IV/IV B. Tech (Supplementary) DEGREE EXAMINATION Feb'2021

Mechanical Engineering

CAD/CAM (14ME 704)

Detailed Scheme of Evaluation

Max. Marks: 60

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1. **Answer all the questions.** (1x12=12)

(a) Define Computer Graphics.

Answer: Computer graphics is an art of drawing pictures on computer screens with the help of programming. It involves computations, creation, and manipulation of data. In other words, we can say that computer graphics is a rendering tool for the generation and manipulation of images

(b) What is Raster Scan Display?

Answer: In a raster scan system, the electron beam is swept across the screen, one row at a time from top to bottom. As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots.

(c) What is Homogeneous coordinate system?

Answer: A homogeneous coordinate system is one in which a 3-dimensional point is represented using four coordinates by adding a dummy coordinate. These are frequently useful in representing the projective operations inherent in computer graphics systems. It has two principal uses:

- It allows the use of 4 × 4 matrices to represent general 3-dimensional transformations
- It allows a simplified representation of mathematical functions – the rational form – in which rational polynomial functions can be simply represented.

(d) List techniques to improve visual realism?

Answer: **Shading, Lighting, Transparency and coloring** are few techniques to improve visual realism

(e) What is normal coordinate system?

Answer: Normal coordinate system *or* Normalized device coordinates (NDCs) make up a coordinate system that describes positions on a virtual plotting device. The lower left corner corresponds to (0, 0), and the upper right corner corresponds to (1, 1).
NDCs can be used when you want to position text, lines, markers, or polygons anywhere on the plotting device (that may or may not already contain a plot).

(f) What is rendering?

Answer: **Rendering** or **image synthesis** is the automatic process of generating a photorealistic or non-photorealistic image from a 2D or 3D model (or models in what collectively could be called a *scene* file) by means of computer programs. Also, the results of displaying such a model can be called a **rendering**. The term "rendering" may be by analogy with an "artist's rendering" of a scene.

(g) What is CNC?

Answer: *Computer numerical control* (CNC) is defined as an NC system whose *MCU* is based on a dedicated microcomputer rather than on a hard-wired controller. Computer numerical control (CNC) is a method for automating control of machine tools through the use of software embedded in a microcomputer attached to the tool. It is commonly used in manufacturing for machining metal and plastic parts.

(h) Explain point to point NC system?

Answer: Also called position systems move the worktable to a programmed location without regard for the path taken to get to that location. Once the move has been completed, some processing action is accomplished by the work head at the location such as drilling or punching a hole. Thus, the program consists of a series of point locations, at which operations are performed.

(i) What is post processor?

Answer: A Post Processor is a unique "driver" specific to a CNC machine, robot or mechanism; some machines start at different locations or require extra movement between each operation, the Post-Processor works with the CAM software or off-line programming software to make sure the G-Code output or program is correct for a specific machine build.

The Post-Processor will alter the program output to suit a specific machine; a "Post" can be used for complex things like producing a proprietary machine language other than G-Code or M-Code, or a Post-Processor may be used to start a machine from a specific position

(j) Explain composite part concept.

Answer: The composite part concept is based on part families. It conceives of a hypothetical part for a given family that includes all of the design and manufacturing attributes of the family. In general, an individual part in the family will have some of the features that characterize the family, but not all of them. The composite part possesses all of the features.

(k) State any **two** benefits of CAPP.

Answer:
1) Process rationalization
2) Higher productivity of the process planners
3) Faster planning
4) Good visibility
5) Operate with other software

(l) State the applications of FMS

Answer: Historically, most of the applications of flexible machining systems have been in milling and drilling type operations (non rotational parts), using NC and subsequently CNC machining centers. FMS applications for turning (rotational parts) were much less common until recently, and the systems that are installed tend to consist of fewer machines. For example, single machine cells consisting of parts storage units, part loading robots, and CNC turning centers are widely used today, although not always in a flexible mode.

UNIT-I

2. (a) Differentiate between Random scan and Raster scan display systems (5M)

Parameter	Raster Scan System	Random Scan System
Resolution	It has poor or **less Resolution** because picture definition is stored as a intensity value.	It has **High Resolution** because it stores picture definition as a set of line commands.
Electron-Beam	**Electron Beam** is directed from top to bottom and one row at a time on screen, but electron beam is directed to whole screen.	**Electron Beam** is directed to only that part of screen where picture is required to be drawn, one line at a time so also called **Vector Display**.
Cost	It is **less expensive** than Random Scan System.	It is **Costlier** than Raster Scan System.
Refresh Rate	Refresh rate is **60 to 80 frames per second**.	Refresh Rate depends on the number of lines to be displayed i.e. **30 to 60 times per second**.
Picture Definition	It Stores **picture definition** in **Refresh Buffer** also called **Frame Buffer**.	It Stores picture definition as a set of **line commands** called **Refresh Display File**.
Line Drawing	**Zig – Zag line** is produced because plotted values are discrete.	**Smooth line** is produced because directly the line path is followed by electron beam .
Realism in display	It contains shadow, advance shading and hidden surface technique so gives the **realistic display** of scenes.	It does not contain shadow and hidden surface technique so it cannot give realistic display of scenes.
Image Drawing	It uses **Pixels** along scan lines for drawing an image.	It is designed for line drawing applications and uses various mathematical function to draw.

