1. a) What is Computer Integrated manufacturing write in brief evaluation of CIM.

Answer: Computer integrated manufacturing is the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organizational and personnel efficiency.

CIM is most closely associated with functions in manufacturing engineering such a process planning and numerical control (NC) part programming.

The important applications of CIM in manufacturing control:

- The applications of computer process control are pervasive today in automated production systems.
- Quality control includes a variety of approaches to ensure the highest possible quality levels in the manufactured product.
- Shop floor control refers to production management techniques.
CIM stands for a holistic and methodological approach to the activities of the manufacturing enterprise in order to achieve vast improvement in its performance. Manufacturing engineers are required to achieve the following objectives to be competitive in a global context.

- Reduction in inventory
- Lower the cost of the product
- Reduce waste
- Improve quality
- Increase flexibility
- Quality in manufacturing to achieve immediate and rapid response to:
  - Product changes
  - Production changes
  - Process change
  - Equipment change
  - Change of personnel

CIM technology is an enabling technology to meet the above challenges to the manufacturing environment.

**Evolution of CIM**

Computer Integrated Manufacturing (CIM) is considered a natural evolution of the technology of AD/CAM which by itself evolved by the integration of CAD and CAM. Massachusetts Institute of Technology (MIT, USA) is credited with pioneering the development in both CAD and CAM. If we review the manufacturing scenario during 80's we will find that the manufacturing is characterized by a few islands of automation. In the case of design, the task is well automated. In the case of manufacture, CNC machines, DNC systems, FMC, FMS etc provide tightly controlled automation systems. Similarly computer control has been implemented in several areas like manufacturing resource planning, accounting, sales, marketing and purchase. Yet the full potential of computerization could not be obtained unless all the segments of manufacturing are integrated, permitting the transfer of data across various functional modules. This realization led to the concept of computer integrated manufacturing. Thus the implementation of CIM required the development of whole lot of computer technologies related to hardware and software.
1. b) What are different types of Automation? Explain in brief the relationship between product variety, production quantity & types of automation with the help of graph.

Answer: Automation is the technology by which a process or procedure is accomplished without human assistance. It is implemented using a program of instructions combined with control system that executes the instructions. To automate a process, power is required to drive the process and to operate the program and control system. Automation can be applied to many areas but it is closely associated with manufacturing industries.

**a) Fixed Automation:** Fixed automation is the system in which the sequence of processing operations is fixed by the equipment configuration. Each of the operation in the sequence is usually simple. It is the integration of more than one operation into one piece of equipment, which makes the system complex.

*Typical features of fixed automation are:*-

1) High initial investment for custom engineered equipment.
2) High Production rates.
3) Relatively inflexible in accommodating product variety.

**b) Programmable Automation:** In programmable automation, the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. The operation sequence is controlled by a program.

*Typical features of programmable automation are:*-

1) High investment in general purpose equipment.
2) Lower production rates than fixed automation.
3) It can deal with variations and changes in product configurations.
4) Most suitable for batch production.

**c) Flexible Automation:** It is an extension of programmable automation. It is capable of producing variety of parts with no time lost for changeovers from one part style to next. There is no production time lost while reprogramming the system.

*Typical features of programmable automation are:*-

1) High investment in Custom purpose equipment.
2) Continuous production of variable mixtures of products.
3) Medium production rates.
4) Flexibility to deal with product design variations.
Definition: - It is technology concerned with the application of Mechanical, electronic & computer-based systems to operate and control production in order to improve productions.

If includes:-

1) Automated m/c tools.
2) Automated assembly m/c’s
3) Industrial robots.
4) Automated material handling & storage systems
5) Automated inspection system for quality control
6) Feedback control & computer process control
7) Computer integrated system for planning, data collection, decision making.

Examples: Automotive, Electronics, Applications, Aircraft manufacturing industries.

Type of Automation:

1) Fixed Automation
2) Programmable Automation
3) Flexible Automation

1) Fixed Automation:-

- Fixed automation is a system in which the sequence of processing is fixed by equipment configuration.
- The operation sequence is simple.
- Higher initial investment of custom equipment
- High production capacity
- Inflexible to accommodate product changes

Example: Automated material handling & transfer lines & assembly equipments.

2) Programmable Automation:

- In it production equipment is designed with the capability to change the sequence of operation to accommodate change of product design.
- The operation sequence is controlled by a program in form of coded instructions.
- For producing new batch of new design product the system can be reprogrammed.
- High investment initially
- Low production as compare to fixed automation.
- Flexibility to accommodate new design of product.
- It is most suitable of batch production.
  Examples: - NC controlled m/c tolls & Industrial robots.

3) Flexible Automation:

- It is an extension of programmable automation.
- It is flexible automated system which can accommodate design change of product.
- In it one advantage is that there is time lost for change over’s from one product to the next.
- There is no production time lost while reprogramming the system and allotting the physical setup of tolling, fixtures, machines setting.
- High investment initially
- Continuous production with Varity of product.
- Medium production rate.
- Flexibility for verity of product design change over.
  Example: - CNC m/c tools, reprogrammable Industrial robots.
2. a) Explain in detail scope and different computerized elements of CIM with the help of CIM wheel. (6)
Answer:

CIM wheel captures the concept of total integration of all industrial functions.

CIM – A concept or Technology

- A concept- For top management, a blueprint for success.
- A Technology – for middle management and line managers, a physical realization of resources that are more capable and flexible.

Importance of CIM

CIM is important to an organization in achieving the following goals:

1. More productive and efficient processes.
2. Increase product reliability.
3. Decrease cost of production and maintenance.
4. Reduce number of hazardous jobs.
5. Increase involvement of educated and able humans in manufacturing and design.

Functioning of CIM

1. Evaluating and developing different product strategies.
3. Analyzing product / market characteristics & generates concept of possible manufacturing system (FMS & FMC).
4. Designing and analyzing components for machining, inspection, assembly and other processes.
5. Evaluating and determining batch sizes, manufacturing capacity, scheduling and control strategies.
7. Analysis of system disturbances and economic factors.

Role of the elements of CIM system

Nine major elements of a CIM system

• Marketing
• Product Design
• Planning
• Purchase
• Manufacturing Engineering
• Factory Automation hardware
• Warehousing
• Logistics and Supply Chain Management
• Finance
• Information Management
i. Marketing: The need for a product is identified by the marketing division. The specifications of the product, the projection of manufacturing quantities and the strategy for marketing the product are also decided by the marketing department. Marketing also works out the manufacturing costs to assess the economic viability of the product.

ii. Product Design: The design department of the company establishes the initial database for production of a proposed product. In a CIM system this is accomplished through activities such as geometric modeling and computer aided design while considering the product requirements and concepts generated by the creativity of the design engineer.

iii. Planning: The planning department takes the database established by the design department and enriches it with production data and information to produce a plan for the production of the product. Planning involves several subsystems dealing with materials, facility, process, tools, manpower, capacity, scheduling, outsourcing, assembly, inspection, logistics etc.

iv. Purchase: The purchase departments is responsible for placing the purchase orders and follow up, ensure quality in the production process of the vendor, receive the items, arrange for inspection and supply the items to the stores or arrange timely delivery depending on the production schedule for eventual supply to manufacture and assembly.

v. Manufacturing Engineering: Manufacturing Engineering is the activity of carrying out the production of the product, involving further enrichment of the database with performance data and
information about the production equipment and processes. In CIM, this requires activities like CNC programming, simulation and computer aided scheduling of the production activity.

vi. Factory Automation Hardware: Factory automation equipment further enriches the database with equipment and process data, resident either in the operator or the equipment to carry out the production process. In CIM system this consists of computer controlled process machinery such as CNC machine tools, flexible manufacturing systems (FMS)

vii. Warehousing: Warehousing is the function involving storage and retrieval of raw materials, components, finished goods as well as shipment of items. In today's complex outsourcing scenario and the need for just-in-time supply of components and subsystems, logistics and supply chain management as same great importance.

viii. Finance: Finance deals with the resources pertaining to money. Planning of investment, working capital, and cash flow control, realization of receipts, accounting and allocation of funds are the major tasks of the finance departments.

ix. Information Management: Information Management is perhaps one of the crucial tasks in CIM. This involves master production scheduling, database management, communication, manufacturing systems integration and management information systems.

2. b). Explain the concept of concurrent engineering? Give its application & utility in CIM. (7)

Answer: Concurrent engineering refers to an approach used in product development in which the function of design engineering, manufacturing engineering and other functions are integrated to reduce the elapsed time required to bring a new product to market. Also called as simultaneous engineering. In traditional approach, the product design department develops the new design, sometimes without much consideration given to the manufacturing capabilities of the company. There is a little opportunity for manufacturing engineers to offer advice on how the design might be altered to make it more manufacturable. Once of the design is made it is tossed up to the manufacturing department as if there is a wall between them.

