III/IV B.Tech – VI semester – Regular Examinations – July/August 2023

20ME601 – CAD/CAM

Scheme and Solutions

1. Solutions to one mark Questions.

a) The role of CAD/CAM in the product life cycle is to facilitate efficient design, development, and manufacturing processes by enabling digital design, analysis, and production of products.

b) Graphics Tablet (Digitizer) , Mouse , Keyboard , Stylus/Pen , 3D Scanner

c) A display device that uses Basic CRT (Cathode Ray Tube) technology is a traditional CRT monitor.

d) The purpose of a cubic spline in curve representation is to create a smooth and continuous curve that passes through a set of specified points while maintaining a certain level of smoothness and control over the curvature. This is particularly useful in computer graphics, computer-aided design (CAD), and other fields where accurate and visually pleasing curves are needed.

e) Wireframe modeling is used for representing and visualizing the basic structure of 3D objects in computer graphics and computer-aided design (CAD). It provides a simplified representation of objects using lines and points to outline their shape and form without including surface details or textures. Wireframe models are often used as a preliminary step in the design process, aiding in conceptualization, visualization, and understanding of object structures before adding more detailed elements like surfaces, textures, and shading.

f) CSG stands for "Constructive Solid Geometry" in solid modeling.

g) Numerical Control (NC) systems can be classified into two main categories:
Point-to-Point System: This type of NC system controls the motion of the tool by specifying specific points that the tool should move to. It is suitable for operations where the tool moves directly from one point to another without following a continuous path.
Continuous Path System: In this type of NC system, the tool's motion is defined by specifying a continuous path that it should follow. This allows for more complex and smooth tool movements, such as curves and arcs.

h) One method of manual part programming is the "manual data input" method.

i) APT programming, which stands for "Automatically Programmed Tool," is a high-level language used in computer-aided design and computer-aided manufacturing (CAD/CAM) systems. It was developed in the 1960s to automate the process of generating machine tool paths for manufacturing parts.
APT programming involves creating text-based instructions that define the tool's movements, machining operations, and other relevant parameters. A postprocessor into machine-specific G-code instructions that control the actual machining equipment then translates these instructions.

j) Performing a single linear cut along the X-axis. Here's a breakdown of the G-code commands used:

```
% Program Start
G90     ; Set to Absolute Positioning
M3 S1000 ; Start spindle at 1000 RPM in clockwise direction
G0 X0 Y0 ; Rapid move to the starting point
Z0      ; Move the tool to the workpiece surface
G1 X100 F200 ; Move along the X-axis to the end point at a feed rate of 200 mm/min
G0 Z10   ; Move the tool up to the safe clearance height
M5      ; Stop the spindle
G0 X0 Y0 ; Rapid move back to the starting point
M2      ; Program end
```

k) The purpose of parts classification and coding in Cellular Manufacturing is to facilitate efficient and organized production within a cell.

l) Generative CAPP (Computer-Aided Process Planning) systems are used for automatically generating process plans based on product designs and specific manufacturing capabilities.
m) The concept of integration in CIM (Computer Integrated Manufacturing) refers to the seamless coordination and communication between various functions and processes within a manufacturing environment to achieve improved efficiency and productivity.
n) One benefit of implementing a Flexible Manufacturing System (FMS) in manufacturing is increased production flexibility.

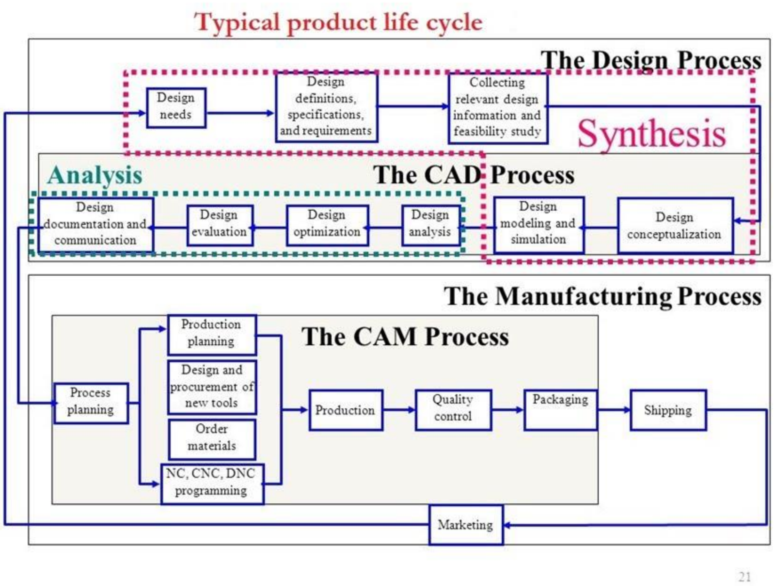
Total 14 Questions Each Answer - 1 Mark Total - 14 Marks

Unit-I

2.

a. **Draw the CAD/CAM product cycle with neat sketch.**

The CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) product cycle involves the integration of design and manufacturing processes using computer technology.