(b) Develop 'C' code to draw a line (7M)

Answer:

```
/*C graphics program to draw a line.*/

#include <graphics.h>
#include <conio.h>

main()
{
   int gd = DETECT, gm;

   //init graphics
   initgraph(&gd, &gm, "C:/TURBOC3/BGI");
   /*
   if you are using turboc2 use below line to init graphics:
   initgraph(&gd, &gm, "C:/TC/BGI");
   */

   //draw a line

   /*
   line() function description
   parameter left to right
   x1: 100
   y1: 100
   x2: 200
   y2: 100
   */
   line(100,100,200,100);     //will draw a horizontal line
```

```
    line(10,10,200,10); //will draw another horizonatl line

    getch();
    closegraph();
    return 0;
}
```

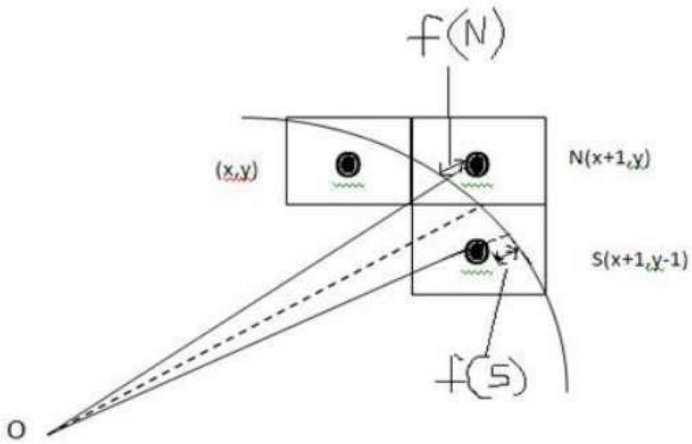
(OR)

3. (a) Develop Bresenham's algorithm to generate a Circle and highlight its advantages **(8M)**
Answer: We cannot display a continuous arc on the raster display. Instead, we have to choose the nearest pixel position to complete the arc.

From the following illustration, you can see that we have put the pixel at (X, Y) location and now need to decide where to put the next pixel − at N (X+1, Y) or at S (X+1, Y-1).

This can be decided by the decision parameter **d**.

- If d <= 0, then N(X+1, Y) is to be chosen as next pixel.
- If d > 0, then S(X+1, Y-1) is to be chosen as the next pixel.



Algorithm

Step 1 − Get the coordinates of the center of the circle and radius, and store them in x, y, and R respectively. Set P=0 and Q=R.

Step 2 − Set decision parameter D = 3 – 2R.

Step 3 − Repeat through step-8 while P ≤ Q.

Step 4 − Call Draw Circle (X, Y, P, Q).

Step 5 − Increment the value of P.

Step 6 − If D < 0 then D = D + 4P + 6.

Step 7 − Else Set R = R - 1, D = D + 4(P-Q) + 10.

Step 8 − Call Draw Circle (X, Y, P, Q).

(b) Explain the difference between 2D and 3D Transformations (4M)

Answer: Transformation means changing some graphics into something else by applying rules. We can have various types of transformations such as translation, scaling up or down, rotation, shearing, etc. When a transformation takes place on a 2D plane, it is called 2D transformation. Two-dimensional (2D) and three-dimensional (3D) computer graphics are all around us and enable us to be able to visualize and manipulate data everyday. What is the difference between 2D and 3D computer graphics, such as 3D Models? Let's explore the difference and similarities between them.

2D computer graphics:

2D computer graphics are digital images that are computer-based. They include 2Dgeometric models, such as image compositions, pixel art, art, photographs, and text. 2D graphics are used everyday on traditional printing and drawing. There are two kinds of 2D computer graphics - raster and vector graphics. Raster graphics or bitmaps are composed of arrays of pixels. Each pixel can be a different color or shade. They are edited on the pixel level and are used on most old computer and video games, graphing calculator games, and many mobile phone games. Vector graphics are composed of paths. Paths are used to describe the images by establishing mathematical relationships between points within an image. Vector graphics are mainly used on photographic images.

3D computer graphics:

3D computer graphics are graphics that use 3D representation of geometric data. This geometric data is then manipulated by computers via 3D computer graphics software in order to customize their display, movements, and appearance. 3D computer graphics are often referred to as3d models. A 3d model is a mathematical representation of geometric data that is contained in a data file. 3D models, can be used for real-time 3D viewing in animations, videos, movies, training, simulations, architectural visualizations or for display as 2D rendered images (2D renders).In contrast to a 2D graphics, a 3D model is a "mathematical representation of any 3Dobject." A 3D model is not technically a graphic until it is visually displayed as a 2Dimage through a process called 3D rendering. 3D models can also be or used in non-graphical computer simulations and calculations. One of the advantages that 2D graphics have over 3D models is that they allow more direct control of the image and are easier to change with relatively simple software packages. 3D models are not so easy to change because it requires specific 3D modeling skills and more complex and powerful 3D model software.3D models use many of the same mathematical algorithms as 2D vector graphics in the wire frame model. Also, when 3d models they are finally displayed as renders, they use similar algorithms as the 2D raster graphics. 3D models use many of the 2D rendering techniques, while 2D computer graphics use many of the 3D techniques to achieve realistic effects such as lighting.