Concurrent engineering, also known as simultaneous engineering, is a method of designing and developing products, in which the different stages run simultaneously, rather than consecutively. It decreases product development time and also the time to market, leading to improved productivity and reduced costs.
Advantages of Concurrent Engineering over Sequential Engineering

By contrast in a company that practices concurrent engineering, the manufacturing engineering department becomes involved in the product development cycle early on, providing advice on how the product & its components can be designed to facilitate manufacture and assembly. It also proceeds with the early stages of planning for the product. Functions like Quality engineering, manufacturing departments, field services, Vendors supplying critical components are also involved in Concurrent engineering. The product development cycle is substantially reduced in Concurrent engineering.
Concurrent Engineering can be used with differing focus and using different elements to build the system. The focus can consist of one or more (adapted and fulfilled): 

1. Shorter total lead time 
2. Products improved overall quality 
3. Decreased manufacturing costs 
4. Earlier break-even point 
5. Life-cycle cost reduction 
6. Better customer satisfaction 
7. Reduced changes / changes earlier / less changes after ramp-up 
8. Less risk of failure 
9. Lower risk to flop with product in general 
10. More predictable / accurate results / process (e.g. in feasibility) 
11. Global engineering environment development 

3. a) What are the basic components of an NC system. Explain with the help of block diagram. (4) 
Answer: 
1) Combining control system with coded programmed and machine tools is formed Numerical controlled machine tools (NC machines) 
2) NC machines having variety of complexities & capabilities. Conventionally NC control units added to machine tools which were used to control the position of work piece and relative motion of cutting tool. But the operator was required to select the cutting tolls, speed & feeds etc.
3) But as time passes the capabilities of machines tools improved and in addition to maintaining cutting tools & work piece relationship, the material removal was also controlled by the numerical control system.

4) NC machines consisting of following types of components.
   1) Program of instruction (paper tape or magnetic tape)
   2) Machine control Unit.
   3) Machine tool or processing equipment.

Diagram:

NC Machine System

1) Program of instruction: The instructions to NC machines are fed through an external medium i.e. paper tape or magnetic tape. The information coded on the paper tape and magnetic tape inform of coded pointer with specific position. Which defines, cutting tool position with respect to the work piece.

2) Machines control Unit: - The information read through an external medium i.e., paper tap or magnetic tape processed and decoded in form of digital signals which converts these digital signals into analog signals and control the motion of cutting tool with respect to work piece. This read information stored into the memory of the control system called “buffer storage” and is processed by the machine is working on one instructions block, the next block read from the tape and stored in the memory of machine control system.

3) Machine tool or processing unit: - Since the part cannot be produced without a tape being run through the control unit these types of NC machines called tape controlled machines. The machine tool, reads the digital signals inform of analog and transmit inform of mechanical motion for producing components. The tape has to be run repeatedly to be produced. Also if there is minor change inhering of component, the tape has to be discarded and new tape with changed program has to be produced.
3. b) Write manual part programming the billet size 100 x 100 x 10 material aluminum, depth of cut 2 mm.

4. a) Explain the tool pre-setting and qualified tools used in CNC machines.

Answer: Components of CNC Machines

1) In case of computer is used to perform all basic NC functions to control the machine tools this type of machine tool system is called CNC machine (computer numerical controlled machine)

2) The complete part program to produce a component is input and stored in the computer memory and the information for each operation is fed to the machine tools i.e. motors, etc.

3) The programs can be stored in memory of the computer and used in future.

CNC machine consist of following component:-

- Program instruction
- Machine control unit
- Machine tool or processing equipment.

Diagram:-
CNC Machine system

- Program instruction: The program of CNC machine in two type’s manual part programming & APT manual part programming use in special coded instructions for different machining operation ‘G’ code & ‘H’ code form. After the completion of part program it is allow to execute without actual operation and check where her it is correct or not in control unit of CNC machine.
- Machine Control Unit (MCU):- The machine control unit through which reading of the part programming and convert these coded instruction to the main operation instruction in digital mode and transmit the coded digital signal of instruction to the machine tool.
- MCU also provides the actual working interface of the actual operation without machine tool running which can be helpful to find out defects an part programming.
- MCU work as a management unit of CNC machine tool for managing various operational activities and store the information like program and sort of instruction for future use.

4. b) Write a manual part programming for given object. The raw material available is 20 mm dia bar (10)

Perform the following operation.

i) Facing
ii) Turn to 15 mm diameter over 15 mm length.
iii) Taper turning.
5. a) What is GT? Under what conditions GT is most appropriate? What benefit does GT provide in CAD/CAM manufacturing environment?

Answer: GT is a manufacturing technique in which parts having similarities in geometry, manufacturing process and/or functions are manufactured in one location using a small number of machines or processes. Group technology is based on a general principle that many problems are similar and by grouping similar problems, a single solution can be found to a set of problems, thus saving time and effort.

The group of similar parts is known as part family and the group of machineries used to process an individual part family is known as machine cell. It is not necessary for each part of a part family to be processed by every machine of corresponding machine cell. This type of manufacturing in which a part family is produced by a machine cell is known as cellular manufacturing. The manufacturing efficiencies are generally increased by employing GT because the required operations may be confined to only a small cell and thus avoiding the need for transportation of in-process parts.

Group technology is an approach in which similar parts are identified and grouped together in order to take advantage of the similarities in design and production. Similarities among parts permit them to be classified into part families.

The advantage of GT can be divided into three groups:

1. Engineering
2. Manufacturing
3. Process Planning

Disadvantages of GT Manufacturing:

1. Involves less manufacturing flexibility
2. Increases the machine down time as machines are grouped as cells which may not be functional throughout the production process.

Group technology (GT) offers substantial benefits to companies.

1) GT promotes standardization of tooling, fixtures and setups.
2) Material handling is reduced because parts are moved within a machine cell rather than within the entire factory.
3) Process planning and production scheduling are simplified.
4) Setup times are reduced, resulting in lower manufacturing lead times.
5) Work in process is reduced.
6) Worker satisfaction usually improves when workers collaborative in a GT cell.
7) Higher quality work is accomplished using group technology.

5. b) Write the three method of grouping part families and explain each one in brief. 

Answer: There are three methods of grouping part families

- Visual method
- Production flow anal.
- Part coding Analysis

![Fig. Methods of group formation](image-url)
Production Flow Analysis (PFA)

To group machines, part routings must be known. Section this presents a method for clustering part operations onto specific machines to provide this routing information.

The basic idea is:

- identify items that are made with the same processes / the same equipment
- These parts are assembled into a part family
- Can be grouped into a cell to minimize material handling requirements.

The clustering methods can be classified into:

- Part family grouping: Form part families and then group machines into cells
- Machine grouping: Form machine cells based upon similarities in part routing and then allocate parts to cells
- Machine-part grouping: Form part families and machine cells simultaneously.

The most typical methods are the machine-part grouping ones. Typically one starts with a matrix that shows which part types require which machine types. The aim is to sort the part types and machines such that some kind of block diagonal structure is obtained:

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<tr>
<th>Machine</th>
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Matrix of machine usage (Askin and Standridge)

In case of the example in Figure, it is easy to build groups:

- Group 1: parts \{13, 2, 8, 6, 11\}, machines \{B, D\}
- Group 2: parts \{5, 1, 10, 7, 4, 3\}, machines \{A, H, I, E\}
- Group 3: parts \{15, 9, 12, 14\}, machines \{C, G, F\}

But the question is how this sorting can be done. Various heuristic and exact methods have been developed. The simplest one is binary ordering, also known as rank order clustering or King’s algorithm.
6. a) List the various manufacturing and design attributes considered in GT. (4)

Answer: Most classification and coding systems are one of the following:

- Systems based on part design attributes
- Systems based on part manufacturing attributes
- Systems based on both design and manufacturing attributes

Part Design Attributes
- Major dimensions
- Basic external shape
- Basic internal shape
- Length/diameter ratio
- Material type
- Part function
- Tolerances
- Surface finish

Part Manufacturing Attributes
- Major process
- Operation sequence
- Batch size
- Annual production
- Machine tools
- Cutting tools
- Material type

6. b) Describe the four types of GT cell configuration with block diagram. (9)

Answer: Machine Cell Designs (Types of GT cells:)

(a) Single machine
(b) Multiple machines with manual handling
(c) Multiple machines with mechanized handling
(d) Flexible manufacturing cell
(e) Flexible manufacturing system
7. a) What is FMS? Explain the two category of flexibility.