Introduction – 1 Mark
Explanation – 3 Marks
Diagram – 3 Marks

b. Explain the product cycle and CAD/CAM product cycle?

1. Product Cycle:
The product cycle refers to the stages a product goes through from conceptualization to market launch and beyond. It encompasses various phases, including design, development, manufacturing, distribution, and end-of-life considerations. Here's a simplified breakdown of the product cycle:

Idea Generation: Concepts for new products are generated based on market needs, consumer feedback, or technological advancements.

Concept Development: Initial concepts are refined, and feasibility studies are conducted to evaluate potential product viability.
Design: Detailed designs are created, specifying product features, components, and aesthetics.
Prototyping: Physical prototypes are built to test and validate design concepts.
Testing and Iteration: Prototypes are tested for functionality, performance, and user experience. Iterations and improvements are made.
Manufacturing: The product is produced at scale using appropriate manufacturing processes.
Quality Control: Products are inspected to ensure they meet quality standards.
Distribution and Sales: Products are packaged, marketed, and distributed to retailers or consumers.
Customer Use: Consumers purchase and use the product.
Maintenance and Support: Post-sales services, updates, and maintenance are provided.
Disposal or Recycling: At the end of its life, the product is disposed of responsibly or recycled.

2. CAD/CAM Product Cycle:

The CAD/CAM product cycle is a specific subset of the overall product cycle that focuses on the integration of computer-aided design (CAD) and computer-aided manufacturing (CAM) technologies. It emphasizes the seamless transition from design to production. Here's an overview of the CAD/CAM product cycle:

CAD Phase:
Conceptual Design: Engineers create initial design concepts using CAD software.
Detailed Design: Detailed designs are developed, including 2D/3D modeling and specifications.
Analysis and Simulation: CAD tools simulate and analyze the design's behavior.
Virtual Prototyping: 3D models are used to create virtual prototypes.

CAM Phase:

Process Planning: CAM software selects suitable manufacturing processes based on the design.
Toolpath Generation: CAM generates toolpaths for machining operations.
NC Code Generation: CAM software converts toolpaths into machine-readable numerical control (NC) code.
CNC Machining: CNC machines execute the machining operations.
Feedback and Iteration Phase:
Data from manufacturing processes is fed back into the CAD/CAM system for analysis, improvement, and potential design adjustments.

The CAD/CAM product cycle streamlines the design and manufacturing processes, facilitating faster iterations, better communication between design and production, and ultimately delivering higher-quality products to the market.

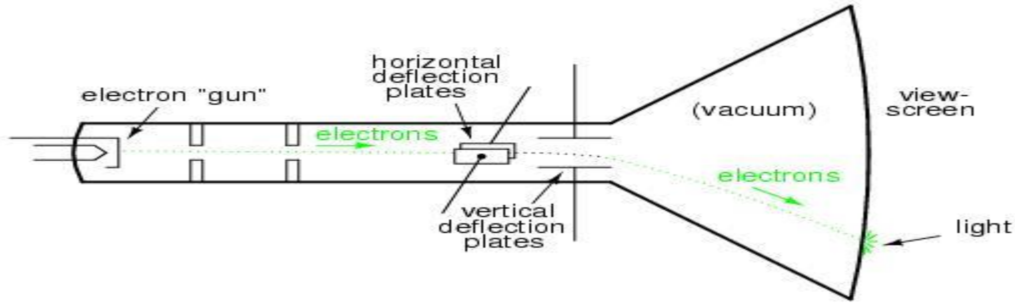
Explanation – 7 Marks

3. Compare and contrast the characteristics and working principles of basic CRT and DVST display devices. Discuss their advantages, disadvantages, and common applications.