UNIT-II

4. (a) Differentiate between boundary representations and CSG methods. (6M)

Answer: In computer-aided design, boundary representation—often abbreviated as B-rep or BREP—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. The basic method was developed independently in the early 1970s by Braid in Cambridge (for CAD) and Baumgart in America (for computer vision). Braid continued his work with the research solid modeller BUILD which was the forerunner of many research and commercial solid modelling systems. Braid worked on the commercial systems ROMULUS, the forerunner of Parasolid, and on ACIS. Parasolid and ACIS are the basis for many of today's commercial CAD systems.

Boundary representation models are comprised of two parts: topology and geometry. The main topological items are: faces, edges and vertices. A face is a bounded portion of a surface; an edge is a bounded piece of a curve and a vertex lies at a point. Other elements are the shell (a set of connected faces), the loop (a circuit of edges bounding a face) and loop-edge links (also known as winged-edge links or half-edges) which are used to create the edge circuits.

Unlike the constructive solid geometry (CSG) representation, which represents objects as a collection of primitive objects and Boolean operations to combine them, boundary representation is more flexible and has a much richer operation set. This richer operation set makes boundary representation a more appropriate choice for CAD systems than CSG. CSG was used initially by several commercial systems because it was easier to implement but the advent of reliable commercial B-rep kernel systems like Parasolid and ACIS, mentioned above, has led to widespread adoption of B-rep for CAD. As well as the Boolean operations, B-rep has extrusion, chamfering, blending, drafting, shelling, tweaking and other operations which make use of these.

Boundary representation is essentially a local representation connecting faces, edges and vertices. An extension of this was to group sub-elements of the shape into logical units called "features". Pioneering work was done on this by Kyprianou in Cambridge using the BUILD system and continued and extended by Jared and others. Much other work on this topic has been done in several research centres throughout the world and it is a subject of continuing interest. Features, or geometric features, are the basis of many other developments, allowing high-level "geometric reasoning" about shape for comparison, process-planning, manufacturing, etc.

Boundary representation has also been extended to allow special, non-solid model types called non-manifold models. As described by Braid, normal solids found in nature have the property that, at every point on the boundary, a small enough sphere around the point is divided into two pieces, one inside and one outside the object. Non-manifold models break this rule. An important sub-class of non-manifold models are sheet objects which are used to represent thin-plate objects and integrate surface modelling into a solid modelling environment.

(b) Develop the algorithm for rendering technique in Visual Realism. (6M)

Answer: **Rendering** or **image synthesis** is the automatic process of generating a photorealistic or non-photorealistic image from a 2D or 3D model (or models in what collectively could be called a *scene* file) by means of computer programs. Also, the results of displaying such a model can be called a **render**. A scene file contains objects in a strictly defined language or data structure; it would contain geometry, viewpoint, texture, lighting, and shading information as a description of the virtual scene. The data contained in the scene file is then passed to a rendering program to be processed and output to a digital image or raster graphics image file. The term "rendering" may be by analogy with an "artist's rendering" of a scene.

Many rendering **algorithms** have been researched, and software used for rendering may employ a number of different techniques to obtain a final image.

Tracing every particle of light in a scene is nearly always completely impractical and would take a stupendous amount of time. Even tracing a portion large enough to produce an image takes an inordinate amount of time if the sampling is not intelligently restricted.

Therefore, a few loose families of more-efficient light transport modelling techniques have emerged:

- ***rasterization,*** including scanline rendering, geometrically projects objects in the scene to an image plane, without advanced optical effects;
- ***ray casting*** considers the scene as observed from a specific point of view, calculating the observed image based only on geometry and very basic optical laws of reflection intensity, and perhaps using Monte Carlo techniques to reduce artifacts;
- ***ray tracing*** is similar to ray casting, but employs more advanced optical simulation, and usually uses Monte Carlo techniques to obtain more realistic results at a speed that is often orders of magnitude faster.

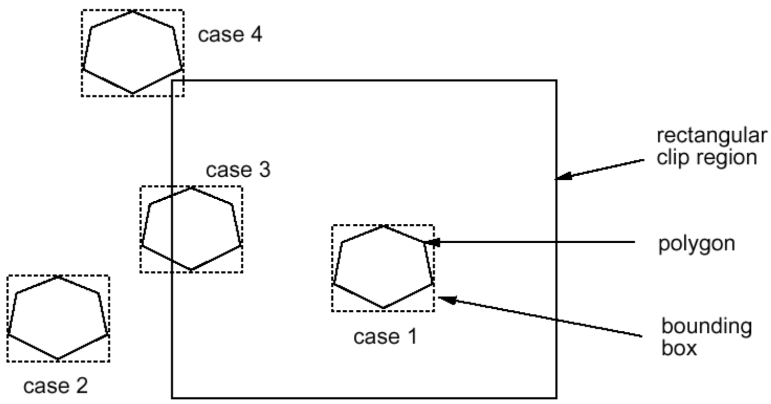
In **ray casting** the geometry which has been modeled is parsed pixel by pixel, line by line, from the point of view outward, as if casting rays out from the point of view. Where an object is intersected, the color value at the point may be evaluated using several methods. In the simplest, the color value of the object at the point of intersection becomes the value of that pixel. The color may be determined from a texture-map. A more sophisticated method is to modify the colour value by an illumination factor, but without calculating the relationship to a simulated light source. To reduce artifacts, a number of rays in slightly different directions may be averaged.