Answer: Today flexibility means to produce reasonably priced customized products of high quality that can be quickly delivered to customers.

Different approaches to flexibility are

<table>
<thead>
<tr>
<th>Approach</th>
<th>Flexibility meaning</th>
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</table>
| Manufacturing | • The capability of producing different parts without major retooling  
• A measure of how fast the company converts its process(es) from making an old line of products to produce a new product  
• The ability to change a production schedule, to modify a part, or to handle multiple parts |
| Operational | • The ability to efficiently produce highly customized and unique products                                                                       |
| Customer   | • The ability to exploit various dimension of speed of delivery                                                                                   |
| Strategic  | • The ability of a company to offer a wide variety of products to its customers                                                                    |
| Capacity   | • The ability to rapidly increase or decrease production levels or to shift capacity quickly from one product or service to another                  |

There are three levels of manufacturing flexibility.

(a) **Basic flexibilities**

- Machine flexibility - the ease with which a machine can process various operations
- Material handling flexibility - a measure of the ease with which different part types can be transported and properly positioned at the various machine tools in a system
- Operation flexibility - a measure of the ease with which alternative operation sequences can be used for processing a part type

(b) **System flexibilities**

- Volume flexibility - a measure of a system’s capability to be operated profitably at different volumes of the existing part types
- Expansion flexibility - the ability to build a system and expand it incrementally
- Routing flexibility - a measure of the alternative paths that a part can effectively follow through a system for a given process plan
- Process flexibility - a measure of the volume of the set of part types that a system can produce without incurring any setup
- Product flexibility - the volume of the set of part types that can be manufactured in a system with minor setup

(c) Aggregate flexibilities
- Program flexibility - the ability of a system to run for reasonably long periods without external intervention
- Production flexibility - the volume of the set of part types that a system can produce without major investment in capital equipment
- Market flexibility - the ability of a system to efficiently adapt to changing market conditions

7. b) Describe the major elements and features of FMS also explain functions of each elements. (10)

Answer: Elements of flexible manufacturing system

A flexible manufacturing system consists of two subsystems
- Physical subsystem
- Control subsystem

Physical subsystem includes the following elements

1. Workstations: It consists of NC machines, machine-tools, inspection equipments, loading and unloading operation, and machining area. More recent flexible manufacturing system, however, include other types of processing equipment.
2. Storage-retrieval systems: It acts as a buffer during WIP (work-in-processes) and holds devices such as carousels used to store parts temporarily between work stations or operations.
3. Material handling systems: it consists of power vehicles, various types of automated material handling equipment such as conveyors [76], automated guided vehicles, in floor carts and robots are used to transport the work parts and sub-assemblies to the processing or workstation.

**Hardware components of flexible manufacturing system**

1. Pallets and fixtures
2. Machining centers
3. Robots
4. Inspection equipment
5. Chip removal system
6. In-process storage facility
7. Material handling systems

Advantages and disadvantages of FMSs implementation

Advantages

- Faster, lower-cost changes from one part to another which will improve capital utilization
- Lower direct labor cost, due to the reduction in number of workers
- Reduced inventory, due to the planning and programming precision
- Consistent and better quality, due to the automated control
- Lower cost/unit of output, due to the greater productivity using the same number of workers
- Savings from the indirect labor, from reduced errors, rework, repairs and rejects

Disadvantages

- Limited ability to adapt to changes in product or product mix (ex. machines are of limited capacity and the tooling necessary for products, even of the same family, is not always feasible in a given FMS)
- Substantial pre-planning activity
- Expensive, costing millions of dollars
- Technological problems of exact component positioning and precise timing necessary to process a component
- Sophisticated manufacturing systems

8. a) Explain different types of FMS based on number of machines and level of flexibility. (6)

Answer: FMSs as a possible way to overcome the said issues while making reliable and good quality and cost effective yields. Flexible manufacturing system has advanced as a tool to bridge the gap between high mechanized line and CNC Machines with efficient mid-volume production of a various part mix with low setup time, low work-in-process, low inventory, short manufacturing lead time, high machine utilization and high quality.

Types of Flexible manufacturing systems (FMS)

Flexible manufacturing systems can be separated into various types subject to their natures:

1. Depending Upon Kinds of Operation

   Flexible manufacturing system can be illustrious subject to the kinds of operation performed:
a) **Processing operation:** It performs some activities on a given job. Such activities convert the job from one shape to another continuous up to the final product. It enhances significance by altering the geometry, features or appearance of the initial materials.

b) **Assembly operation:** It comprises an assembly of two or more parts to make a new component which is called an assembly/subassembly. The subassemblies which are joined permanently use processes like welding, brazing, soldering, adhesive bonding, rivets, press fitting.

2. **Based on Number of Machines**

   There are typical varieties of FMS based on the number of machines in the system:
   
a) **Single machine cell (SMC):** It consists of completely automated machines which are capable of performing unattended operations within a time period lengthier than one complete machine cycle. It is skilful of dispensing various parts mix, reacting to fluctuations in manufacture plan, and inviting introduction of a part as a new entry. It is a sequence dependent production system.

   b) **Flexible manufacturing cell (FMC):** It entails two or three dispensing workstations and a material handling system. The material handling system is linked to a load/unload station. It is a simultaneous production system.

   c) **Flexible Manufacturing System (FMS):** It has four or more processing work stations (typically CNC machining centers or turning centers) connected mechanically by a common part handling system and automatically by a distributed computer system. It also includes non-processing work stations that support production but do not directly participate in it e.g., part / pallet washing stations, co-ordinate measuring machines. These features significantly differentiate it from Flexible manufacturing cell (FMC).

Fig: Comparison for three categories of FMS
3. **Based on Level of Flexibility**

FMS is further classified based on the level of flexibility related to the manufacturing system. Two categories are depicted here:

a) **Dedicated FMS:** It is made to produce a certain variety of part styles. The product design is considered fixed. So, the system can be designed with a certain amount of process specialization to make the operation more efficient.

b) **Random order FMS:** It is able to handle the substantial variations in part configurations. To accommodate these variations, a random order FMS must be more flexible than the dedicated FMS. A random order FMS is capable of processing parts that have a higher degree of complexity. Thus, to deal with these kinds of complexity, sophisticated computer control system is used for this FMS type.

![Differences between dedicated and random-order FMS types](image)

**Fig.:** Differences between dedicated and random-order FMS types

8. b) Explain various types of FMS layout configuration with the help of net diagram. (7)

**Answer:** The material handling system establishes the FMS layout. Most layout configurations found in today's FMSs can he divided into five categories:

1. **In-Line Layout.**
2. **Loop Layout.**
3. **Ladder Layout.**
4. **Open Field Layout**
5. **Robot-Centered Cell.**

1) **In the in-line layout,** the machines and handling system are arranged in a straight line. In its simplest form, the parts progress from one workstation to the next in a well-defined sequence, with work always moving in one direction and no back flow. The operation of this type of system is simpler to a transfer line
except that a variety of work parts are processed in the system. Since all work units follow the same routing sequence, even though the processing varies at each station. For in-line systems requiring greater routing flexibility, a linear transfer system that permits movement in two directions can be installed.

2) **In the loop layout**, the workstations are organized in loop that is served by part handling system in the same shape. Parts usually flow in one direction around the loop, with the capability to stop and be transferred to any station. A secondary handling system is shown at each workstation to permit parts to move without obstruction around the loop. The load/unload arc typically located at one end of the loop. An alternative form of loop layout is the *rectangular layout*. This arrangement might be used to return pallets to the starting position in a straight line machine arrangement.

3) **The ladder layout** consists of a loop with rungs between the straight sections of the loop, on which workstations are located. The rungs increase the possible ways of getting from one machine to the next, and obviate the need for a secondary handling system. This reduces average travel distance and minimizes congestion in the handling system, thereby reducing transport time between workstations.
4) **The open field layout consists** of multiple loops and ladders and may include sidings as well. This layout type is generally appropriate for processing a large family of parts. The number of different machine types may be limited, and parts are routed to different workstations depending on which one becomes available first.
4) **The robot-centered cell** uses one or more robots as the material handling system. Industrial robots can be equipped with grippers that make them well suited for the handling of rotational parts, and robot-centered FMS layouts are often used to process cylindrical or disk-shaped parts.

9. a) Discuss Generative type process planning and state its benefits and limitations. 