Basic CRT (Cathode Ray Tube) Display:

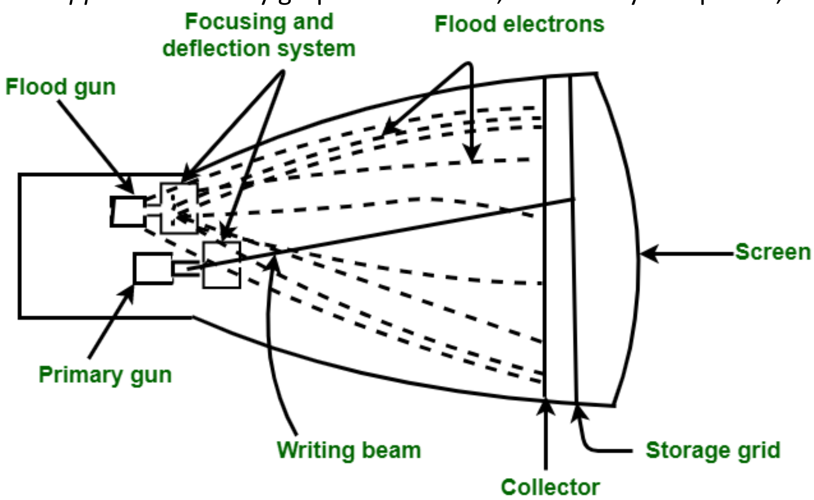
Working Principle: CRT displays work by using an electron beam to scan a phosphorescent screen, producing images through the emission of light.
Characteristics: It has a bulky size, curved screen, and uses a cathode ray tube for display. It relies on analog signals and requires a refreshing process to maintain the image.

Advantages: Good color reproduction, high contrast, wide viewing angles, and support for various resolutions.
Disadvantages: Bulky, heavy, consumes more power, emits radiation, and has limited screen size options.
Common Applications: Older computer monitors, televisions, radar displays, oscilloscopes.



DVST (Direct-View Storage Tube) Display:

Working Principle: DVST displays work by using a thin phosphor layer on a metal backing plate, with the phosphors storing the image temporarily when hit by an electron beam.
Characteristics: It's flatter and lighter compared to CRTs. It uses digital signals and doesn't require constant refreshing.
Advantages: Slimmer, lighter, consumes less power, produces less radiation, and supports digital signals.
Disadvantages: Limited color range, lower brightness compared to CRTs, and may suffer from burn-in issues.
Common Applications: Early graphics terminals, some early computers, military applications.



Advantages of CRT:
Excellent color and contrast.
Wide viewing angles.
Wide range of resolutions.
Good for real-time applications (no lag).
Good for multimedia and gaming.
Disadvantages of CRT:
Bulky and heavy.
Consumes more power.
Emitted radiation (health concerns).
Limited screen size options.

Requires constant refreshing.

Advantages of DVST:

Slim and lightweight.

Lower power consumption.

Digital signal compatibility.

Reduced radiation emission.

No constant refreshing required.

Disadvantages of DVST:

Limited color range.

Lower brightness compared to CRTs.

Susceptible to burn-in (image retention) issues.

Limited application due to technological advancements.

Common Applications:

Common Applications of CRT:

Older computer monitors and TVs.

Radar displays in aviation and military.

Medical imaging equipment.

Oscilloscopes and scientific instruments.

Common Applications of DVST:

Early graphics terminals.

Some early computers.

Specialized military displays.

Display devices in certain critical systems.

Please note that both CRT and DVST technologies have largely been replaced by newer display technologies such as LCD (Liquid Crystal Display), LED (Light Emitting Diode), and OLED (Organic Light Emitting Diode) displays, which offer improved performance, reduced size, and more energy efficiency.

CRT & DVST (Explanation, Figures , Comparison) – 10 Marks
Advantages & Disadvantages, Applications – 4 Marks

Unit-II

4. Explain the concept of non-parametric representation of analytical curves. Discuss the advantages and limitations of using non-parametric curves in computer graphics.

In computer graphics, curves are often used to represent smooth shapes and contours. The traditional approach to represent curves is using parametric equations, where each point on the curve is defined as a function of a parameter. However, non-parametric representation provides an alternative way to describe curves using sets of discrete data points without explicitly defining a parametric equation.

Non-parametric representation involves storing a set of points or control vertices that define the shape of the curve. These points are connected by algorithms to produce a continuous curve. Bézier curves and B-spline curves are two common examples of non-parametric curves used in computer graphics.