Ray casting involves calculating the "view direction" (from camera position), and incrementally following along that "ray cast" through "solid 3d objects" in the scene, while accumulating the resulting value from each point in 3D space. This is related and similar to "ray tracing" except that the raycast is usually not "bounced" off surfaces (where the "ray tracing" indicates that it is tracing out the lights path including bounces). "Ray casting" implies that the light ray is following a straight path (which may include travelling through semi-transparent objects). The ray cast is a vector that can originate from the camera or from the scene endpoint ("back to front", or "front to back"). Sometimes the final light value is a derived from a "transfer function" and sometimes it's used directly.

(OR)

5. (a) Explain about clipping process in solid modelling. (5M)

Answer: The purpose of 3D clipping is to identify and save all surface segments within the view volume for display on the output device. All parts of objects that are outside the view volume are discarded. Thus the computing time is saved. 3D clipping is based on 2D clipping. To understand the basic concept we consider the following algorithm:



<u>Polygon Clipping</u>

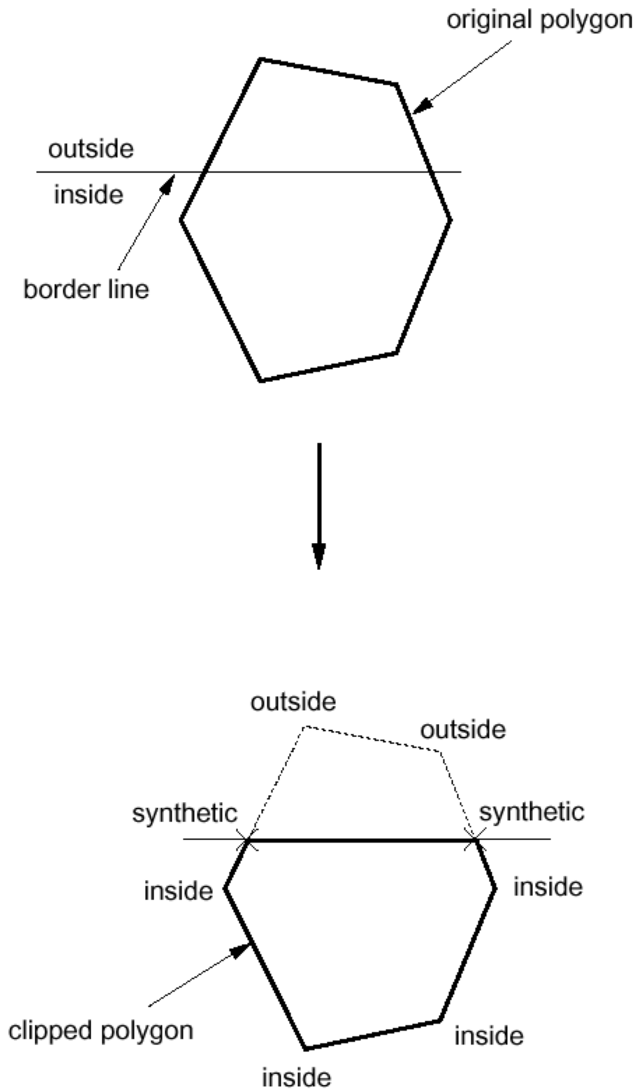
Assuming the clip region is a rectangular area,

1. The rectangular clip region can be represented by x_{min}, x_{max}, y_{min} and y_{max}.
2. Find the bounding box for the

polygon: ie. the smallest rectangle enclosing the entire polygon.
3. Compare the bounding box with the clip region (by comparing their x_{min}, x_{max}, y_{min} and y_{max}).
4. If the bounding box for the polygon is completely outside the clip region (case 2), the polygon is outside the clip region and no clipping is needed.
5. If the bounding box for the polygon is completely inside the clip region (case 1), the polygon is inside the clip region and no clipping is needed.
6. Otherwise, the bounding box for the polygon overlaps with the clip region (cases 3 and 4) and the polygon is likely to be partly inside and partly outside of the clip region.

In that case, we clip the polygon against each of the 4 border lines of the clip region in sequence as follows:

1. Using the first vertex as the current vertex. If the point is in
the inside of the border line, mark it as 'inside'. If it is outside,
mark it as 'outside'.
2. Check the next vertex. Again mark it 'inside' or 'outside' accordingly.
3. Compare the current and the next vertices. If one is marked 'inside' and the other 'outside', the edge joining the 2 vertices crosses the border line.
4. In this case, we need to calculate where the edge intersects the border (i.e. intersection between 2 lines).
5. The intersection point becomes a new vertex and we mark it as 'synthetic'.
6. Now we set the next vertex as the current vertex and the following vertex as the next vertex, and we repeat the same operations until all the edges of the polygon have been considered.
7. After the whole polygon has been clipped by a border, we throw away all the vertices marked 'outside' while keeping those marked as 'inside' or 'synthetic' to create a new polygon.
8. We repeat the clipping process with the new polygon against the next border line of the clip region.
7. This clipping operation results in a polygon which is totally inside the clip region.



