“CAD CAM”

Unit - 1

1. DEFINE CAD AND CAM. WHAT ARE THE BENEFITS OF CAD CAM?

Computer-aided design/computer-aided manufacturing (CAD/CAM) is a combination of two terms CAD and CAM to describe the software that is used to design and manufacture prototypes, finished products, and product runs.

CAD
CAD is a software tool used by engineers, architects, designers, and drafters to create digital 2D and 3D drawings to design a variety of items and spaces. Computer models are created and defined by geometrical patterns. CAD allows designers to test the objects by simulating real-world conditions. It can design anything from a simple shampoo bottle to a complex jet plane.

CAM
CAM uses geometrical design data to control automated machinery. These systems are associated with CNC or direct numerical control (DNC) systems, in which both can mechanically encode geometric data. The main purpose of CAM is to create a faster production process and allow components and tools to have precise dimensions and material consistency.

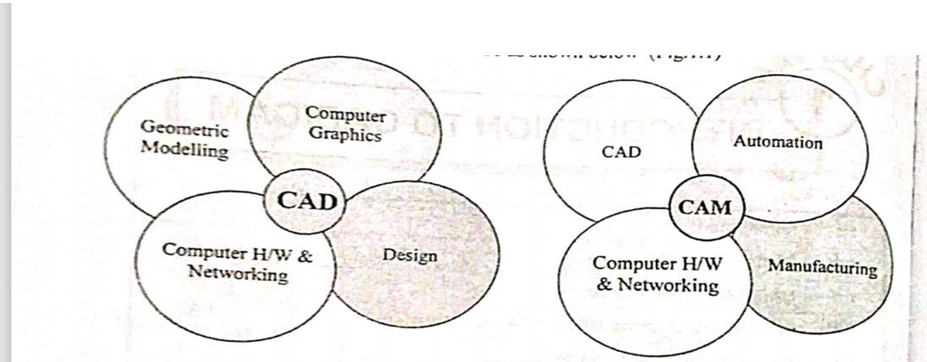


Fig. 1.1

Benefits of CAD-CAM
Today, every manufacturing plant uses at least a type of CAD-CAM system to control their operations. Here are the various advantages they can avail by using these software applications.

- ***Improves Machining Capabilities:***
  By using a CAD-CAM system, manufacturers can improve their machining capabilities. For example, when a manufacturer takes up a complex 3-axis machining task, they rely on the combination software to create a tool path for machining projects such as molding. The CAM system automates the process, and makes it easier for manufacturers to complete the project in time.

- ***Improves Client Accessibility:***
  The CAD-CAM software allows manufacturers to receive CAD files from their customers. After receiving these files, they can set up the machining tool path, and perform simulations, which helps them calculate the machining cycle times. The software allows manufacturers to minimize errors, execute projects easily, and deliver products to the market within a shorter turnaround time.

- ***Helps Improve Productivity of CNC Machines:***
  Most CAM-CAD systems provide high–speed machine tool paths, which help manufacturers minimize their cycle times, reduce tool and machine wear. High-speed tool paths enable manufacturers to improve their cutting quality and accuracy. This type of high- speed machining helps improve the productivity of the CNC machine by more than 50%.

- ***Helps Reduce Material Wastage:***
  As CAM–CAD software feature simulation features, it helps a manufacturer to visually inspect the process of machining. This allows him to capture tool gouges, and collisions at an early phase. This feature contributes to the overall productivity of a manufacturing set up. This also helps them eliminate mistakes, as well as reduce material wastage.

2. EXPLAIN ABOUT PRODUCT CYCLE?

Product cycle

- The product begins with a need which is identified based on customers and market demands.
- In order to establish the scope and definition of CAD/CAM in an engineering environment and identify existing and future related tools, a study of a typical product cycle is necessary.
- The product goes through two main processes from idea of conceptualization to finished product: the design process and manufacturing process.
- Design process starts with design need, ends with design documentation and communication.
- Synthesis is crucial to design.
- The end goal of the synthesis sub-process is a conceptual design of the prospective product.
- Manufacturing process begins with the process planning and ends with the actual product.
- CAD is a subset of the design process.
- CAM is a subset of the manufacturing process.

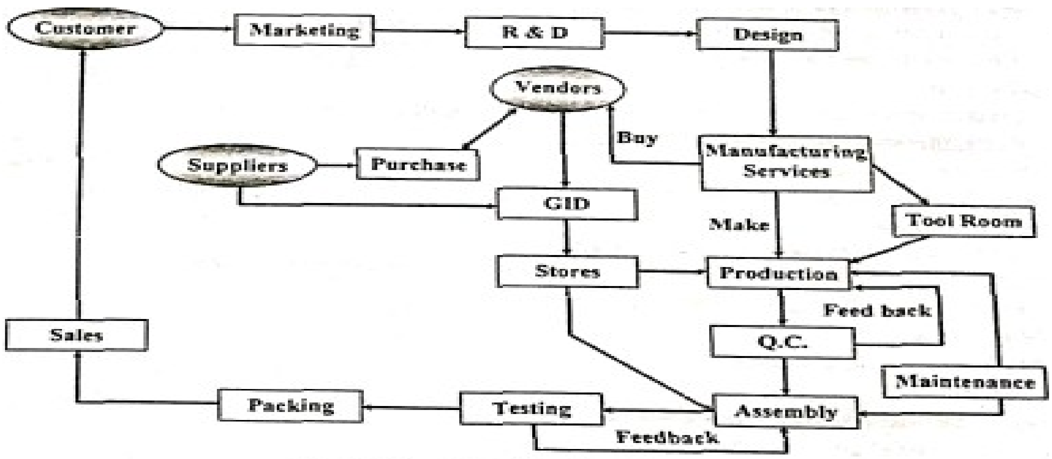


Fig. 1.2 Traditional Product Cycle

The various functions of each department are summarised below-

Marketing Department-

- ✓ Market survey
- ✓ Recognize customer needs
- ✓ Forecasting- Period wise-weekly , monthly, quarterly , product wise, region wise etc.
- ✓ Competitors Survey
- ✓ Customer order information

R & D

- ✓ Product concept
- ✓ Reverse engineering.
- ✓ Prototyping
- ✓ Competitors product comparison
- ✓ Previous product comparison

Design

- ✓ Design, release process- Modelling, assembly, drafting, analysis
- ✓ Optimisation, sensitive analysis
- ✓ New Product development
- ✓ Product specification and manual preparation
- ✓ BOM generation

Manufacturing services (production planning and control)

- ✓ Processes Design
- ✓ Design tools, Jigs , fixtures
- ✓ Capacity planning
- ✓ Make or Buy decision

1.4 CAD / CAM / CAE

- ✓ New resources procurement-man. Machines
- ✓ Coordination between- Production, QC, Maintenance, Tool room, assembly.
- ✓ Time study, method study

Production

- ✓ Prepare production plan day wise, weekly or monthly
- ✓ Assignment- Man, Machine-shift wise
- ✓ Inprocess inspection
- ✓ Involve in new design process-DFM

Quality Control

- ✓ Calibration of gauges, measuring tools
- ✓ Metallurgical testing
- ✓ Goods Inward Department (GID)
- ✓ SQC tools
- ✓ Machine Alignment tests

Tool Room

- ✓ Jig,fixture design and manufacturing.
- ✓ Gauge maintenance

Purchase

- ✓ Procurement , Vendor rating etc.