Advantages of Non-Parametric Curves:

Flexibility: Non-parametric curves can approximate a wide range of shapes, from simple to complex, by adjusting the positions of control points.
Ease of Manipulation: Changing the shape of the curve involves modifying control points, making it intuitive to edit and deform curves.
Local Control: Altering one control point affects only a localized portion of the curve, allowing fine-tuning of specific areas.
Interpolation and Smoothing: Non-parametric curves can interpolate given points or smooth noisy data.
Ease of Rendering: Converting non-parametric curves into parametric forms for rendering can be more straightforward than directly rendering parametric equations.

Limitations of Non-Parametric Curves:

Lack of Global Control: Non-parametric curves lack global control over the overall shape, which can result in unintended deformations.
Complexity Handling: Representing complex shapes might require a large number of control points, leading to increased data storage and computational requirements.
Precision and Accuracy: Achieving precise and accurate curves may require a high density of control points, impacting performance and curve editing.
Smoothness Constraints: Ensuring smoothness between adjacent curve segments can be challenging, especially when dealing with curves of varying degrees.
Mathematical Rigor: Non-parametric curves often rely on iterative algorithms, which may not have the same mathematical elegance as parametric equations.

In computer graphics, the non-parametric representation of analytical curves offers a flexible and intuitive approach to creating and manipulating smooth shapes. The advantages of non-parametric curves, such as ease of manipulation, local control, and interpolation capabilities, make them valuable tools for various applications. However, these benefits come with limitations. Non-parametric curves lack global control, require careful handling of complexity, and can challenge mathematical rigor. Therefore, the choice between non-parametric and parametric curve representations depends on the specific requirements of the task at hand. While non-parametric curves provide a practical way to create and modify curves with ease, they may need to be carefully balanced with the constraints posed by precision, accuracy, and overall shape control.

Introduction - 2 mark
Explanation - 5 marks
Advantages - 3 marks
Limitations – 3 marks
Conclusion - 1 mark

5. Discuss the advantages and disadvantages of using B-splines over Bezier curves and cubic splines for curve representation.

Advantages of Using B-Splines Over Bezier Curves:
Smoothness and Continuity:
B-splines offer higher continuity between curve segments compared to Bezier curves, resulting in smoother connections at control points.
Local Control:
B-splines provide greater local control over curve segments. Adjusting a control point affects only a localized portion of the curve, allowing for more precise adjustments.
Knot Vector Flexibility:

B-splines allow more flexibility in defining knot vectors, enabling designers to create complex shapes with adjustable knot spacing.
Interpolation and Approximation:
B-splines can be used for both interpolation and approximation, providing versatile curve fitting capabilities.

Disadvantages of Using B-Splines Over Bezier Curves:
Complexity of Understanding:
B-splines involve knots, basis functions, and control points, which might be more complex to understand compared to Bezier curves.
Initial Control Point Assignment:
Defining initial control points and their weights for B-splines may require more expertise to achieve the desired curve behavior.
Curve Deformation Behavior:
The local control of B-splines can lead to unintended deformations if control points are not managed carefully.
Higher Degree Complexity:
Higher-degree B-splines introduce more control points, potentially increasing data storage and computational requirements.

Advantages of Using B-Splines Over Cubic Splines:
Higher Continuity:
B-splines offer better continuity between curve segments compared to cubic splines, resulting in smoother connections at control points.
Knot Vector Flexibility:
B-splines provide more flexibility in defining knot vectors, allowing for complex shape creation with adjustable knot spacing.
Interpolation and Approximation:
B-splines are versatile for both interpolation and approximation, making them useful for various design needs.