(b) Develop parametric equation to generate Bezier Curve and highlight its advantages (7M)

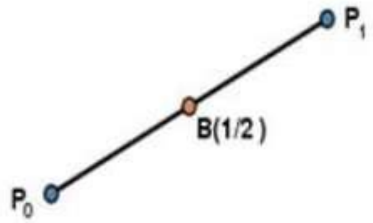
Answer: Bezier curve is discovered by the French engineer **Pierre Bézier**. These curves can be generated under the control of other points. Approximate tangents by using control points are used to generate curve. The Bezier curve can be represented mathematically as −

$$\sum_{k=0}^{n} P_i B_i^n(t)$$

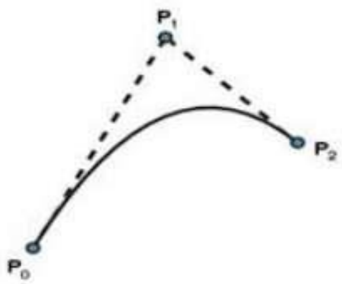
Where p_i is the set of points and $B^n{}_i(t)$ represents the Bernstein polynomials which are given by −

$$B_i^n(t) = \binom{n}{i}(1-t)^{n-t}t^i$$

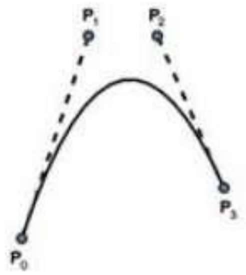
Where **n** is the polynomial degree, **i** is the index, and **t** is the variable. The simplest Bézier curve is the straight line from the point P_0 to P_1. A quadratic Bezier curve is determined by three control points. A cubic Bezier curve is determined by four control points.



Simple Bezier Curve



Quadratic Bazier Curve



Cubic Bazier Curve

UNIT-III

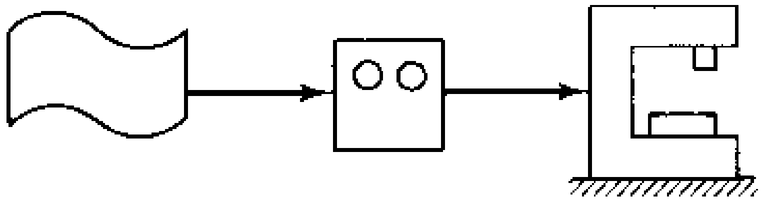
6. (a) What is NC? Describe the basic components of NC system. (6M)

Answer: *Numerical control* (NC) is a form of programmable automation in which the mechanical actions of a machine tool or other equipment are controlled by a program containing coded alphanumeric data. The alphanumerical data represent relative positions between a workhead and the work part as well as other instructions needed to operate the machine, The workhead i.e a cutting tool or other processing apparatus, and the workpart is the object being processed, When the current job is completed, the program of instructions can be changed to process a new job.

Basic components of NC system: An operational numerical control system consists of the following three basic components:

1. Program of instructions.
2. Controller unit also called machine tool unit.
3. Machine tool or other controlled process.

The program of instructions serves as input to the controller unit, which in turn commands the machine tool or other process to be controlled.



7.1 Three basic components of a numerical control system.

***Program of Instructions**:* The program of instructions is the detailed step by step set of instructions which tell the machine 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 one is the 1-inch-wide punched tape. Over the years, other forms of input media have been used, including punched cards, magnetic tape, and even 35mm motion picture film.
There are two other methods of input to the NC system which should be mentioned. The first is by manual entry of instructional data to the controller unit. This is time consuming and is rarely used except as an auxiliary means of control or when one or a very limited no. of parts to be made. The second method of input is by means of a direct link with the computer. This is called direct numerical control, or DNC.

Controller Unit: The second basic component of NC system is the controller unit. This consists of electronics and hardware that read and interpret the program of instructions and convert it to mechanical actions of the machine tool. The typical elements of the controller unit include the tape reader, a data buffer, signal output channels to the machine tool, and the sequence controls to coordinate the overall operation of the foregoing elements.
The tape reader is an electrical-mechanical device for the winding and reading the punched tape containing the program of instructions. The signal output channels are connected to the servomotors and other controls in machine tools. Most N.C. tools today are provided with positive feedback controls for this purpose and are referred as ***closed loop systems.*** However there has been growth in the ***open loop systems*** which do not make use of feedback signals to the controller unit. The advocates of the open loop concept claim that the reliability of the system is great enough that the feedback controls are not needed.

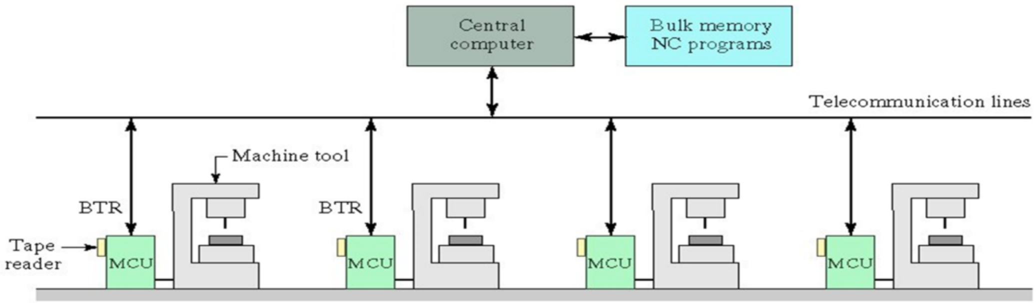
Machine Tool: The third basic component of an NC system is the machine tool or other controlled process. It is part of the NC system which performs useful work. In the most common example of an NC system, one designed to perform machining operations, the machine tool consists of the worktable and spindle as well as the motors and controls necessary to drive them. It also includes the cutting tools, work fixtures and other auxiliary equipment needed in machining operation.