Answer: The generative type processes planning having following components 

- The various components of a generative system are:
- A part description, which identifies a series of component characteristics, including geometric features, dimensions, tolerances and surface condition.
- A subsystem to define the machining parameters, for example using look-up tables and analytical results for cutting parameters.
- A database of available machines and tooling.
- A report generator which prepares the process plan report.
Advantages of Generative CAPP System

The generative CAPP has the following advantages:
- It can generate consistent process plans rapidly.
- New components can be planned as easily as existing components.
- It has potential for integrating with an automated manufacturing facility to provide detailed control information

Drawbacks of Generative CAPP System
- The generative approach is complex.
- It is very difficult to develop.
Answer: Traditional Manufacturing Process Planning

The whole process of planning is done in different way in different companies. In some companies the machinists are merely given the drawing and asked to complete the job. In some cases the manufacturing engineering gives detailed list of the steps of the machining operations and also mentioning the work center on which the operation has to be carried out.

It is the duty of the manufacturing engineer within the company to write the process plans for the new part designs to be manufactured in the machine shop. The process planning task is usually too much dependent on the experience and the judgment of the engineer working in the production shop since years.

Until recently, the whole process planning tasks were being done manually. However, the individual engineers have their own opinions about what constitutes the best routing for the manufacture of a job. Due to this there are differences in the sequence of the machining operations developed by different planners. But now the computers are being used for manufacturing planning tasks. The use of computers for process planning enables removing a number of problems associated with the manual process planning.

Computer Aided Process Planning

The use of computers for process planning is called as Computer Aided Process Planning or simply CAPP. With CAPP the routine clerical tasks of the manufacturing engineers are reduced, so they can invest their time in more productive tasks. Further, with computers it becomes easier to generate production routings that are rational, and consistent without depending on the experience or the judgment of the individuals.

There are two approaches for computer aided planning process: retrieval type CAPP systems and generative CAPP systems. Both these systems have been described below.

1) Retrieval Type Process Planning System or CAPP System

In the retrieval type of CAPP system the various parts to be manufactured are classified, given codes and grouped within certain families. Within each part family standard process plan is established, which is stored in the computer. This process plan is also used for the new parts that come under the same family. The system developed is such that it is easier to retrieve the process plans for the new work parts. The whole process plan documents the operations as well as the sequence of operations on different machines. The retrieval CAPP system offers lots of flexibility as one can do lots of editing and changes as per the requirements.

2) Generative Process Planning Systems or CAPP Systems

In the generative process planning systems new plan is made automatically from scratch for each part using the computers, without involving human assistance. The computer program uses a set of algorithms that enables it to take a number of technical and logical decisions to attain the optimum final manufacturing process plan. One has to give certain inputs to the systems like detailed description of the part to be
manufactured. This CAPP system synthesizes the design of the optimum process sequence based on the analysis of the part geometry, material and other relevant parameters.

Benefits of CAPP

Whether one is using the retrieval system or the generative system, there are number of benefits of CAPP as described below:

1) **Process rationalization:** In CAPP the same software carries out the process planning and its procedure remains the same whoever uses it. Thus the process planning becomes logical, consistent and rationalized as it does not depends on the individualistic experience or judgment.

2) **Higher productivity of the process planners:** With CAPP the amount of the clerical work is greatly reduced for the process engineers and there are fewer chances of errors. The planners can invest their time on more skilled jobs and also attain the better process plan that is eventually translated into their higher productivity.

3) **Faster planning:** With CAPP system the engineers can make the routing sheets for the jobs faster resulting in lesser lead times for the manufacturing process.

4) **Good visibility:** The documents made from the computer are neat, clean and clear, which makes reading the routing sheets easier.

5) **Operate with other software:** The CAPP software can be easily integrated with the other software like designing and manufacturing software. This makes the whole process of designing, planning and manufacturing an integrated process.

9. c) Contrast production planning with process planning. (4)
Answer: The process of PPC follows a pre designed formulation. The purpose is to ensure that the plans are implemented properly. These plans are for a specified time period keeping in mind the stipulated costs and agreed policies. The costs include the capital cost of the facility, assets and labor. The steps or the procedure followed in PPC are as under:

**Demand predictions:** The production planning process begins with estimating or forecasting the demand among the consumers for the product or the service which is being offered

- Preparation of production budget: to compute the total cost of production.
- Design the facility layout
- Prescribe the types of machines and equipments to be used
- Appropriation of production requirements: At the planning stage itself the appropriation of raw materials, men and machinery required is done. Specifics regarding their quality and quantity are decided.

**Schedule:** The schedule of production is drawn. Date by which a particular operation or production step should be completed is stipulated and reasonable allowances are made for any possible delays or errors.
The shortage or excess of the end product is ascertained in relation to efficiency of labor and equipment. According to the fluctuation in the demand for the product, necessary adjustments are made in capacity of machines and the number of labor.

Plans are drawn in case of a sudden surge in demand as in seasonal advantages of certain products. Cost of surplus inventory and stocks are taken account of.

**Rate of production:** The rate and scale of production is set up. It is broken into realistic time periods and schedules. The stipulated or specified job needs to be finished by a particular date to start the next step.

**Process planning is also called:** manufacturing planning, process planning, material processing, process engineering, and machine routing.

- Which machining processes and parameters are to be used (as well as those machines capable of performing these processes) to convert (machine) a piece part from its initial form to a final form predetermined (usually by a design engineer) from an engineering drawing.

- The act of preparing detailed work instructions to produce a part.

- How to realize a given product design.

10. a) Briefly explain various activities carried out under production planning. (6)

**Answer:** Activity Carried out Production Planning are

**a) Estimating** - Estimating involves deciding the quantity of products to be produced and cost involved in it on the basis of sales forecast. Estimating manpower, machine capacity and materials required to meet the planned production targets are the key activities before budgeting for resources.

**b) Routing** - Routing means, determination of path or route on which manufacturing operations will travel, establishing the sequence of operations to be followed in manufacturing a particular product. This route path is determined in advance. Routing information is provided by product or process engineering function and it is useful to prepare machine loading charts and schedules.

**c) Scheduling** - Scheduling involves fixing priorities for each job and determines the starting time and finishing time for each operation, the starting dates and finishing dates for each part, sub assembly and final assembly. Scheduling lays down a time table for production, indicating the total time required for the manufacture of a product and also the time required for carrying out the operation for each part on each machine or equipment.

**d) Dispatching** - The functions of routing and scheduling as discussed above are paper work only. No actual production has yet been started. Dispatching is the part of production control that translates the paper work into actual production in accordance with the details worked out under routing and scheduling functions. Dispatching deals with setting the production activities in motion through the release of orders and instructions in accordance with the previously planned timings as embodied in production schedules.

**e) Expediting/ Follow-up/ Progressing** - Expediting - progressing ensures that, the work is carried out as per the plan and delivery schedules are met. Expediting includes activities such as status reporting, attending to bottlenecks or holdups in production removing the same, controlling variations or deviations from planned performance levels, following up and monitoring progress of work through all stages of production, coordinating with purchase, stores, tool room and maintenance departments and modifying the production plans and re-plan if necessary.
c) **Inspection** - Inspection is the process of examining an object for identification or checking it for verification of quality and quantity in any of its characteristics. It is an important tool for ascertaining and controlling the quality of a product. Inspection is an appraisal activity that compares goods or services to a standard.

10. b) State the objectives of material requirement planning. What are the inputs required for carrying out MRP?

Answer: The objectives of material requirement planning are as follows:

- Demand for all products.
- Lead times for all finished goods, components, parts and raw materials.
- Lot sizing policies for all parts.
- Opening inventory levels.
- Safety stock requirements.
- Any orders previously placed but which haven’t arrived yet.

**Inputs to MRP**

- The three important inputs to MRP are:
  - 1. Master production schedule,
  - 2. Bill of materials file and
  - 3. Inventory record file.
10.c) Write brief note on MRP - II.
Answer: **Manufacturing Resource Planning (MRP-II) include**

1. Management planning — business strategy, aggregate production planning, master production scheduling, rough-cut capacity planning and budget planning.
2. Customer services — sales forecasting, order entry, sales analysis and finished goods inventory.
3. Operations planning — purchase order and work order release.
4. Operations execution — purchasing, product scheduling and control, work-in-process inventory control, shop floor control and labour hour tracking.
5. Financial functions — cost accounting, accounts receivable, accounts payable, general ledger and payroll.

Now-a-days many commercial software are available incorporating MRP II functions with more features.