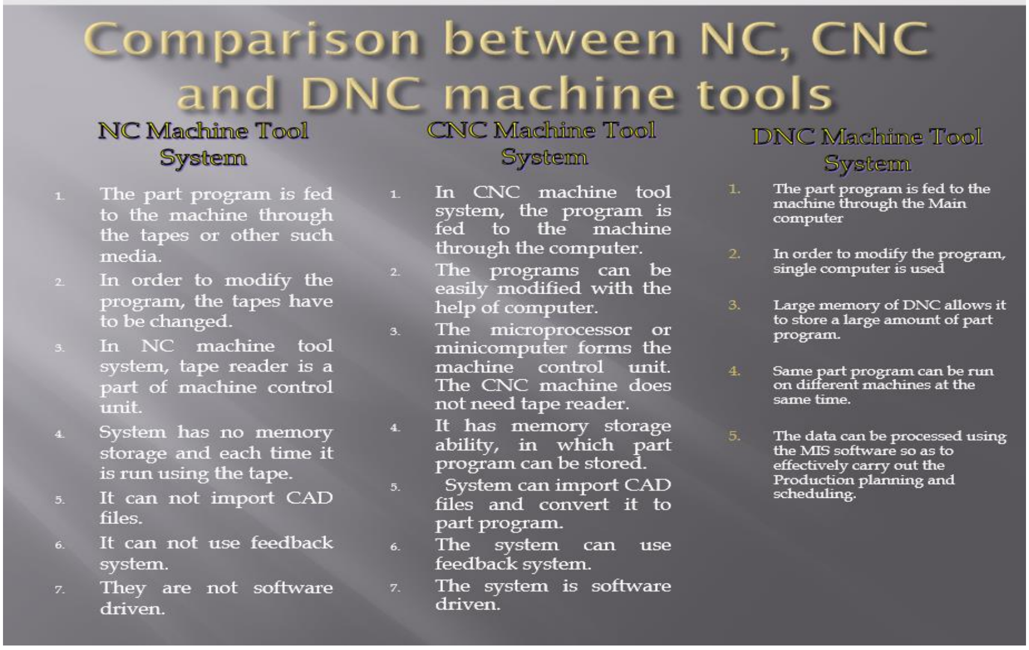
Disadvantages of Using B-Splines Over Cubic Splines:
Complexity of Understanding:
Understanding the concept of knots, basis functions, and control points in B-splines can be more complex compared to cubic splines.
Initial Control Point Assignment:
Defining initial control points and their weights for B-splines may require more expertise to achieve the desired curve behavior.
Curve Deformation Behavior:
The local control of B-splines can lead to unintended deformations if control points are not managed carefully.

B Spline over Bezier Curves – 7 Marks
B Spline over Cubic Splines – 7 Marks

Unit-III

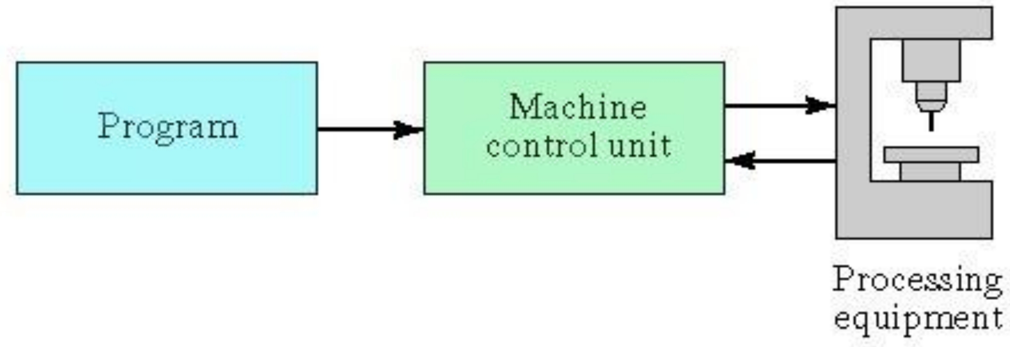
6.

a. List the differences between NC and CNC.



Explanation – 7 Marks

b. List out and Explain about basic components of an NC system



The three important components of an NC (Numerical Control) system are:

Part Program:
The part program is a sequence of coded instructions that defines the machining operations to be executed on the workpiece. It includes commands for tool movements, tool changes, feed rates, spindle speeds, and other relevant parameters. The accuracy and clarity of the part program directly influence the quality and precision of the machined part.

Controller:
The controller is the brain of the NC system. It interprets the part program and generates control signals that dictate the movements of the machine tool. The controller performs tasks such as trajectory planning, interpolation, and coordination of various machine functions. It ensures that the machine executes the part program accurately and efficiently.

Machine Tool:

The machine tool is the physical equipment that performs the actual machining operations on the workpiece. It includes the mechanical structure, motion systems (such as linear and rotary axes), spindle, tool holders, and other components necessary for cutting, shaping, or forming the material as per the instructions provided by the part program.

These three components work together to automate the manufacturing process, allowing for precise and efficient production of parts based on digital instructions provided in the part program.

