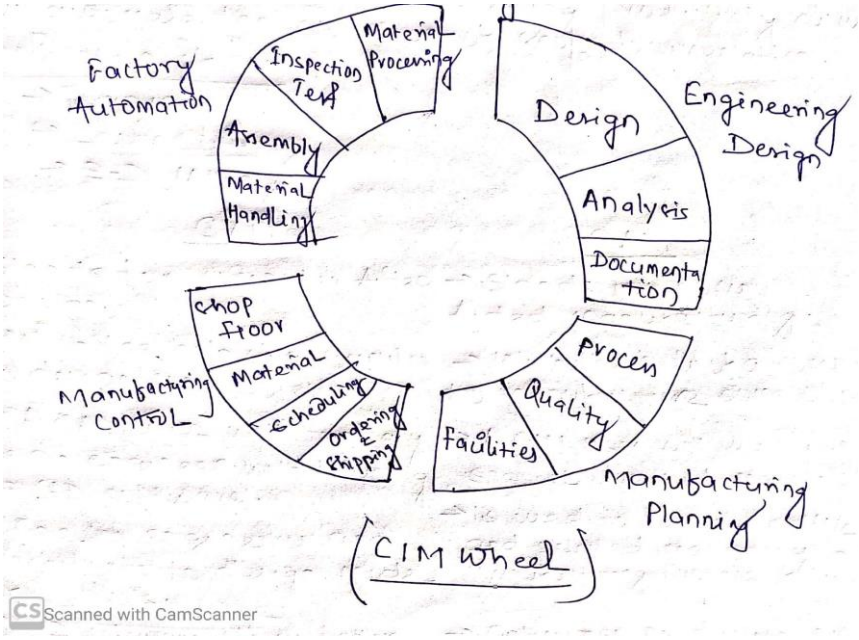
CIM Software

CIM software comprises computer programmes to carry out following functions:-

- Management Information system
- Sales
- Marketing
- Finance
- Modelling & design
- Analysis
- Communications
- Monitoring
- Production control
- Manufacturing area control
- Material handling
- Process planning



(Elements Of CIM System)



ASSIGNMENT

SHORT TYPE

1. Define CIM.
2. Define CAD.
3. Define CAM.

LONG TYPE

1. Differentiate between CAD and CAM.
2. State the benefits of CAD & CAM.
3. Explain briefly about CAD software & hardware.
4. Explain CIM hardware & software.