11. Write short note on: (13)
1) CMM
2) CAQC
3) Pull system of production control.

Answer:
1) CMM

Answer: Functions of CMM
To measure the actual size of w/p comparison with desired shape and evaluation of metrological information such as
- Size
- Form
- Location
- Position
- Actual size
is obtained by probing the surface at discrete measuring points. Every points expressed in terms of its x, y, z coordinates Functions of CMM Mechanical Setup with 3 axes movement & the displacement transducer. Probe head to probe the work piece in spatial direction .computer with software to calculate & represent the results CMM system components
2) CAQC

Answer: The use of the computers for quality control of the product is called as the computer aided quality control or CAQC. The two major parts of quality control are inspection and testing, which are traditionally performed manually with the help of gages, measuring devices and the testing apparatus. The two major parts of computer aided quality control are computer aided inspection (CAI) and computer aided testing (CAT). CAI and CAT are performed by using the latest computer automation and sensor technology. CAI and CAT are the standalone systems and without them the full potential of CAQC cannot be achieved. The main objectives of the CAQC are to improve the quality of the product, increase the productivity in the inspection process and reduce the lead times in manufacturing. The implementation of CAQC in the company results in the major change in the way the process of quality control is carried out in the company.

The advantages and the highlights of the computer aided quality control process:

1) **100% testing and inspection:** In the traditional manual process the testing and inspection is done by the sampling process out of the hundreds and thousands of products or parts manufactured by the company since it is not feasible to check each and every product. With CAI and CAT hundred percent inspection and testing can be accomplished without much difficulty. With 100% inspection the company does not have to depend on statistical quality control method in which it is assumed that anything less than 100% of quality is acceptable. With computer controlled inspection, it is not necessary for the quality control department to settle for less than perfection.

2) **Inspection integrated with manufacturing process:** In the traditional process there is separate quality control department where the manufactured product is taken for the inspection and testing. In CAQC the inspection process is integrated with the manufacturing process and it is located along the production line. Thus as soon as the product is manufactured it is tested immediately by the computerized process without moving it to some other location. This helps in reducing the overall time required for manufacturing the product.

3) **Use of non-contact sensors:** In the traditional process the product or the part to be inspected is handled manually since it has to be positioned properly for inspection on the desk or suitable location. In CAQC non-contact sensors are used for the inspection purpose and they inspect the product without coming in contact with the product. The non-contact sensors operated by the computer are kept along the production line and they can check the product very quickly in the fraction of seconds. In future with further advancements in the technology, the robots would be used to carry-out the inspection process thus further automating and speeding the process.

4) **Computerized feedback control system:** The data collected by the non-contact sensors is sent as the feedback to the computerized control systems. These systems would carry out the analysis of the data including statistical trend analysis. This helps in identifying the problem going on in the manufacturing line and find appropriate solution to it. For instance, the results from non-contact sensors may indicate that the parts manufactured are not within the acceptable tolerance limits. This would help the production or quality control personnel to find out the precise location of the problem and its exact cause.
5) **Computer aided quality control and CAD/CAM integration:** Apart from inspection and testing, computers are used in a number of other areas of the quality control. All the applications of CAQC can be integrated with CAD/CAM to make the whole process of designing and manufacturing controlled by the computers converted into fully automated process.

3) Pull system of production control.

Answer: The following system are used

**Triangle Kanban**

The method that Toyota facilities would follow most of the time in connecting a batch process to a downstream assembly process is called the triangle kanban. Below is an example in rough detail of how to evaluate to use this method for implementation.

**Triangle Kanban Detail**

![Triangle Kanban Diagram](image)

There are three basic types of pull production systems:

**Supermarket Pull System**

The most basic and widespread type, also known as a fill-up or replenishment pull system. In a supermarket pull system each process has a store -- a supermarket -- that holds an amount of each product it produces. Each process simply produces to replenish what is withdrawn from its supermarket. The disadvantage of a supermarket system is that a process must carry an inventory of all part numbers it produces, which may not be feasible if the number of part numbers is large.

**Sequential Pull System**

A sequential pull system may be used when there are too many part numbers to hold inventory of each in a supermarket. Products are essentially “made-to-order” while overall system inventory is minimized. In a sequential system, the scheduling department must set the right mix and quantity of products to be produced. A sequential system requires strong management to maintain, and improving it may be a challenge on the shop floor.
Mixed Supermarket and Sequential Pull System

Supermarket and sequential pull systems may be used together in a mixed system. A mixed system may be appropriate when an 80/20 rule applies, with a small percentage of part numbers (perhaps 20%) accounting for the majority (perhaps 80%) of daily production volume.

12. Write short note on: (13)
   i) Manufacturing system control.
   ii) Shop floor control.
   iii) Inventory control.

   i) Manufacturing system control.
   Answer: The term manufacturing system refers to a collection or arrangement of operations and processes used to make a desired product or component. It includes the actual equipments for composing the processes and the arrangement of those processes. In a manufacturing system, if there is a change or disturbance in the system, the system should accommodate or adjust itself and continue to function efficiently.

   ii) Shop floor control.
   Answer: Shopfloor control (SFC) is concerned with:
   (i) The release of production orders to the factory.
   (ii) Monitoring and controlling the progress of the orders through the various work centres.
   (iii) Acquiring information on the status of the orders.
   (iv) Shop floor control deals with managing the work-in-process.
Functions of Shop Floor Control
The major functions of shop floor control are:
1. Assigning priority of each shop order (Scheduling).
3. Conveying shop-order status information to the office (Follow up).
4. Providing actual output data for capacity control purposes.
5. Providing quantity by location by shop order for work-in-process inventory and accounting purposes.
6. Providing measurement of efficiency, utilisation and productivity of manpower and machines.

iii) Inventory control.

Answer: **Inventory Control**

Inventory Management:

It is defined as the scientific method of determining what to order, when to order and how much to order and how much to stock so that costs associated with buying and storing are optimal without interrupting production and sales.

Objective of Inventory Control

The main objectives of inventory control are:
(i) To ensure continuous supply of materials so that production should not suffer at any time.
(ii) To maintain the overall investment in inventory at the lowest level, consistent with operating requirements.
(iii) To minimize holding, replacement and shortage cost of inventories and maximize the efficiency in production and distribution.
(iv) To keep inactive, waste, surplus, scrap and obsolete items at the minimum level.
(v) To supply the product, raw material, WIP, etc., to its users as per their requirements at right time and at right price.
(vi) To ensure timely action for replenishment.
(vii) To maintain timely record of inventories of all the items and to maintain the stock within the desired limits.
(viii) To avoid both over-stocking and under-stocking of inventory costs.

Associated with Inventory (What are Inventory Costs?)
Q1. "CIM is an island of Automation", Explain & Justify with today's industrial context. (6)

Answer: Islands of automation was a popular term used largely during the 1980s to describe how rapidly developing automation systems were at first unable to communicate easily with each other. Industrial communication protocols, network technologies, and system integration helped to improve this situation. Just a few of the many examples of helping technologies are Modbus, Fieldbus, Ethernet, etc.

It is more recently used by automation specialists to describe a discrete and fully enclosed automated system applied in a largely manual environment.

In today’s interconnected world it is uncommon for automated systems to be fully stand alone. Therefore, the old usage is defunct and the new usage is more appropriate for companies that wish to automate in a limited fashion.

This study is concerned with a research programme on automation and computer integrated manufacturing (CIM) in food processing industry, culminating in an implementation framework detailing the extent of automation and application of computer based technologies in Irish food processing industries.

The key findings point to the existence of a linear relationship between practice and performance. From the perspective of competitive advantage, the traditional postal survey gives a higher response rate than web-based survey, but on the other hand the web based survey takes shorter response time and cost s less than a traditional postal survey. The results of this study show variable levels of automation. A large number of the manufacturing plants are applying automation, and are trying to increase the automation level in their plants. This work has demonstrated that the manufacturers have the desire to adopt CIM systems at different levels, despite the cost obstacle of implementing them.
1.b) Enlist & Explain with neat sketch various elements of computer integrated manufacturing.(7)

Answer : The following are the role of the elements of CIM system

Nine major elements of a CIM system

- Marketing
- Product Design
- Planning
- Purchase
- Manufacturing Engineering
- Factory Automation hardware
- Warehousing
- Logistics and Supply Chain Management
- Finance
- Information Management

![Diagram of CIM system elements](image)

Figure 2 Major elements of CIM systems

i. Marketing: The need for a product is identified by the marketing division. The specifications of the product, the projection of manufacturing quantities and the strategy for marketing the
product are also decided by the marketing department. Marketing also works out the manufacturing costs to assess the economic viability of the product.

ii. Product Design: The design department of the company establishes the initial database for production of a proposed product. In a CIM system this is accomplished through activities such as geometric modeling and computer aided design while considering the product requirements and concepts generated by the creativity of the design engineer.

iii. Planning: The planning department takes the database established by the design department and enriches it with production data and information to produce a plan for the production of the product. Planning involves several subsystems dealing with materials, facility, process, tools, manpower, capacity, scheduling, outsourcing, assembly, inspection, logistics etc.