List and Diagram – 2 Marks
Explanation – 3 Marks

7.

a. Differentiate Manual part programming and Computer assisted part programming

Manual Part Programming:

Manual part programming involves writing the instructions for machining operations by hand, typically using G-code or other machine-specific languages. Here's how it differs:

Human Involvement: Manual part programming relies solely on human operators to write the code. Operators need to have a deep understanding of the machine's capabilities, the machining process, and the programming language.

Time-Consuming: Writing manual code can be time-consuming and error-prone, especially for complex parts and intricate machining operations. Operators need to calculate tool paths, coordinates, and feed rates manually.

Limited Complexity: Manual programming can be limiting for complex parts or operations that require intricate tool paths. Writing detailed code for such cases might be challenging and prone to errors.

High Skill Requirement: Manual programming requires skilled operators with a strong grasp of machining concepts and programming languages. The operator needs to visualize the machining process and translate it into code.

Computer-Assisted Part Programming:

Computer-assisted part programming involves the use of software tools to generate part programs. This can include CAM (Computer-Aided Manufacturing) software or CAD/CAM integrated systems. Here's the differentiation:

Software Assistance: Computer-assisted programming leverages software tools to help generate part programs. The software calculates tool paths, feed rates, and other parameters based on the design and manufacturing requirements.

Automation: Computer-assisted programming automates many aspects of the programming process. The software can optimize tool paths, avoid collisions, and ensure efficient material removal.

Complexity Handling: Computer-assisted programming can handle complex parts and operations more effectively. The software can calculate intricate tool paths and optimize the machining process for efficiency and accuracy.

Reduced Skill Requirement: Computer-assisted programming reduces the skill requirement for generating part programs. Operators need to understand the software interface and machining concepts, but they don't need to manually write intricate code.

Time Efficiency: Computer-assisted programming is generally faster than manual programming. The software generates accurate code quickly, saving time and reducing the risk of errors.

In summary, while manual part programming relies on human operators to write code by hand, computer-assisted part programming employs software tools to automate and optimize the programming process. The latter is more efficient, accurate, and capable of handling complex machining operations.

Explanation – 7 Marks

b. Briefly explain about NC Coordinate systems.

NC (Numerical Control) coordinate systems are essential for specifying the positions and movements of machine tools in a consistent and standardized manner. These coordinate systems provide a reference framework that allows for accurate communication between the part program and the machine tool. There are two main types of NC coordinate systems: Absolute and Incremental.

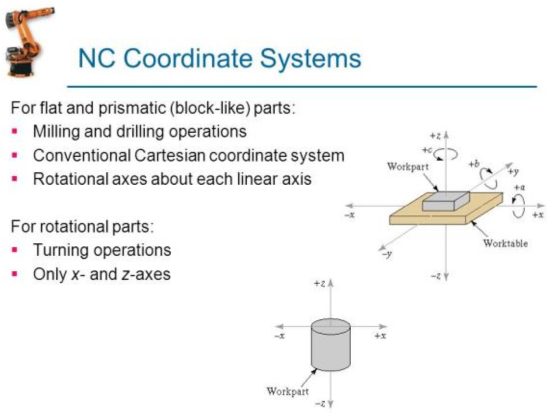
Absolute Coordinate System:
In the absolute coordinate system, the positions of the machine tool are defined with respect to a fixed reference point called the machine's origin. This origin is typically located at a specific corner or point on the worktable. Absolute coordinates directly indicate the exact position of the tool in relation to this origin. Commands to move to specific coordinates are given as absolute values. Absolute coordinates are suitable for describing tool positions accurately and directly but can be cumbersome for large or complex parts due to the need for long coordinate values.

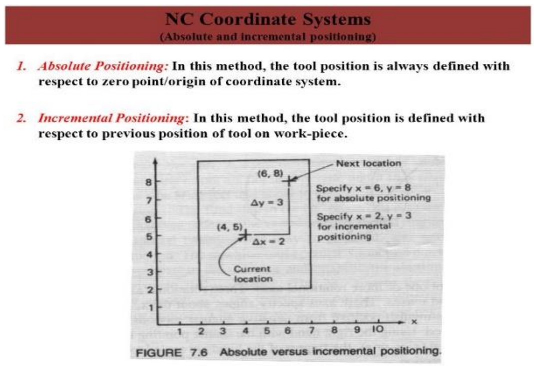
Incremental Coordinate System:
In the incremental coordinate system, movements are defined as changes from the current position. Instead of specifying the exact position, incremental coordinates indicate how much the tool should move in each axis direction. This approach is particularly useful for describing tool paths and movements between specific points. Incremental coordinates are generally easier to work with for complex operations and large parts because they focus on relative changes rather than specifying absolute positions.