(b) Differentiate between Direct Numerical control and Distributed Numerical control **(6M)**

Answer:**Direct Numerical Control:**The first attempt to use a digital computer to drive the NC machine tool was DNC. As initially implemented DNC involvedthe control or a number of machine tools by a single (mainframe) computer through direct connection and in real time. Instead of using a punched tape reader to enter the part programinto the MCU, the program was transmitted to the MCU directly from the computer,one block of instructions at a time. This mode of operation was referred to by the name***behind the tape reader***(BTR).

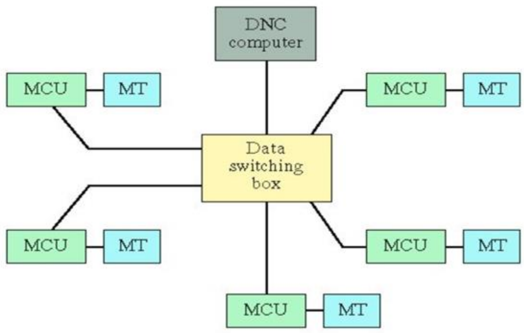
The DNC computer provided instruction blocks to the machinetool on demand; when a machine needed control commands, they were communicatedto it immediately. As each block was executed by the machine, the next block was transmitted.As far as the machine tool was concerned, the operation was no different from thatof a conventional NC controller. In theory, DNC relieved the NC system of its least reliablecomponents: the punched tape and tape reader.

The general configuration of a DNC system is depicted in Figure. The system consisted of four components: (1) central computer, (2) bulk memory at the central computer site, (3) set of controlled machines, and (4) telecommunications lines to connect the machines to the central computer. In operation, the computer caned the required part program from bulk memory and sent it (one block at a time) to the designated machine tool. This procedure was replicated for all machine toots under direct control of the computer.

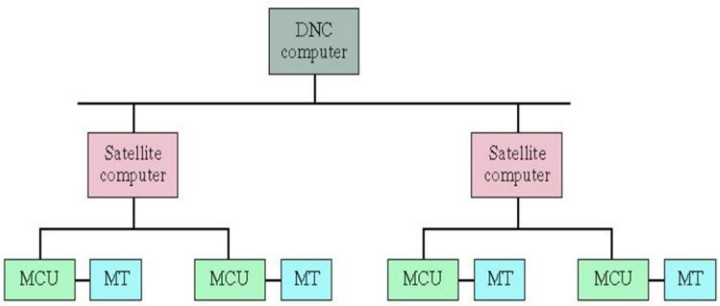


Distributed Numerical Control: The configuration of the DNC is very similar to that of Direct numerical control except that the central computer is connected to MCUs, which are themselves computers. This permits complete part programs to be sent to the machine tools rather than one block at a time. It also permits easier and less costly installation of the overall system, because the individual CNC machines can be put into service and the distributed NC can be added later.

Redundant computers improve system reliability compared with the original DNC. The new DNC permits two-way communication of data between the shop floor and the central computer which was one of the important features included in the old DNC. However, improvements in data collection devices as well as advances in computer and communications technologies have expanded the range and flexibility of the information that can be gathered and disseminated. Distributed NC systems can take on a variety of physical configurations, depending on the number of machine tools included, job complexity, security requirements, and equipment availability and preferences. There are several ways to configure a DNC system.



(a) Switching network



(b) LAN

(OR)

7. (a) Explain how spindle speed and feed rate are coded in manual part programming? (6M)

Answer: CNC programs are list of instructions to be performed in the order they are written. They read like a book, left to right and top-down. Each sentence in a CNC program is written on a separate line, called a Block. Blocks are arranged in a specific sequence that promotes safety, predictability and readability, so it is important to adhere to a standard program structure.

The blocks are arranged in the following order:

- Program Start
- Load Tool
- Spindle On
- Coolant On
- Rapid to position above part
- Machining operation
- Coolant Off
- Spindle Off
- Move to safe position
- End program

The following are the types of words used to represent different parameters in CNC programming.

N - Sequence number

Prefix G - preparatory words

- Example: G00 = PTP rapid traverse move X, Y, Z - prefixes for *x*, *y*, and *z*-axes

F - Feed rate

Prefix S - Spindle speed

T - Tool selection

M - Miscellaneous command

For example:

GOI G94 X050.0 Y086.5 Z100.0 F40 S800

The above command specifies that the tool is to move in a straight line from its current position to the location defined by x = *50.0mm, y 0=* 86.5 mm, and *z =100* mm at a feed rate of 40 mm/min and Spindle speed of 800 rev *min.*

(b) What are the functions of post processor? (6M)

Answer: A Post Processor is a unique "driver" specific to a CNC machine, robot or mechanism; some machines start at different locations or require extra movement between each operation, the Post-Processor works with the CAM software or off-line programming software to make sure the G-Code output or program is correct for a specific machine build.