iv. Purchase: The purchase departments is responsible for placing the purchase orders and follow up, ensure quality in the production process of the vendor, receive the items, arrange for inspection and supply the items to the stores or arrange timely delivery depending on the production schedule for eventual supply to manufacture and assembly.

v. Manufacturing Engineering: Manufacturing Engineering is the activity of carrying out the production of the product, involving further enrichment of the database with performance data and information about the production equipment and processes. In CIM, this requires activities like CNC programming, simulation and computer aided scheduling of the production activity.

vi. Factory Automation Hardware: Factory automation equipment further enriches the database with equipment and process data, resident either in the operator or the equipment to carry out the production process. In CIM system this consists of computer controlled process machinery such as CNC machine tools, flexible manufacturing systems (FMS).

vii. Warehousing: Warehousing is the function involving storage and retrieval of raw materials, components, finished goods as well as shipment of items. In today's complex outsourcing scenario and the need for just-in-time supply of components and subsystems, logistics and supply chain management as same great importance.
viii. Finance: Finance deals with the resources pertaining to money. Planning of investment, working capital, and cash flow control, realization of receipts, accounting and allocation of funds are the major tasks of the finance departments.

ix. Information Management: Information Management is perhaps one of the crucial tasks in CIM. This involves master production scheduling, database management, communication, manufacturing systems integration and management information systems.

2.a) Explain the scope of CIM using CIM CASA/SME wheel. (7)

Answer: The Computer and Automated Systems Association (CASA) of the Society of Manufacturing Engineers (SME) of the United States, also known as the organizer of the CIM-Fair and the Auto fact Congress. The original CIM picture of the CASA/SME has undergone a number of changes in recent years. This development has resulted in the realization that CIM, apart from factory automation and functions indirectly related to the operational performance such as design (product/process) and production planning and control, is also linked to common business administrative tasks such as manufacturing management, strategic planning, finance, marketing and human resource management.

CIM is defined differently by different users, and can be implemented in varying an increasing degree of complexity. For many companies, improving shopfloor communications is the primary goal. Others extend the degree of integration to encompass communication between engineering and manufacturing functions. The ultimate benefit of CIM is the improvement of communication and control of information flow to all aspects of an enterprise. The computer and automated systems association of the society of Manufacturing Engineers (CASA/SEM) defines CIM is the integration of total manufacturing enterprise by using integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency.
Manufacturing equipment such as CNC machines or computerized work centers, robotic work cells, DNC/FMS systems, work handling and tool handling devices, storage devices, sensors, shop floor data collection devices, inspection machines etc.

Computers, controllers, CAD/CAM systems, workstations / terminals, data entry terminals, barcode readers, RFID tags, printers, plotters and other peripheral devices, modems, cables, connectors etc.,

CIM software comprises computer programs to carry out the following functions:

- Management Information System
- Job Tracking
- Sales
- Inventory Control
- Marketing
- Shop Floor Data Collection
- Finance
- Order Entry
- Database Management
- Materials Handling
- Modeling and Design
- Device Drivers
2.b). Discuss in detail the concept of "Concurrent Engineering". State its advantages & Limitation.

Answer: Concurrent engineering refers to an approach used in product development in which the function of design engineering, manufacturing engineering and other functions are integrated to reduce the elapsed time required to bring a new product to market. Also called as simultaneous engineering. In traditional approach, the product design department develops the new design, sometimes without much consideration given to the manufacturing capabilities of the company. There is little opportunity for manufacturing engineers to offer advice on how the design might be altered to make it more manufacturable. Once of the design is made it is tossed up to the manufacturing department as if there is a wall between them.

Concurrent engineering, also known as simultaneous engineering, is a method of designing and developing products, in which the different stages run simultaneously, rather than consecutively. It decreases product development time and also the time to market, leading to improved productivity and reduced costs.

Advantages of Concurrent Engineering over Sequential Engineering

By contrast in a company that practices concurrent engineering, the manufacturing engineering department becomes involved in the product development cycle early on, providing advice on how the product & its components can be designed to facilitate manufacture and assembly. It also proceeds with the early stages of planning for the product. Functions like Quality engineering, manufacturing departments, field services, Vendors supplying critical components are also involved in Concurrent engineering. The product development cycle is substantially reduced in Concurrent engineering.
Concurrent Engineering can be used with differing focus and using different elements to build the system. The focus can consist of one or more (adapted and fulfilled):

1. Shorter total lead time
2. Products improved overall quality
3. Decreased manufacturing costs
4. Earlier break-even point
5. Life-cycle cost reduction
6. Better customer satisfaction
7. Reduced changes / changes earlier / less changes after ramp-up

8. Less risk of failure

9. Lower risk to flop with product in general

10. More predictable / accurate results / process (e.g. in feasibility)

11. Global engineering environment development

3. a) Explain components & operational features of NC system with neat sketch. Also compare open loop & close loop CNC system.

Answer:

1) Combining control system with coded programmed and machine tools is formed Numerical controlled machine tools (NC machines)

2) NC machines having variety of complexities & capabilities. Conventionally NC control units added to machine tools which were used to control the position of work piece and relative motion of cutting tool. But the operator was required to select the cutting tolls, speed & feeds etc.

3) But As time passes the capabilities of machines tools improved and in addition to maintaining cutting tools & work piece relationship, the material removal was also controlled by the numerical control system.

NC machines consisting of following types of components.

1) Program of instruction (paper tape or magnetic tape)

2) Machine control Unit.
3) Machine tool or processing equipment.

Diagram:

```
Program Instructions  →  Machine Control Unit  →  Transformation Process
```

NC Machine System

1) Program of instruction: The instructions to NC machines are fed through an external medium i.e. paper tape or magnetic tape. The information coded on the paper tape and magnetic tap inform of coded punter with specific position. Which defines, cutting tool position with respect to the work piece.

2) Machines control Unit :- The information read through an external medium i.e., paper tap or magnetic tape processed and decoded in for m of digital signals which converts these digital signals into analog signals and control the motion of cutting tool with respect to work piece. This read information stored into the memory of the control system called “buffer storage” and is processed by the machine is working on one instructions block, the next block read from the tape and stored in the memory of machine control system.

3) Machine tool or processing unit: - Since the part cannot be produced without a tape being run through the control unit these types of NC machines called tape controlled machines. The machine tool. reads the digital signals inform of analog and transmit inform of mechanical motion for producing components. The tape has to be run repeatedly to be produced. Also if there is minor change inhering of component, the tape has to be discarded and new tape with changed program has to be produced.
3.b) Write a manual part program to turn a bar of 50 mm dia to 40 mm dia over a length of 30 mm. Assume data if needed. All dimensions are in mm.

Answer:

```
% START OF PROGRAM
N001 G90 G71  
N005 G96 G95 T01 
N010 G00 X26000 Z66000 F0 
N015 M03 S750 M08 
N020 G11 X23000 F225 
N025 Z23000 
N030 X23500 
N035 G00 Z66000 F0 
N040 G01 X21000 F225 
N045 Z25000 
N050 X25000 
N055 G00 Z66000 F0 
N060 G01 X18000 F225 
N065 X21000 Z50000 
N070 X23500 
N075 G00 Z66000 F0 
N080 G01 X16000 F225
```

- N001 G90 G71: Rapid move to tool start position (SP)
- N005 G96 G95 T01: Turn on spindle and coolant
- N010 G00 X26000 Z66000 F0: Position tool for first cut (DOC = 2 mm)
- N015 M03 S750 M08: First rough cut

**Notes:**
- First rough taper
- Position for start of rough taper
- First rough taper
- Off the workpoint
- RHS safe position
4. a) Explain the following terminologies with reference to NC system.

i) Absolute & Incremental positioning system.

Answer: Absolute and incremental positioning are used interchangeably when discussing the position values of the DRO. Both absolute and incremental position methods give the operator greater flexibility when machining a part.

Absolute coordinates are defined as each position on the work piece is unique. Using Figure 1 below, the absolute coordinates for position 1 are $X = 20$ mm, $Y = 10$ mm and $Z = 15$ mm.

With incremental coordinates, the last point traveled to becomes the new reference point on which the operator bases his next move. In Figure 2, the operator wants to move from position 2 to position 3. The operator would input the following values to move to position 3 incrementally.