NC coordinate systems typically have three axes: X, Y, and Z, representing horizontal, vertical, and depth movements, respectively. These axes create a Cartesian coordinate system that guides the tool's movements within the three-dimensional space.

The choice between using absolute and incremental coordinate systems depends on the specific machining task and the nature of the part program. Absolute coordinates are ideal for positioning and operations that require precise placement at specific points. Incremental coordinates are more suitable for describing tool paths, curves, and complex movements.

Overall, NC coordinate systems play a vital role in ensuring accurate and consistent communication between the part program and the machine tool, enabling precise machining operations.





Explanation with Diagrams – 7 Marks

Unit-IV

8.

a. Explain various benefits and limitations of group technology

Benefits of Group Technology:

Reduced Setup Time: Grouping similar parts together allows for the standardization of setups and tooling. This leads to reduced setup time as machines can be configured more efficiently for batches of similar parts.

Enhanced Efficiency: Group technology minimizes machine idle time by clustering similar parts, which leads to a smoother flow of production and optimized machine utilization.

Streamlined Material Flow: Similar parts being produced together help streamline material handling and reduce the need for frequent reconfigurations of machines and workstations.

Simplified Scheduling: Group technology simplifies production scheduling since similar parts have similar processing times and requirements, making it easier to plan production runs.

Consistent Quality: With standardized processes for similar parts, it becomes easier to maintain consistent quality control and reduce variations in production.

Reduced Lead Time: Efficient production flow, reduced setup times, and streamlined scheduling contribute to shorter lead times for delivering products to customers.

Skill Enhancement: Operators and technicians become specialized in producing specific families of parts, leading to skill enhancement and reduced learning curves.

Limitations of Group Technology:

Part Variety: Group technology might not be suitable for industries with a high variety of unique products, as the benefits of standardization are more limited in such cases.

Initial Implementation Effort: Setting up group technology systems requires considerable effort in analyzing parts, classifying them, and reorganizing the manufacturing process.

Maintenance and Updates: As the product mix changes or new parts are introduced, the groupings need to be updated, requiring ongoing maintenance efforts.

Lost Economies of Scale: While group technology can optimize smaller batch production, it might not leverage economies of scale for large volume production.

Rigidity: Group technology systems might introduce rigidity in production processes, making it challenging to accommodate sudden changes or customization.

Complexity: For larger organizations with diverse product lines, implementing and managing group technology systems can become complex.

Resistance to Change: Employees and management might resist the changes required for implementing group technology due to the need to adapt to new workflows and procedures.

In summary, group technology offers significant benefits in terms of efficiency, quality, and reduced lead time, particularly for industries with standardized or similar parts. However, its implementation requires careful planning and consideration of the limitations associated with changing processes and adapting to new workflows.

Explanation– 7 Marks

b. What is CAPP? List out the benefits of CAPP.

Computer-Aided Process Planning (CAPP):

Computer-Aided Process Planning (CAPP) is a technology that uses computer systems to assist in generating the sequence of manufacturing operations and instructions required to produce a part or product. CAPP aims to automate and optimize the process planning stage of manufacturing, enhancing efficiency, accuracy, and consistency.

Benefits of CAPP:

Reduced Lead Time: CAPP helps streamline the process planning phase, leading to quicker generation of manufacturing instructions and reduced overall lead time for product development.

Consistency: CAPP ensures that the same standards and guidelines are followed for each part, resulting in consistent quality and reduced variations in production.

Efficiency: Automated process planning eliminates the need for manual calculations and decision-making, increasing the efficiency of generating manufacturing routes.

Optimized Resource Utilization: CAPP considers machine availability, tooling, and other resources, leading to optimized utilization and better allocation of resources.

Cost Savings: Improved resource utilization, reduced setup times, and efficient machining processes result in cost savings through reduced waste and improved productivity.

Accurate Documentation: CAPP systems generate detailed manufacturing instructions, reducing the chances of errors and misunderstandings on the shop floor.

Easy Updates: When design changes occur, CAPP systems can quickly update the manufacturing instructions, ensuring that the production process remains aligned with the design.

Process Visualization: CAPP often includes visual aids, such as animations and simulations, that help operators understand the manufacturing process better.

Improved Communication: CAPP facilitates better communication between design, engineering, and production teams by providing standardized instructions.