Sales

- ✓ After sales services
- ✓ Sales analysis- productwise, period, region, customer type.
- ✓ Sales comparison with competitors

3. *EXPLAIN ABOUT REFRESH DISPLAY. WRITE ITS ADVNTAGES AND DISADVANTAGES.*

Output devices form the other half of a CAD/CAM workstation, the first being the input devices. While CAD/CAM applications require the conventional output devices such as alphanumeric (video) displays (terminals) and hardcopy printers, they require output devices to display graphics to the user. Graphics output devices can be divided into soft and hard devices. The former refers to the graphics displays or terminals which only display information on a screen. Hard output devices refer to hardcopy printers and plotters that can provide permanent copies of the displayed information.

Refresh Display.

- Early displays in the 1960's was refresh displays. The figure shows the main components of atypical refresh display.
- The deflection system of the CRT is controlled and driven by the vector and character generator and digital-to-analogue convertors.
- The refresh buffer stores the display file or programs.
- Refresh processer/display processor redraw or refresh the graphics on the CRT at least 30 to 60 times per second.
- It generates graphics based on vector scan concepts.

In this system, the deflection system of the CRT is controlled and driven by the vector and character generators and digital-to-analog converters. The refresh buffer stores the display file or program, which contains points, lines, characters, and other attributes of the picture to be drawn these commands are interpreted and processed by the display processor. The electron beam accordingly excites the phosphor, which glows for a short period. To maintain a steady flicker-free image, the screen must be refreshed or redrawn at least 30 to 60 times per second, that is, at a rate of 30 to 60 Hz.

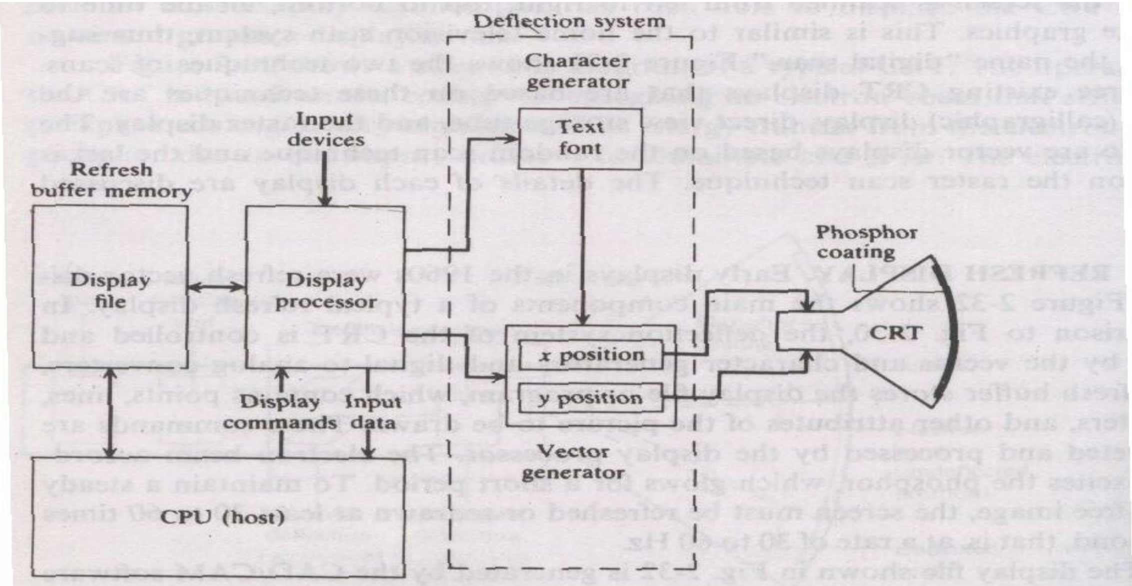


FIGURE 2-32
Refresh display.

The display file is generated by the CAD/CAM software and is considered a data structure which must be updated and constructed according to the needs of the application program, that is, the software. Changes made to the display file by the software must be synchronized with the display refresh cycle to prevent the display of an incomplete picture. If the software updates the file fast enough, then it is possible to use the dynamic techniques such as animation to stimulate movements as well as developing responsive user interfaces.

Advantages:

1.It is high resolution (4096x4096) device.

2.It generates high quality pictures.

3. It is an expensive device.

Disadvantages:

1.The refresh display is able to generate only two levels of colour intensity (i.e., Two colour images).

2.It is very expensive.

4. Derive the parametric equation for Bezier curve.

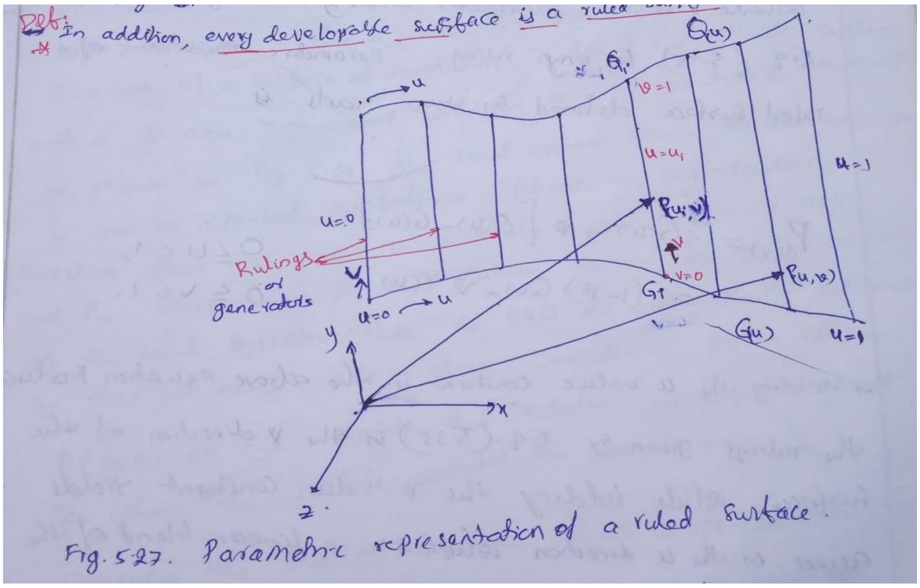
5. ***Derive the parametric equation for Hermit cubic curve.***

Unit - 2

1. Derive the parametric equation for Ruled surface and coons' patch.

Ruled Surface.

- A ruled surface is generated by joining corresponding points on two space curves (vails) G(u) and Q(u) lines. They are also called as rulings and generators.
- The main characteristics of ruled surface is that there is at least one straight line passing through P(u,v) and lying entirely on the surface.
- In addition, every developable surface is a ruled surface.