$X_{I} = 10$ mm  
$Y_{I} = 5$ mm  
$Z_{I} = 20$ mm

Incremental coordinate positioning is very useful tool when the operator doesn’t want to do addition or subtraction to figure out the absolute coordinates. Figure 3 shows how the operator can put in $X_{I} = 30$ and $Y_{I} = 30$ instead of doing the addition to find out what the absolute coordinate of position 2 is when moving from position 1.
Also, incremental coordinates are used with bolt-hole patterns so the operator doesn’t have to know the exact coordinates of each bolt hole but rather move until each axis display is zero before drilling a hole. In conclusion, each coordinate system has its benefits and it is truly up to the operator to take advantage of the benefits of each coordinate measurement system.
ii) Types of motion control system.
Answer: Based on the motion type point to point, straight line & contouring system.

a) Point to Point control system :-

1) point to point control is one where accurate positional slides only to place the machine slides in fixed position & the machine tool slide is required to reach a particular fixed to co-ordinate point in the shortest possible time.

2) The machining operating are performed at specific points and there is no machining while the machine table/slide move from one point to the next. No machining takes place until the machine slides have reached the programmed co-ordinate point and slide movement ceases. Since there is no machining when the machine slides move from one point to other point.

3) Here path of movement of tool is not important but care must be taken to ensure that the costing tool should not hit the work piece while moving from one position to the next.

4) The movement along different axis may be sequential or simultaneous. The sequential or simultaneous movement reducing machining time.

5) Point to point system is suitable for drilling, boring, tapping, punch presses and jig boring machines.

![Diagram](Point-to-point-system)

b) Straight line control system :-

1. It is extension of point to point control system in which special provision for machining along a straight line as in case of milling, turning & facing.
2. In this control system controlled feed provides along the axis in line motion.
3. In this control system it is capable of calculating and displacing the slides simultaneously at suitable feed rates to reach the desired points.

![Straight line control system](image)

### C) Continuous path or contouring control system

1. The contouring system is a high technology and most versatile control system. The control system generates continuous motion of tool and work piece along different coordinate axis.
2. This system enables the machining of profile, contours and curved surfaces.
3. This system designed for continuous path machining hence in it we can perform point to point & straight line machining also
4. In this system the machine tool, tool & work piece movement control simultaneously relative positions and velocities at every point throughout the operation.

![Contouring System](image)
4. b) Write manual part program for profile as shown in fig. 2 Aluminum billet of size 100 x 100 x 10 Depth of slot - 2 mm. Cutter Dia - 2 mm. Assume suitable machining parameters. (8)

5. a) What is Group Technology in modern manufacturing environment? Explain various part Identification & coding system. (6)

Answer: GT can produce considerable improvements where it is appropriate and the basic idea can be utilized in all manufacturing environments:

To the manufacturing engineer GT can be viewed as a role model to obtain the advantages of flow line systems in environments previously ruled by job shop layouts. The idea is to form groups and to aim at a product-type layout within each group (for a family of parts). Whenever possible, new parts are designed to be compatible with the processes and tooling of an existing part family. This way, production experience is quickly obtained, and standard process plans and tooling can be developed for this restricted part set.

To the design engineer the idea of GT can mean to standardize products and process plans. If a new part should be designed, first retrieve the design for a similar, existing part. Maybe, the
need for the new part is eliminated if an existing part will suffice. If a new part is actually needed, the new plan can be developed quickly by relying on decisions and documentation previously made for similar parts. Hence, the resulting plan will match current manufacturing procedures and document preparation time is reduced. The design engineer is freed to concentrate on optimal design.

There are three basic steps in group technology planning:
1. coding
2. classification
3. layout.

**Coding schemes**

The knowledge concerning the similarities between parts must be coded somehow. This will facilitate determination and retrieval of similar parts. Often this involves the assignment of a symbolic or numerical description to parts (part number) based on their design and manufacturing characteristics. However, it may also simply mean listing the machines used by each part.

There are four major issues in the construction of a coding system:
- part (component) population
- code detail
- code structure, and
- (digital) representation.

Numerous codes exist, including Brisch-Birn, MULTICLASS, and KK-3. One of the most widely used coding systems is OPITZ. Many firms customize existing coding systems to their specific needs. Important aspects are

- The code should be sufficiently flexible to handle future as well as current parts.
- The scope of part types to be included must be known (e.g. are the parts rotational, prismatic, sheet metal, etc.?)
- To be useful, the code must discriminate between parts with different values for key attributes (material, tolerances, required machines, etc.)
- Code detail is crucial to the success of the coding project. Ideal is a short code that uniquely identifies each part and fully describes the part from design and manufacturing viewpoints.

Too much detail results in cumbersome codes and the waste of resources in data collection.
5.b) Explain with neat sketch: Opitz Parts Coding System

Answer: It is a mixed (hybrid) coding system

- developed by Opitz, Technical University of Aachen, 1970
- it is widely used in industry
- it provides a basic framework for understanding the classification and coding process
- it can be applied to machined parts, non-machined parts (both formed and cast) and purchased parts
- it considers both design and manufacturing information

The Opitz coding system consists of three groups of digits:

Form code: 12345
Supplementary code: 6789
Secondary code: ABCD

- Part geometry and features relevant to part design
- Information relevant to manufacturing (polycode)
- Production processes and production sequences

Geometrical Form Code:

Digit 1: Component class
- 0: L/D ≤ 0.5
- 1: 0.5 < L/D ≤ 3
- 2: L/D > 3

Digit 2: Main shape
- External shape
- Internal shape

Digit 3: Rotational surface machining
- Rotational machining, internal and external shape elements

Digit 4: Plane surface machining
- Principal bore
- Planar surface machining

Digit 5: Auxiliary holes
- Gear teeth forming
- Aux. holes, gear teeth forming
- Aux. holes, teeth forming

Special Supplementary Code

- 1: Dimensions
- 2: Material
- 3: Raw material form
- 4: Accuracy
Digit 1: shows whether the part is rotational and also the basic dimension ratio (length/diameter if rotational, length/width if non rotational).

Digit 2: main external shape; partly dependent on digit 1.

Digit 3: main internal shape.

Digit 4: machining requirements for plane surfaces.

Digit 5: auxiliary features like additional holes, etc.

6.a). Explain the concept of Production Flow Analysis. (7)

Answer: **Production Flow Analysis (PFA)**

Method of grouping part into families

Used to analyze the operation steps and machine routes for the parts produced groups parts with similar or identical routings together. These groups can be used to form logical machine cells in a get layout.

Uses manufacturing data rather than design data to make groups, so takes care of the problem of:

Parts whose basic geometry may differ but might take same or similar process routes
Parts whose basic geometry may be same or similar but require different process routings

**Disadvantage:**

Takes the route details the way they are, no check for optimal, consistent or logical routing.

**Production Flow Analysis: Procedure**

1. **Data Collection**

   Define the population of the parts to be analyzed
   
   Study a sample or the whole population
   
   Minimum data needed is the part number and routing sequence of each part (route sheets) additional data as lot size, annual production rate, can be used to design cells of the desired productivity

2. **Sorting of Process (Routings)**

   Arrange the parts according to the similarity of their process routings
   
   Sorting procedure is used to arrange the parts into “packs”
   
   “pack: is a group of parts with identical process routings
each pack is given a pack identification number or letter

3. PFA Chart

Processes used for each pack are displayed graphically on a PFA chart
Plot of the process code numbers for all the packs that have been determined

4. Analysis

Most difficult and crucial step
From the PFA chart, similar groups are identified
Minimum data needed is the part number and routing sequence of each part (route sheets)
Additional data as lot size, annual production rate, can be used to design cells of the desired
Productivity
Example (Matrix Form)

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Milling</th>
<th>Lathe 1</th>
<th>Lathe 2</th>
<th>Lathe 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>02346</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>78901</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>23456</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

6.b) Discuss in detail concept of Machine Cell Design. Enlist it's advantages

Answer: **Machine cell Concept**

- A Composite Part for a given family, which includes all of the design and manufacturing attributes of the family
- An individual part in the family will have some of the features that characterize the family but not all of them
- Composite part possesses all of the features
Machine Cell Designs: Types

Term “cellular manufacturing” is used to describe the operations of a GT machine cell that can be classified, based on number of machines and the degree to which the material flow is mechanized between the machines:

1. single machine cell
2. group machine cell with manual handling
3. group machine cell with semi-integrated handling
4. flexible manufacturing system (FMS)

Machine Cell Designs: Type 1

Single machine cell

1. It consists of 1 machine plus supporting fixtures and tooling to make one or more part families
2. It can be applied to work parts that is made by one type of process, such as turning or milling
Machine Cell Designs: Type 2

**Group machine cell with manual handling using a U-shaped layout**

1. It consists of more than one machine used collectively to make one or more part families

2. There no provision for mechanized part movement between machines

3. Human operators running cell, perform material handling; if size of the part is huge or arrangement of machines in cell is large, regular handling crew may be required