CAM software uses geometry from a CAD model and converts it to G-code. The CAM software analyzes the CAD model, determines what tooling and tool paths will be used to mill the desired features. Doing so requires a CAM post processor that generates the exact g-code dialect used by the machine that is being targeted. An instance of such a translation is often referred to as a "post". There will be a different “post” for each g-code dialect the CAM software supports. Post Processors usually do not convert g-code from one dialect to the next; rather the “post” uses an intermediate format that captures the G-code commands in a dialect-independent form. Most CAM software accomplishes this with an intermediate format called "CL Data."

The Post-Processor will alter the program output to suit a specific machine; a "Post" can be used for complex things like producing a proprietary machine language other than G-Code or M-Code, or a Post-Processor may be used to start a machine from a specific position.

Another example of use for a Post-Processor would be an ATC (Automatic-Tool-Change) for a CNC, the Post-Processor is required so the correct Tool is collected from the correct location.

UNIT-IV

8. (a) What is production flow analysis? Explain (6M)

Answer: *Production flow analysis* (PFA) is a method for identifying part families and associated machine groupings that use the information contained on production route sheets rather than on part drawings. Work parts with identical or similar routings are classified into part families. These families can then be used to form logical machine cells in a group technology layout. Since PFA uses manufacturing data rather than design data to identify part families, it can overcome two possible anomalies that can occur in parts classification and coding. ***First,*** parts whose basic geometries are quite different may nevertheless require similar or even identical process routings. ***Second,*** parts whose geometries are quite similar may nevertheless require process routings that are quite different.

The procedure in production flow analysis must begin by defining the scope of the study, which means deciding on the population of parts to be analyzed. Should all of the parts in the shop be Included in the study, or should a representative sample be selected for analysis! Once this decision is made, then the procedure in PFA consists of the following steps:

1. ***Data collection:*** The minimum data needed in the analysis are the part number and operation sequence, which is contained in shop documents called route sheets or operation sheets or some similar name. Each operation is usually associated with a particular machine, so determining the operation sequence also determines the machine sequence. Additional data, such as lot size, time standards, and annual demand might be useful for designing machine cells of the required production capacity.

2. Sortation of process routings: In this step, the parts are arranged into groups according to the similarity of their process routings. To facilitate this step, all operations or machines included in the shop are reduced to code numbers. For each part, the operation codes are listed in the order in which they are performed. A sortation procedure is then used to arrange parts into "packs," which are groups of parts with identical routings. Some packs may contain only one part number, indicating the uniqueness of the processing of that part. Other packs will contain many parts, and these will constitute a part family.

3. PFA chart: The processes used for each pack are then displayed in a PFA chart.

4. Cluster analysis: From the pattern of data in the PFA chart, related groupings are identified and rearranged into a new pattern that brings together packs with similar machine sequences.

(b) What is FMS? Explain its basic components. (6M)

Answer: A **flexible manufacturing system (FMS)** is a highly automated CIM system. Regardless of its components, any FMS has as its goal making the plant more flexible—that is, achieving the ability to quickly produce wide varieties of products using the same equipment. There are several basic components of an FMS: (1) workstations, (2) material handling and storage system, and (3) computer control system. In addition, even though an FMS is highly automated, (4) people are required to manage and operate the system.

1. Workstations: The processing or assembly equipment used in an FMS depends on the type of work accomplished by the system. In a system designed for machining operations, the principle types of processing station are CNC machine tools. However, the FMS concept is also applicable to various other processes as well.

2. Material Handling and Storage System:

The second major component of an FMS is its material handling and storage system. In this subsection, we discuss the functions of the handling system, material handling equipment typically used in an FMS, and types of FMS layout.

3. Computer Control System:

The FMS includes a distributed computer system that is interfaced to the workstations, material handling system, and other hardware components. A typical FMS computer system consists of a central computer and microcomputers controlling the individual machines and other components. The central computer coordinates the activities of the components to achieve smooth overall operation of the system.

4. Human Resources:

One additional component in the FMS is human labor. Humans are needed to manage the operations of the FMS. Functions typically performed by humans include: (1) loading raw workparts into the system, (2) unloading finished parts (or assemblies) from the system. (3) Changing and setting tools. (4) Equipment maintenance and repair, (5) NC part programming in a machining system, (6) programming and operating the computer system, and (7) overall management of the system

(OR)

9. (a) Describe generative CAPP system (6M)

Answer: In the generative CAPP, process plans are generated by means of decision logic, formulas, technology algorithms and geometry based data to perform uniquely many processing decisions for converting part from raw material to finished state. There are **two major** components of generative CAPP; **geometry based coding scheme** and **process knowledge** in form of decision logic data. The geometry based coding scheme defines all geometric features for process related surfaces together with feature dimensions, locations, tolerances and the surface finish desired on the features. The level of detail is much greater in a generative system than a variant system. For example, details such as rough and finished states of the parts and process capability of machine tools to transform these parts to the desired states are provided. Process knowledge in form of in the form of decision logic and data matches the part geometry requirements with the manufacturing capabilities using knowledge base. It includes selection of processes, machine tools, jigs or fixtures, tools, inspection equipments and sequencing operations. Development of manufacturing knowledge base is backbone of generative CAPP. The tools that are widely used in development of this database are flow-charts, decision tables, decision trees, iterative algorithms, concept of unit machined surfaces, pattern recognition techniques and artificial intelligence techniques such as expert system shells.