Skill Enhancement: As CAPP systems provide clear instructions, less-experienced operators can follow detailed steps, leading to skill enhancement and reduced reliance on expert operators.

Customization: CAPP systems can adapt to different product variations or customization requirements, allowing for efficient handling of product diversity.

Faster Decision-Making: With automated recommendations and options, CAPP accelerates decision-making during the process planning phase.

Better Use of Expertise: Expert knowledge from experienced process planners can be captured and incorporated into CAPP systems, making it available for less-experienced staff.

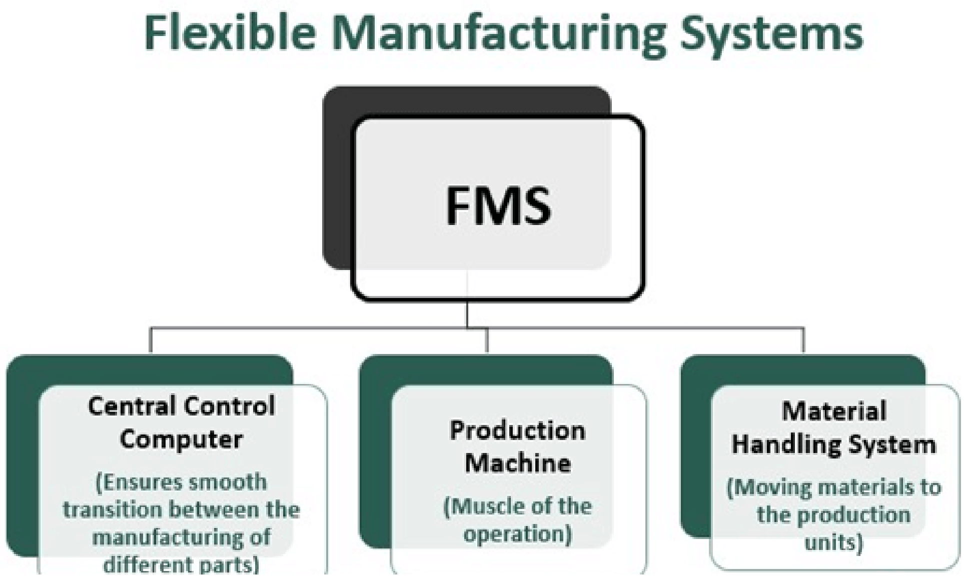
Compliance: CAPP systems can ensure that manufacturing processes adhere to industry standards, regulations, and best practices.

Data Analysis: CAPP generates data that can be analyzed for process improvement, identifying bottlenecks, inefficiencies, and areas for optimization.

In summary, Computer-Aided Process Planning (CAPP) offers numerous benefits that enhance the efficiency, quality, and cost-effectiveness of the process planning phase in manufacturing. It plays a vital role in bridging the gap between design and production by generating accurate and optimized manufacturing instructions.

Explanation– 7 Marks

9. Explain in detail about Components of FMS



Flexible Manufacturing Systems (FMS) can be summarized into four main interconnected systems that work together to create an efficient and adaptable production environment:

Central Control System:
The central control system serves as the core of the FMS, coordinating and managing all activities. It handles job scheduling, resource allocation, and real-time monitoring of the manufacturing process. This system optimizes production sequences, adapts to changes, and ensures efficient utilization of resources.

Workstation and Automation System:
Workstations and automation form the heart of the FMS. These systems consist of CNC machines, robots, assembly stations, and inspection points. They perform various manufacturing tasks with precision and speed. These workstations are flexible and reconfigurable, allowing them to adapt to different processes and products.

Material Handling and Storage System:
The material handling and storage system ensures the smooth flow of materials within the FMS. Automated guided vehicles (AGVs), conveyor belts, and robotic arms transport materials between workstations and storage areas. Automated storage and retrieval systems (AS/RS) manage inventory and ensure efficient material handling.

Control Software and Communication Network:
The control software acts as the brain behind the FMS, managing communication and data exchange between different components. It orchestrates the activities of workstations, material handling systems, and quality control stations. The communication network connects sensors, devices, and the central control system for real-time monitoring and decision-making.

These four interconnected systems enable an FMS to achieve its primary goals: increased efficiency, reduced lead times, improved quality, and adaptability to changing production needs. By seamlessly integrating manufacturing processes, automation, material handling, and control, FMS revolutionizes modern manufacturing practices.

Diagram – 2 Marks
Explanation – 12 Marks

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