- Cone and cylinders are examples of ruled surfaces and plane surfaces is considered as the simplest of a surface.
- To develop the parametric equation of a ruled surface, consider the ruling u = u_i, joining points G_i and Q_i on the vails G(u) and Q(u) respectively. The equation of ruling becomes

$$P_{(u_i,v_i)} = G_i + v(Q_i - G_i)$$

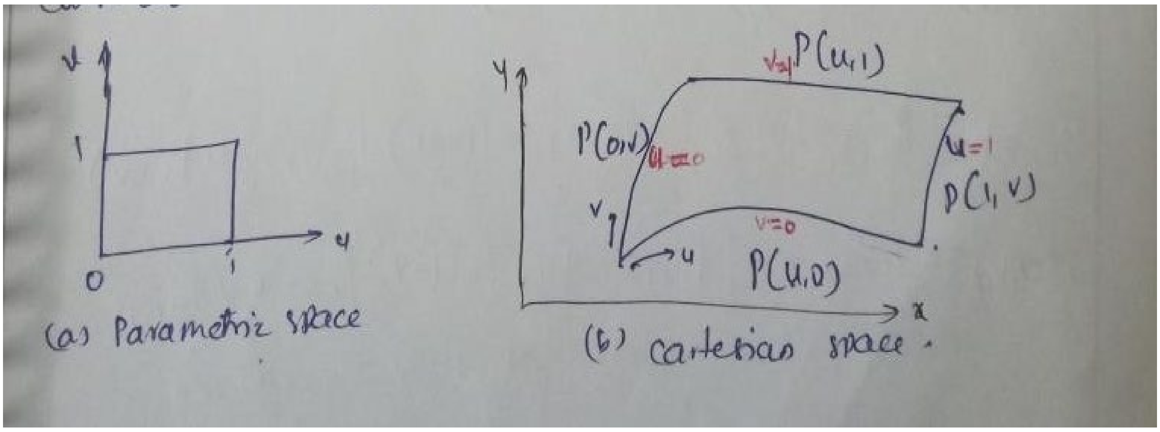
- Where v is the parameter along the ruling. Generating equation for any ruling, parametric equation of a rules surface defined by two vails is

$$P_{(u,v)} = G_{(u)} + v\left(Q_{(u)} - G_{(u)}\right)$$
$$= (1 - v)G_{(u)} + vQ_{(u)} \qquad 0 \le u \le 1,\ 0 \le v \le 1.$$

- Holding u value constant in the above equation produces the rulings given by the ruling equation in the v direction of the surfaces which holding the v values constant yields arrives in the direction which are a linear blend of the vails.

Coons' patch.

- All the surfaces introduced thus share one common philosophy that is they all require a finite number of data points to generate the respective surface.
- In contract, a coon's surface patch is a form of transfinite interpolation, which indicates that coons scheme interpolates to an infinite number of data points. i.e., to all the points of a curve segment to generate the surface.
- The coon's patch is particularly useful in blending four prescribed intersecting curves which form a closed boundary.
- The figure shows the four boundary curves as $P_{(u,0)}$, $P_{(1,v)}$, $P_{(u,1)}$, $P_{(0,v)}$. It is assumed that u and v range from 0 to 1 along the boundaries and that each pair of opposite boundary curve are identically parameterized.



- Let us first consider the case of a bilinearly blended coons' patch which interpolates to the four boundary curves shown.
- For this case it is useful to recall that a rules surface interpolates linearly between two given boundary curves in one direction. Therefore, the superposition of two ruled surface connecting the two pairs boundary curves might satisfy the boundary curve condition and produces the coon's patch. Let us investigate this claim utilizing v and u directions, which gives respectively.

$$P_{1(u,v)} = P_{(0,v)} + u\left(P_{(1,v)} - P_{(0,v)}\right) = (1-u)\,P_{(0,v)} + u\,P_{(1,v)} \qquad \text{-----1}$$

$$P_{2(u,v)} = P_{(u,0)} + v\left(P_{(u,1)} - P_{(u,0)}\right) = (1-v)\,P_{(u,0)} + v\,P_{(u,1)} \qquad \text{-------2}$$

Adding the above two equations gives then equation surface.

$$P_{(u,v)} = P_{1(u,v)} + P_{2(u,v)}$$

2. *Derive the parametric equation for Bezier surface.*

- Bezier surface is an extension of the Bezier curve in two parametric directions u and v.
- An orderly set of data or control points is used to build a topologically rectangular surface. The surface parametric equation can be written as:

$$P(u,v) = \sum_{i=0}^{n} \sum_{j=0}^{m} P_{ij}\, B_{i,n}(u)\, B_{j,m}(v) \quad \text{: (i) — 5.62}$$

$$0 \le u \le 1, \quad 0 \le v \le 1.$$

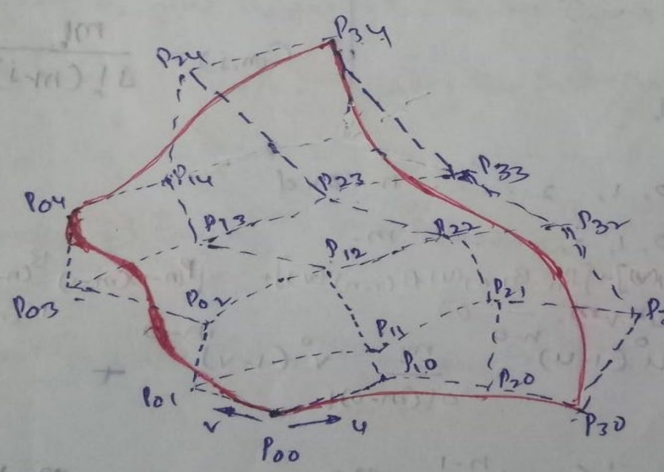


Fig 5-33. A 4×5 Bezier surface.

- Where P(u,v) is any point on the surface and Pij are the control points.
- These points form the vertices of the control or characteristic polyhedron of the resulting Bezier surface.
- The points are arranged in an (n+1) * (m+1) rectangular array, as seen from the above equation.

→ Where $B_{i,n}$ and $B_{j,m}$ are Bernstein polynomials

$$B_{(i,n)}(u) = C(n,i)\, u^{i} (1-u)^{n-i} \qquad B_{(j,m)}(v) = C(m,j)\, v^{j} (1-v)^{m-j}$$

$$C(n,i) = \frac{n!}{i!\,(n-i)!} \qquad C(m,j) = \frac{m!}{j!\,(m-j)!}$$

Substitute $i = 0, 1, 2 \ldots n$ and

$j = 0, 1, 2, \ldots m.$

The eqn ① can be expanded as

$$
\begin{aligned}
P_{(u,v)} = {} & P_{00}\, B_{0,n}(u)\, B_{0,m}(v) + P_{11}\, B_{1,n}(u)\, B_{1,m}(v) \\
& P_{22}\, B_{2,n}(u)\, B_{2,m}(v) + P_{33}\, B_{3,n}(u)\, B_{3,m}(v) \\
& + \cdots\cdots \\
& + P_{(n-1)(m-1)}\, B_{(n-1),n}(u)\, B_{(m-1),m}(v) + P_{nm}\, B_{n,n}(u)\, B_{m,m}(v)
\end{aligned}
\quad \text{Symmetric terms in } u \text{ and } v.
$$

$$
\left.
\begin{aligned}
& + P_{10}\, B_{1,n}(u)\, B_{0,m}(v) + P_{01}\, B_{0,n}(u)\, B_{1,m}(v) \\
& + P_{20}\, B_{2,n}(u)\, B_{0,2}(v) + P_{02}\, B_{0,n}(u)\, B_{2,m}(v) \\
& + \cdots\cdots\; P_{n0}\, B_{n,n}(u)\, B_{0,m}(v) + P_{0m}\, B_{0,n}(u)\, B_{m,m}(v) \\
& + \cdots\cdots \\
& + P_{(n-1)(m-2)}\, B_{(n-1),n}(u)\, B_{(m-2),m}(v) + P_{(n-2)(m-1)}\, B_{(n-2),n}(u)\, B_{(m-1),m}(v) \\
& + P_{(n-1)m}\, B_{(n-1),n}(u)\, B_{m,m}(v) + P_{n(m-1)}\, B_{n,n}(u)\, B_{(m-1),m}(v)
\end{aligned}
\right\} \text{Non symmetric terms in } u \text{ and } v. \quad (2)
$$