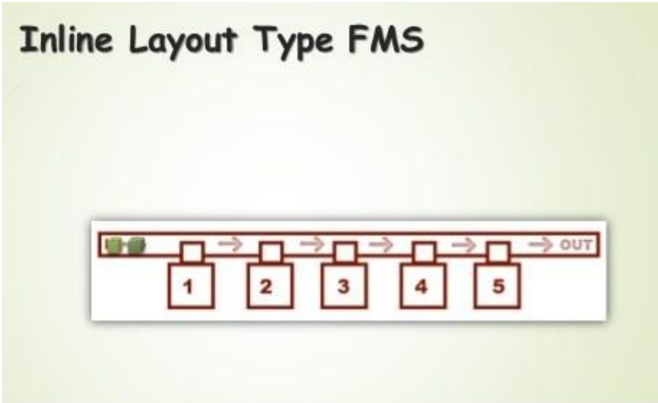
(b) Discuss about FMS layout configurations. (6M)

Answer: Flexible manufacturing system brings rewards in actual manufacture of products as the process is designed for several products to be run on different machines within a manufacturing facility which allows for greater growth and stability with more diversity in the output. A Flexible manufacturing system is designed to provide an effective operation sequence to fulfill the production requirements and reasonably allocate the resources. The objectives of the system are to shorten the throughput time and reduce the resource requirements which include avoiding deadlock in material flow, decreasing in process inventory , balancing the workload of all machines and make good use of the bottleneck devices .

The handling system establishes the basic layout of the FMS. Five layout types can be distinguished:

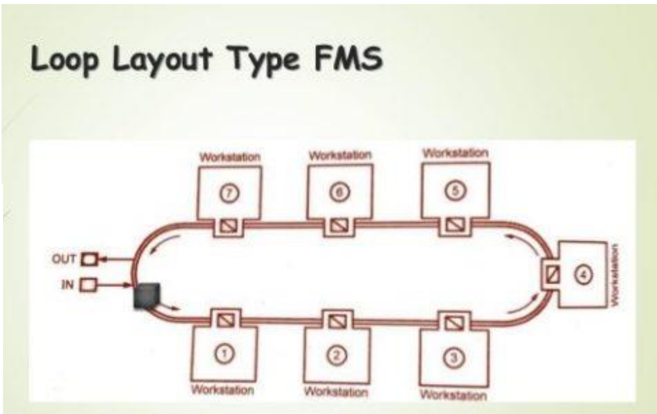
- in-line
- loop
- ladder
- open field
- robot-centered cell

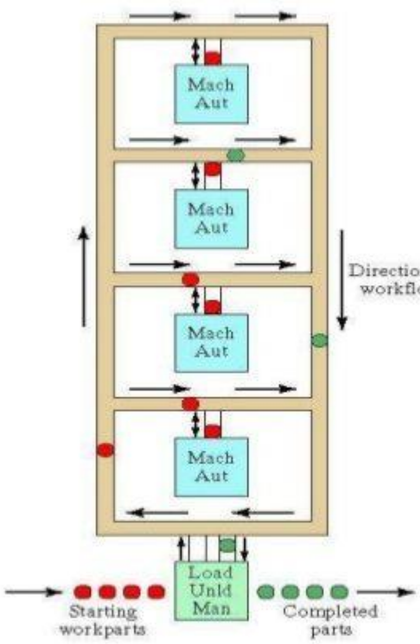
All these basic layouts are shown below in same order.



The **in-line layout** uses a linear transfer system to move parts between processing stations and load/unload station(s). The in-line transfer system is usually capable of two-directional movement; if not, then the FMS operates much like a transfer line, and the different part styles made on the system must follow the same basic processing sequence due to the one-direction flow.

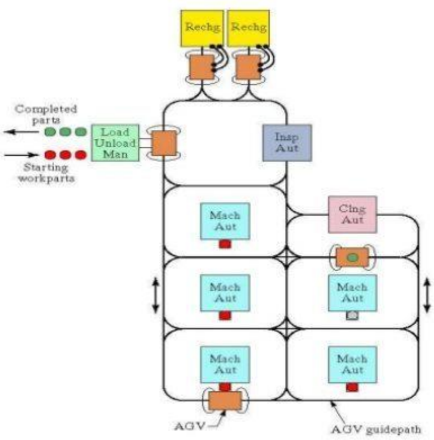
The **loop Layout** consists of a conveyor loop with workstations located around its periphery. This configuration permits any processing sequence, because any station is accessible from any other station.



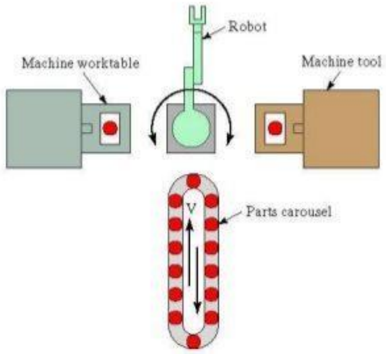


This is also true for the **ladder layout**, in which workstations are located on the rungs of the ladder.

The **open field layout** is the most complex FMS configuration, and consists of several loops tied together.



Finally, **the robot-centered cell** consists of a robot whose work volume includes the load/unload positions of the machines in the cell.



The FMS also includes a central computer that is interfaced to the other hardware components. In addition to the central computer, the individual machines and other components generally have microcomputers as their individual control units. The function of the central computer is to coordinate the activities of the components so as to achieve a smooth overall operation of the system. It accomplishes this function by means of software.

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