$0 \le u \le 1$

$0 \le v \le 1$

$$P(u,v) = P_{00} \frac{n!}{0!(n-0)!} u^0 \cdot (1-u)^{n-0} \cdot \frac{m!}{0!(m-0)!} v^0 (1-v)^{m-0} +$$

$$P_{11} \frac{n!}{1!(n-1)!} u^1 (1-u)^{n-1} \frac{m!}{1!(m-1)!} v^1 (1-v)^{m-1} + P_{22} \frac{n!}{2!(n-2)!} u^2 (1-u)^{n-2} \cdot \frac{m!}{2!(m-2)!} v^2 (1-v)^{m-2}$$

$$+ P_{33} \frac{n!}{3!(n-3)!} u^3 (1-u)^{m-2} \cdot \frac{m!}{3!(m-3)!} v^3 (1-v)^{m-2} +$$

$$\cdots\cdots\cdots\cdots$$

$$P_{(n-1)(m-1)} \cdot \frac{n!}{(n-1)![n-(n-1)]!} u^{n-1} (1-u)^{n-(n-1)} \cdot \frac{m!}{(m-1)![m-(m-1)]!} v^{m-1} \cdot (1-v)^{m-(m-1)} +$$

$$P_{n,m} \frac{n!}{n!(n-n)!} u^n (1-u)^{n-n} \cdot \frac{m!}{m!(m-m)!} v^m (1-v)^{m-m} + \cdots\cdots$$

$$+ P_{10} \frac{n!}{1!(n-1)!} u^1 (1-u)^{n-1} \frac{m!}{0!(m-0)!} v^0 (1-v)^{m-0} + P_{01} \frac{n!}{0!(n-0)!} u^0 (1-u)^{n-0} \cdot \frac{m!}{1!(m-1)!} v^1 (1-v)^{m-1}$$

$$+ P_{20} \frac{n!}{2!(n-2)!} u^2 (1-u)^{n-2} \cdot \frac{m!}{0!(m-0)!} v^0 (1-v)^{m-0} + P_{02} \frac{n!}{0!(n-0)!} u^0 (1-u)^{n-0} \cdot \frac{m!}{2!(m-2)!} v^2 (1-v)^{m-2}$$

$$+ \cdots + \cdots\cdots\cdots$$

$$P_{n0} \frac{n!}{n!(n-n)!} u^n \cdot (1-u)^{n-n} \cdot \frac{m!}{0!(m-0)!} u^0 (1-v)^{m-0} + P_{0m} \cdot \frac{n!}{0!(n-0)!} u^0 (1-u)^{n-0} \cdot \frac{m!}{m!(m-m)!} v^m (1-v)^{m-m} \cdot$$

$$\cdots\cdots\cdots\cdots$$

$$P_{(n-1)m} \cdot \frac{n!}{(n-1)![n-(n-1)]!} u^{n-1} \cdot (1-u)^{n-(n-1)} \cdot \frac{m!}{m!(m-m)!} u^m (1-u)^{m-m} +$$

$$P_{n,(m-1)} \cdot \frac{n!}{n!(n-n)!} u^n (1-u)^{n-n} \cdot \frac{m!}{(m-1)![m-(m-1)]!} v^{m-1} (1-v)^{m-(m-1)}$$

$$0 \le u \le 1 \qquad 0 \le v \le 1 \qquad - (3)$$

$$P(u,v) = P_{00}(1-u)^n(1-v)^m + P_{11}\frac{n!}{1!(n-1)!}u(1-u)^{n-1}\cdot\frac{m!}{1!(m-1)!}v\cdot(1-v)^{m-1}$$

$$P_{22}\frac{n!}{2!(n-2)!}u^2(1-u)^{n-2}\cdot\frac{m!}{2!(m-2)!}v^2(1-v)^{m-2} +$$

$$P_{33}\frac{n!}{3!(n-3)!}u^3(1-u)^{n-3}\cdot\frac{m!}{3!(m-3)!}v^3(1-v)^{m-3} + \cdots\cdots$$

$$P_{(n-1)(m-1)}\frac{n!}{(n-1)!\,1!}u^{n-1}\cdot(1-u)\cdot\frac{m!}{(m-1)!}v^{m-1}(1-v) + \cdots P_{nm}u^n v^m +$$

$$P_{10}\frac{n!}{1!(n-1)!}u(1-u)^{n-1}(1-v)^m + P_{01}(1-u)^n\cdot\frac{m!}{1!(m-1)!}v(1-v)^{m-1} +$$

$$P_{20}\frac{n!}{2!(n-2)!}u^2(1-u)^{n-2}(1-v)^m + P_{02}(1-u)^n\cdot\frac{m!}{2!(m-2)!}v^2(1-v)^{m-2} +$$

$$\cdots\cdots\cdots$$

$$+ P_{n0}u^n(1-v)^m + P_{0m}(1-u)^n v^m + \cdots\cdots$$

$$P_{(n-1)m}\frac{n!}{(n-1)!\,1!}u^{n-1}\cdot(1-u)\cdot v^m + P_{n(m-1)}u^n\cdot\frac{m!}{(m-1)!\,1!}v^{m-1}(1-v)$$

$0 \le u \le 1$

$0 \le v \le 1$

4

3. *What are the primitive solids? Explain.*

- Solid entities are known as solid primitives.
- Primitives are simple basic shapes and are considered as the solid modeling entities which can be considered by a mathematical set of Boolean operations to create the solid.
- Following are description of the most used primitives.

1. ***Block:*** This is a box generated data which is defined by its width, height, and depth. The local coordinates system is x, y, z. Point P defines the origin of the x, y, z system.

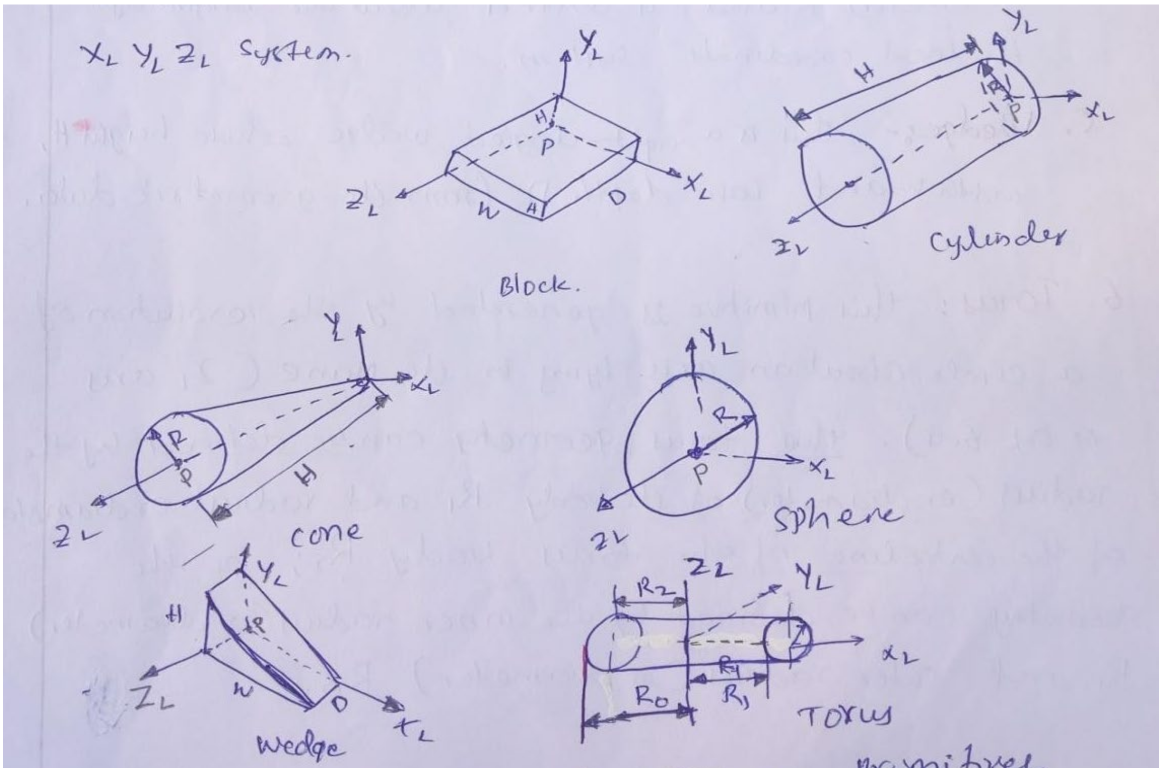


Fig-6.4 Most common primitives.

2. ***Cylinder:*** This primitive is a right circular cylinder whose geometry is defined by its radius or diameter R and length H. The length H is usually taken alongside direction of Z axis.

3. ***Cone:*** This primitive is a right circular cone or a frustum of a right circular cone whose base radius R, top radius (for truncated cone) and height H are user defined.

4. ***Sphere:*** This primitive is defined by its radius or diameter R and is centered about the origin of its local coordinate system.

5. ***Wedge:*** This is a right-angled wedge whose height H, width W and Base depth D from its geometric data.

6. ***Torus:*** This primitive is generated by the revolution of a circle about an axis lying in its plane (z axis). This Torus geometry can be defined by the radius of its body R1 and radius of the centerline of the Torus body R2, or the geometry can be defined by the inner radius R1 and outer radius R0.

4. Explain Boundary representation method.

* Boundary Representation (B-rep)

→ A b-rep solid is represented as a volume contained by a set of faces together with topological information which defines the relationship between the faces.

→ unlike wirefram representation, boundary representation is based on the concept that a solid is bounded by a set of faces as shown in Fig. 4.83. Thus, it is an extension of wireframe by adding the face information.

→ The main advantage of a b-rep model is that a solid is bounded by its surfaces and has its interior and exterior clearly defined.

→ The boundary of a solid seperates inside points from outside points.

* The geometric model of the object can be described by its boundaries, namely, vertices, edges and surfaces or faces. Each face is bounded by edges and each edge is bounded by vertices.

Faces can be formed by either straight line objects or curve segments.

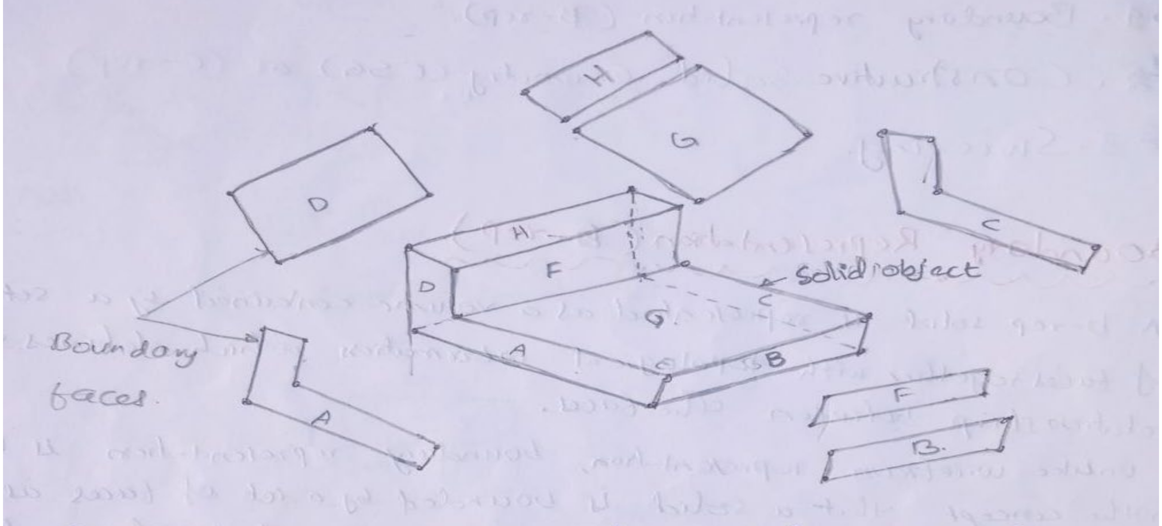


Fig. 4.83. Representation of a solid by its faces.

- Only the boundary surfaces of the model are stored, and the volumetric properties are calculated by the gauss divergence theorem, which relates volume integrated to surface integrates. This schema can model a variable of solids depending on the primitive surfaces (planer, curved or sculptured).
- B. representation is a method for representing shapes using the limits. A solid is Represented as a collection of Connected surface elements, the boundary between Solid and Non-solid.
- Some of the definition of the objects that will be found in B Rep models are:

Vertex: It is a unique point in space.

Edge: A non-intersecting space curve bounded by two vertices that are not necessarily distinct.

Loop: It is an ordered alternating sequence of vertices and edges. A loop defined a non-Self intersecting closed space curve.

Face: It is defined as a finite connected non-Self intersecting region of a closed oriented surface bounded by one or more loops.
Normally, a face is a bounded region of a planar, quadratic, and sculptured surface.

Genus: It is the topological name for the number of handles or through holes in an object.

Body: It is an entity that has a set of faces that bound a single connected closed volume. A minimum body is a point.

The total information present in a B representation model is classified into topological and geometric data.

- The topological part of the data provides the relationship among its objects such as vectors, edges and faces.
- Like that used in a wireframe model along with the orientation of the edges and faces.

Advantages

- Combining wireframe and surface models are possible.
- It is particularly suitable for modeling parts having internal symmetry.
- Computational effort and time required to display the models are less as compared with CSG C-Rep.

Disadvantages

- The data to be stored is more and hence it require more memory.
- There is no guarantee that the object created is valid or not.
- It is usually less robust than the half-space method.

5. Explain in detail about sweeping.

- Schema based on Sweep representation are useful in creating solid model of two and a half dimension objects.
- The class of two and a half dimensional objects includes both solids of uniform thickness in each direction and axisymmetric solids.
- The forms are known as extruded solids and are created via translated sweep, the latter are solids of revolution which can be created via rotational sweep.
- Sweeping is used in general as a means of entire object.

Sweep representations are used to construct three dimensional objects from two-dimensional shape. There are two ways to achieve sweep:

1. Translational sweep
2. Rotational sweep.

In ***translational sweeps,*** the 2D shape is swept along a linear path normal to the plane of the area to construct three-dimensional object. To obtain the wireframe representation we must replicate the 2D shape and draw a set of connecting lines in the direction of shape.

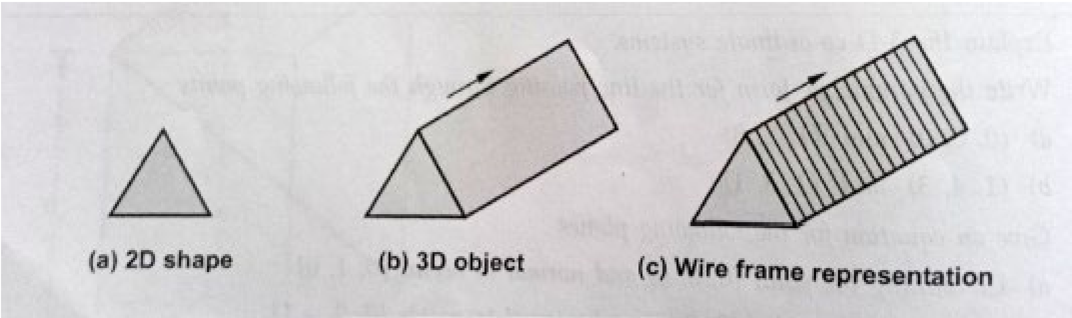


Fig. (8) Translational sweep

In ***rotational sweeps***, the 2D shape is rotated about a axis of rotation specified in the plane of 2D shape to produce three dimensional object. This is illustrated in figure (9).

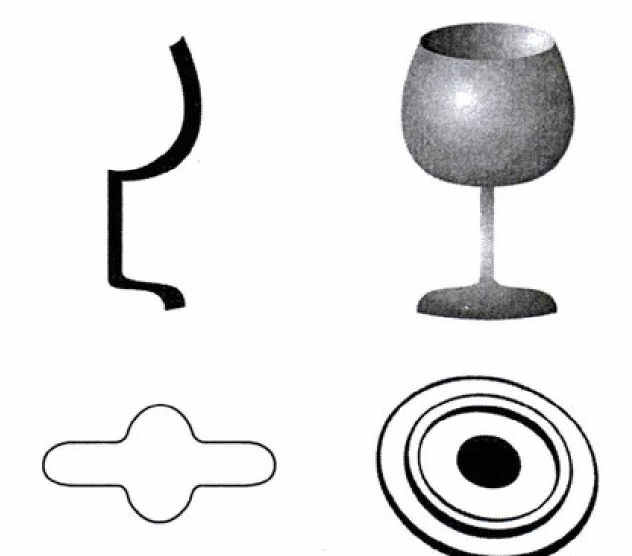
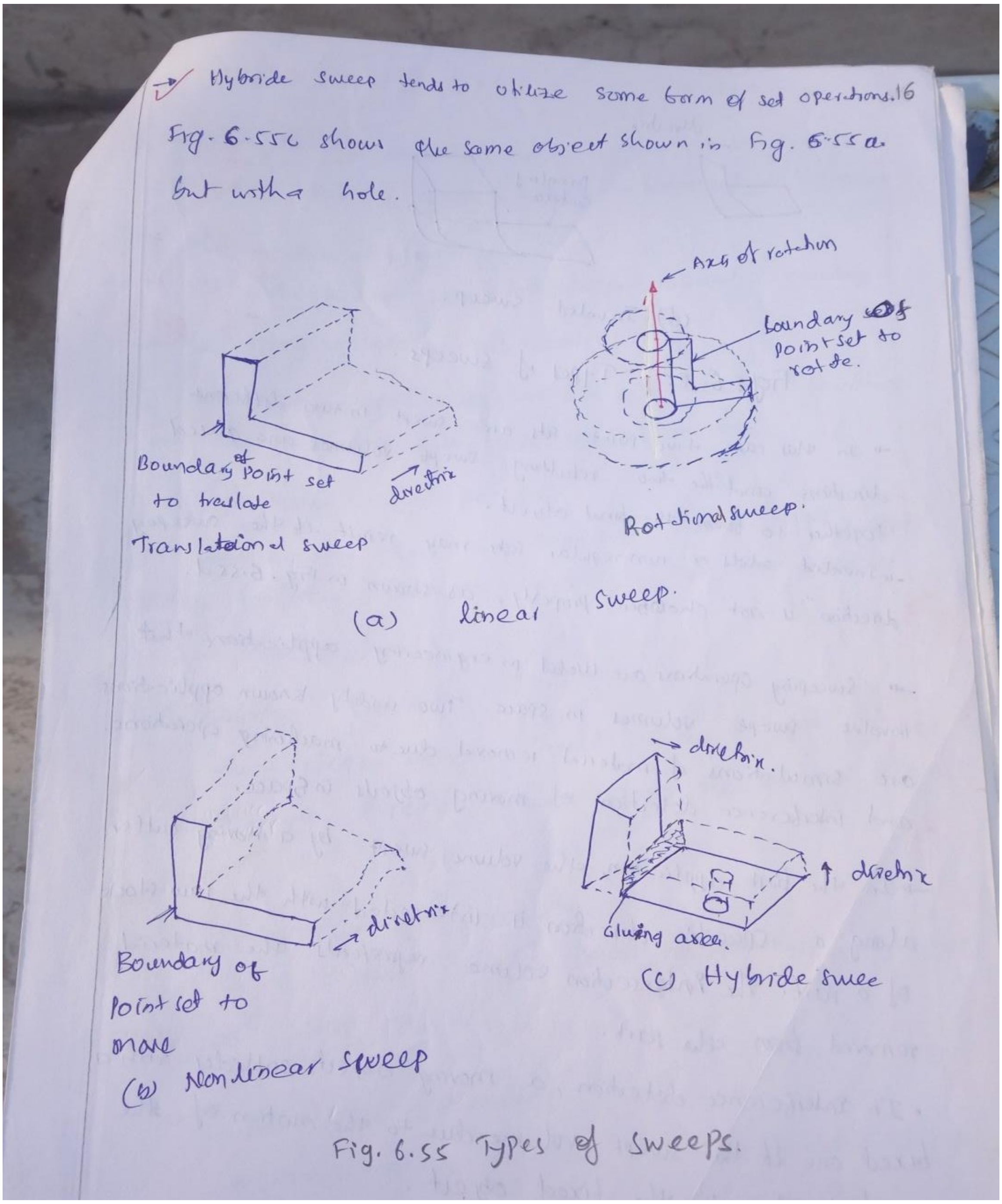


Fig. (9)



In general, we can specify sweep constructions using any path. For translation we can vary the shape or size of the original 2D shape along the sweep path. For rotational sweeps, we can move along a circular path through any angular distance from 0° to 360°. These sweeps whose generating area or volume changes in size, shape, or orientation as they are swept and that follow an arbitrary curved trajectory are called general sweeps. General sweeps are difficult to model efficiently for example, the trajectory and object shape may make the swept object intersect itself, making volume calculations complicated. Furthermore, general sweeps do not always generate solids. For example, sweeping a 2D shape in its own plane generates another 2D shape.

Unit – 3

1. Explain types of NC motion control systems.

In 0rder to accomplish the machining process, the cutting tool and work piece must be moved relative to each other. In NC there are three basic types of motion control systems.

♦ 1.Point- To- Point (PTP)/Positioning

♦ 2.Straight cut/Paraxial

♦ 3.Contouring

♦ PTP system represents the lowest level of the motion control and contouring represents highest level of motion control between the tool and work piece.

1. Point-To-Point (PTP)

♦ PTP is also sometimes called as Positioning system.

♦ Positioning systems are the simplest machine tool control systems and least expensive.

♦ In PTP, the objective of the machine tool control system is to move the cutting tool to a predefined location.

♦ The speed or path by which this movement is accomplished is not important in PTP NC. Once the tool reaches the defined location, the machining operation is performed at that location.

♦ NC drill press is a good example of PTP system.

♦ Figure 8.5 shows PTP type of control system.

♦ Another example of PTP is spot welding.

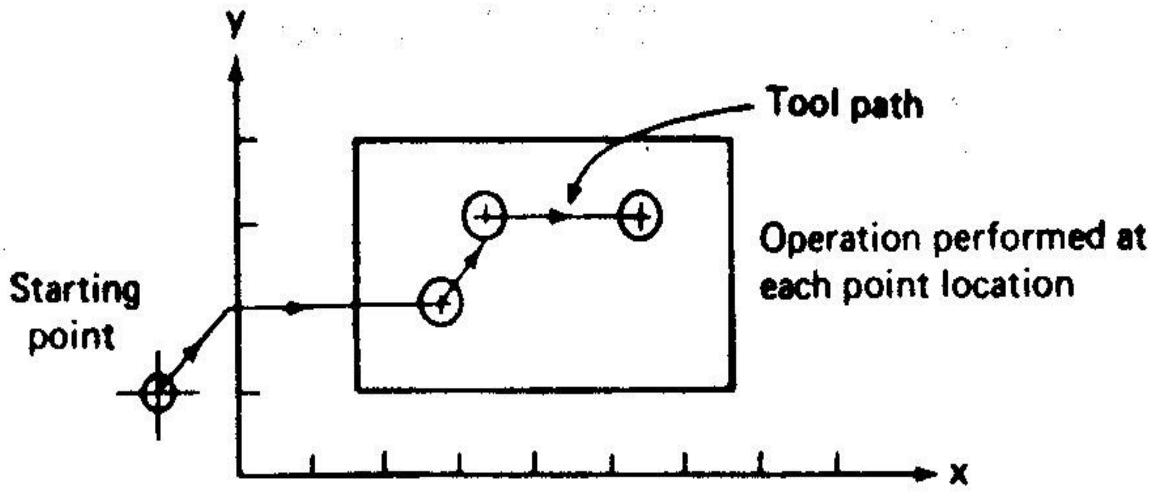


FIGURE 8.5 Point-to-point (positioning) control in NC.

2. Straight cut/Paraxial

♦ Straight cut systems can move the cutting tool parallel to one of the major axes at a controlled rate suitable for machining.

♦ It is therefore appropriate for performing milling operations to fabricate work pieces of rectangular configurations.

♦ 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 work piece would not be possible.

♦ An example of a straight cut operation is shown in figure 8.6.

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

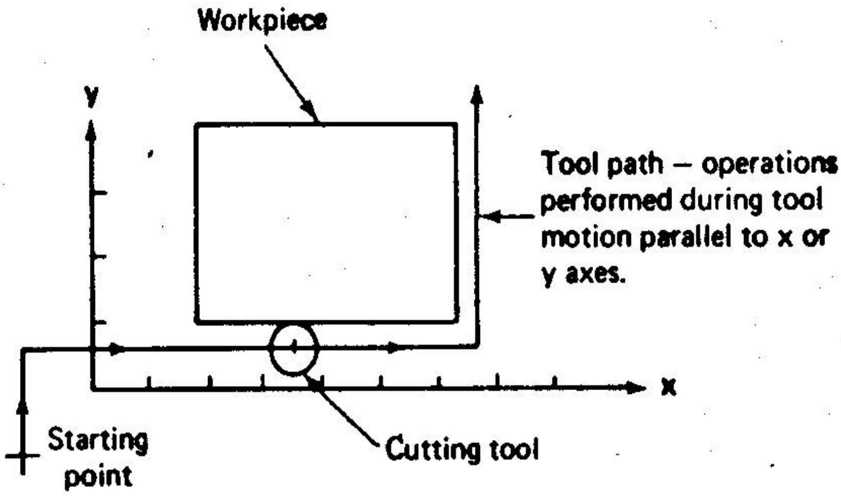


FIGURE 8.6 Straight-cut control in NC.

3. Contouring

♦ Contouring is the most complex, most flexible, and most expensive type of machine tool control system.

♦ It can perform both PTP cut and Straight cut operations.

♦ In addition, the distinguishing feature of the contouring NC system is their capacity for simultaneous control of more than one axis movement of the machine tool.

♦ The path of the cutter is continuously controlled to generate the desired geometry of the work piece. For this reason, contouring systems are also called continuous path NC system.

♦ Straight or plane surfaces at any orientation, circular paths, conical shapes, or any other mathematically definable form are possible under contouring control.

♦ In contouring NC, feed rate is also continuously control.

2. Define NC. Explain NC coordinate system.

Numerical Control can be defined as form of programmable instructions, in which machining processes/operations controlled by numbers, letters and symbols.

♦ In NC, letters and numbers form a program of instructions for a particular work piece or job.

♦ When the job changes, the program of instructions are changed.

♦ The program of instructions is known as block of instructions.

NC CO-ORDINATE SYSTEMS

The part programmer can plan the sequence of positions and movements of the cutting tool relative to work piece.

♦ It is necessary to establish a standard axis system by which the relative positions can be specified.

♦ Using an NC drill press as an example. The spindle is in a fixed vertical position and the table is moved and controlled relative to the spindle.

♦ The two axes x and y are defined in the plane of the table and the Z-axis is perpendicular to this plane and movement in the *z* direction is controlled by the vertical motion of the spindle as shown in the figure 8.2.

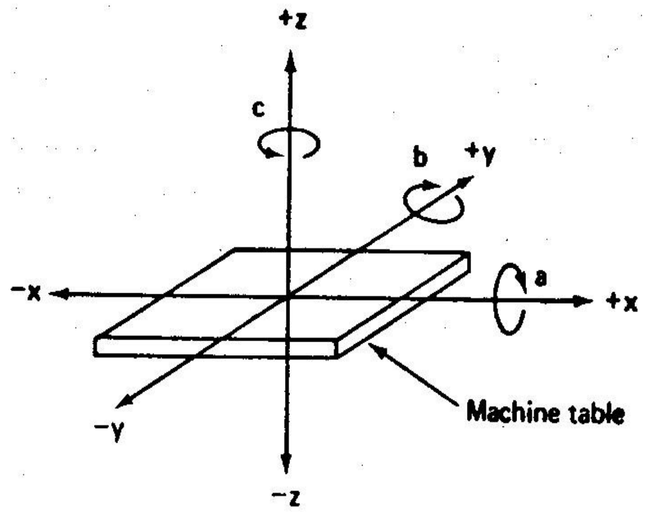


FIGURE 8.2 Machine tool coordinate system for NC.

In addition to the three linear axes, these machines may possess the three rotational axes a, b and c about x, y and z axes.

♦ For turning operations, two axes are normally required to command the movement of the tool relative to the rotating work piece.

♦ The z-axis is the axes of rotation of the work piece and the x-axis defines the radial location of the cutting tool. This arrangement is shown in figure 8.3.

♦ The purpose of the co-ordinate system is to provide a means of locating the tool in relation to the work piece.

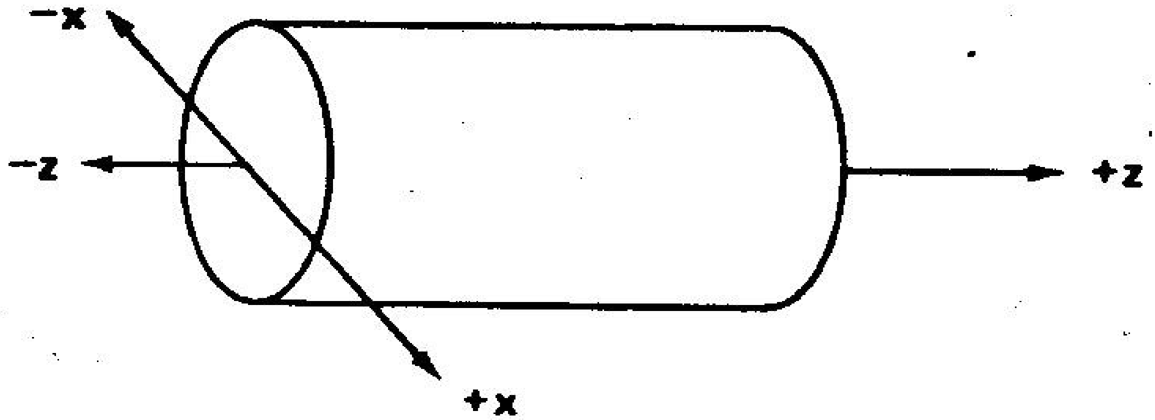


FIGURE 8.3 *x*- and *z*-axes for NC turning.

Fixed zero and Floating zero

♦ The programmer must determine the position of the tool relative to the origin (zero point) of the co-ordinate system. NC machines have two methods for specifying the zero point.

1.Fixed zero and
2.Floating zero

♦ The first possibility is for the machine to have a fixed zero. It is usually located at the southwest corner (i.e., lower left-hand corner).

♦ The second and more common feature on modern NC machines allows the machine operator to set the zero point at any position on the machine table or on the work piece. This feature is called floating zero.

Absolute and incremental positioning

♦ Another option sometimes available to the part programmer is to use either an absolute system of tool positioning or an incremental system of tool positioning.

♦ Absolute positioning means that the tool locations are always defined in relation to the zero point (i.e., either with reference to fixed zero or floating zero).

♦ Incremental positioning means that the next tool location must be defined with reference to the previous tool location.

♦ If in our drilling example, suppose that the previous hole had drilled at an absolute position of x = +4.00 and y = +5.000.

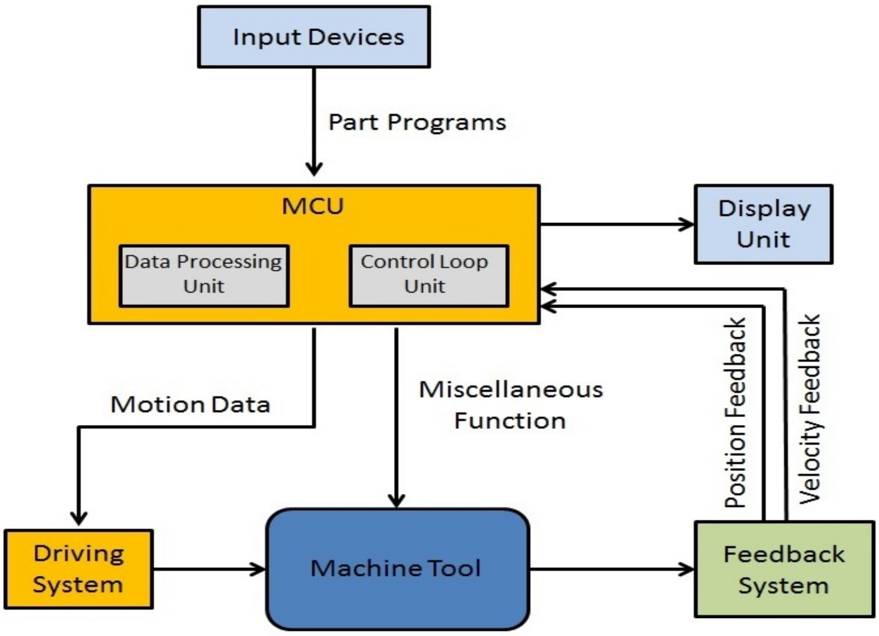
♦ Accordingly, the incremental position instructions would be specified as x = +2.000 and y = +3.00 in order to move the drill to the desired spot.

♦ Figure 8.4 illustrates the difference between absolute and incremental positioning.

3. With a block diagram explain the working of elements of NC system.

CNC stands for Computer Numerical Control.
When computers are used to control a Numerical Control (NC) machine tool than the machine is called CNC machine. In other words, the use of computers to control machine tools like lathe, mills, slotter, shaper etc is called CNC machine.

Block diagram of NC System.



Working of Elements of NC System.

The main parts of the CNC machine are

(i) Input Devices: These are the devices which are used to input the part program in the CNC machine. There are three commonly used input devices, and these are punch tape reader, magnetic tape reader and computer via RS-232-C communication.

(ii) Machine Control Unit (MCU): It is the heart of the CNC machine. It performs all the controlling action of the CNC machine, the various functions performed by the MCU are

- It reads the coded instructions fed into it.
- It decodes the coded instruction.
- It implements interpolation (linear, circular, and helical) to generate axis motion commands.
- It feeds the axis motion commands to the amplifier circuits for driving the axis mechanisms.
- It receives the feedback signals of position and speed for each drive axis.
- It implements the auxiliary control functions such as coolant or spindle on/off and tool change.

(iii) Machine Tool: A CNC machine tool always has a slide table and a spindle to control of the position and speed. The machine table is controlled in X and Y axis direction and the spindle is controlled in the Z axis direction.

(iv) Driving System: The driving system of a CNC machine consists of amplifier circuits, drive motors and ball lead screw. The MCU feeds the signals (i.e., of position and speed) of each axis to the amplifier circuits. The control signals are than augmented (increased) to actuate the drive motors. And the actuated drive motors rotate the ball led screw to position the machine table.

(v) Feedback System: This system consists of transducers that act as sensors. It is also called a measuring system. It contains position and speed transducers that continuously monitor the position and speed of the cutting tool located at any instant. The MCU receives the signals from these transducers and it uses the difference between the reference signals and feedback signals to generate the control signals for correcting the position and speed errors.

(vi) Display Unit: A monitor is used to display the programs, commands and other useful data of CNC machine.

How CNC Machine Works

- First, the part program is inserted into the MCU of the CNC.
- In MCU all the data process takes place and according to the program prepared, it prepares all the motion commands and sends it to the driving system.
- The drive system works as the motion commands are sent by MCU. The drive system controls the motion and velocity of the machine tool.
- The feedback system records the position and velocity measurement of the machine tool and sends a feedback signal to the MCU.
- In MCU, the feedback signals are compared with the reference signals and if there are errors, it corrects it and sends new signals to the machine tool for the right operation to happen.
- A display unit is used to see all the commands, programs, and other important data. It acts as the eye of the machine.