4. It may organized in a U-shape layout when there is variation in work flow in parts; also useful in movement of multi functional workers

5. Design is often achieved without rearranging the process-type layout; simply include certain machines in group and restrict their work to specified part family

6. Saves cost of rearranging but many material handling benefits of GT are not realized

Machine Cell Designs: Type 3

**Group machine cell with semi-integrated handling**

Uses a mechanized handling system, such as a conveyor, to move parts between machines in the cell

Parts made in the cell have identical or similar routing — in-line layout (a)
Machines are laid along a conveyor to match the processing sequence
P routings vary in parts – loop layout (b)
Allows parts to circulate in the handling system
Permits different processing steps in the different parts in the system

Machine Cell Designs: Type 4

**Flexible Manufacturing System (FMS)**

Highly automated machine cells in GT
Combines automated processing stations with a fully integrated material handling system

7. a) Explain "Flexible Manufacturing System" (FMS) with special reference to CIM. Also explain the components of FMS. (8)

Answer: Manufacturing Industries are facing vigorous threats by inflation in market needs, corporate lifestyle and globalization. Hence, in current situation, Industries which are responding rapidly to market fluctuations with more competitiveness will have great capabilities in producing products with high quality and low cost. In the view of manufacturers, production cost is not at all a significant factor which affects them. But, some of the factors which are important to the manufacturer are flexibility, quality, efficient delivery and customer
satisfaction.

Hence, with the help of automation, robotics and other innovative concepts such as just-in-time (JIT), Production planning and control (PPC), enterprise resource planning (ERP) etc., manufacturers are very keen to attain these factors.

Flexible manufacturing is a theory which permits production systems to perform under high modified production needs. The problems such as minimum inventories and market-response time to bump into customer needs, response to adjust as per the deviations in the market. In order to sweep market by reducing the cost of products and services will be mandatory to various companies to shift over to flexible manufacturing systems. FMSs as a possible way to overcome the said issues while making reliable and good quality and cost effective yields.

Flexible manufacturing system has advanced as a tool to bridge the gap between high mechanized line and CNC Machines with efficient mid-volume production of a various part mix with low setup time, low work-in-process, low inventory, short manufacturing lead time, high machine utilization and high quality FMS is especially attractive for medium and low-capacity industries such as automotive, aeronautical, steel and electronics.

Flexible manufacturing system incorporates the following concepts and skills in an automated production system

1. Flexible automation

2. Group technology

3. Computer numerical control machine tools

4. Automated material handling between machines

**Basic features of the physical components of an FMS are discussed below:**

1. **Numerical control machine tools.**

   Machine tools are considered to be the major building blocks of an FMS as they determine the degree of flexibility and capabilities of the FMS. Some of the features of machine tools are described below;

   - The majority of FMSs use horizontal and vertical spindle machines. However, machining centers with vertical spindle machines have lesser flexibility than horizontal machining
centers.

- Machining centers have numerical control on movements made in all directions e.g. spindle movement in x, y, and z directions, rotation of tables, tilting of table etc to ensure the high flexibility.
- The machining centers are able to perform a wide variety of operations e.g. turning, drilling, contouring etc. They consist of the pallet exchangers.

2. Work holding and tooling considerations.

It includes pallets/fixtures, tool changers, tool identification systems, coolant, and chip removal systems. It has the following features:

- Before machining is started on the parts, they are mounted on fixtures. So, fixtures must be designed in a way, to minimize part-handling time. Modular fixturing has come up as an attractive method to fixture a variety of parts quickly.
- The use of automated storage and retrieval system (AS/RS) and material handling systems such as AGVs, lead to high usage of fixtures.
- All the machining centers are well equipped with tool storage systems called tool magazines. Duplication of the most often used tools in the tool magazines is allowed to ensure the least non-operational time. Moreover, employment of quick tool changers, tool regrinders and provision of spares also help for the same.

3. Material-Handling Equipments

The material-handling equipments used in flexible manufacturing systems include robots, conveyers, automated guided vehicle systems, monorails and other rail guided vehicles, and other specially designed vehicles. There important features are:

- They are integrated with the machine centers and the storage and retrieval systems.
- For prismatic part material handling systems are accompanied with modular pallet fixtures. For rotational parts industrial robots are used to load/unload the turning machine and to move parts between stations. The handling system must be capable of being controlled directly by the computer system to direct it the various work station, load/unload stations and storage area.

4. Inspection equipment
It includes coordinate measuring machines (CMMs) used for offline inspection and programmed to measure dimensions, concentricity, perpendicularity, and flatness of surfaces. The distinguishing feature of this equipment is that it is well integrated with the machining centers.

5. Other components

It includes a central coolant and efficient chip separation system. Their features are:

- The system must be capable of recovering the coolant.
- The combination of parts, fixtures, and pallets must be cleaned properly to remove dirt and chips before operation and inspection.

HARDWARE COMPONENTS OF FLEXIBLE MANUFACTURING SYSTEM

1. Pallets and fixtures
2. Machining centers
3. Robots
4. Inspection equipment
5. Chip removal system
6. In process storage facility
7. Material handling systems

b) Describe various types of FMS based on (6)
   i) Kinds of Operation
   ii) Number of Machines
   iii) Level of Flexibility.

Answer: Flexible manufacturing systems can be separated into various types subject to their natures:

1. **Depending upon kinds of operation**

Flexible manufacturing system can be illustrious subject to the kinds of operation performed:

   a. **Processing operation.**
It performs some activities on a given job. Such activities convert the job from one shape to another continuous up to the final product. It enhances significance by altering the geometry, features or appearance of the initial materials.

b. **Assembly operation.** It comprises an assembly of two or more parts to make a new component which is called an assembly/subassembly. The subassemblies which are joined permanently use processes like welding, brazing, soldering, adhesive bonding, rivets, press fitting.

### 2. Based on number of machines

There are typical varieties of FMS based on the number of machines in the system:

**a. Single machine cell (SMC).** It consists of completely automated machines which are capable of performing unattended operations within a time period lengthier than one complete machine cycle. It is skilful of dispensing various part mix, reacting to fluctuations in manufacture plan, and inviting introduction of a part as a new entry. It is a sequence dependent production system.

**B. Flexible manufacturing cell (FMC).** It entails two or three dispensing workstations and a material handling system. The material handling system is linked to a load/unload station. It is a simultaneous production system.

**C. An Flexible Manufacturing System (FMS).** It has four or more processing work stations (typically CNC machining centers or turning centers) connected mechanically by a common part handling system and automatically by a distributed computer system. It also includes non-processing work stations that support production but do not directly participate in it e.g., part / pallet washing stations, co-ordinate measuring machines. These features significantly differentiate it from Flexible manufacturing cell (FMC).

Comparison for three categories of FMS

In this research, authors focused on Flexible manufacturing system
2. BASED ON LEVEL OF FLEXIBILITY

FMS is further classified based on the level of flexibility related to the manufacturing system. Two categories are depicted here:

a. Dedicated FMS. It is made to produce a certain variety of part styles. The product design is considered fixed. So, the system can be designed with a certain amount of process specialization to make the operation more efficient.

b. Random order FMS. It is able to handle the substantial variations in part configurations. To accommodate these variations, a random order FMS must be more flexible than the dedicated FMS. A random order FMS is capable of processing parts that have a higher degree of complexity. Thus, to deal with these kinds of complexity, sophisticated computer control system is used for this FMS type.

In this research, authors consider Random order FMS

\[ \text{Production rate}(Z), \text{ annual volume}(V) \]

Differences between dedicated and random-order FMS types

Flexibility is an attribute that allows a mixed model manufacturing system to cope up with a certain level of variations in part or product style, without having any interruption in production due to changeovers between models. Flexibility measures the ability to adapt “to a
wide range of possible environment”. To be flexible, a manufacturing system must posses the following capabilities:

- Identification of the different production units to perform the correct operation
- Quick changeover of operating instructions to the computer controlled production machines
- Quick changeover of physical setups of fixtures, tools and other working units

8. a) Explain various FMS layout with neat sketch. (8)

**Answer: Flexible manufacturing system layouts**

Flexible manufacturing system has different layouts according to arrangement of machine and flow of parts. According to part flow and arrangement of machine, layout of flexible manufacturing system are discussed below

**In-line FMS layout**

The machines and handling system are arranged in a straight line. In Figure 1(a) parts progress from one workstation to the next in a well-defined sequence with work always moves in one direction and with no back-flow. Similar operation to a transfer line except the system holds a greater variety of parts. Routing flexibility can be increased by installing a linear transfer system with bi-directional flow, as shown in Figure 1(b). Here a secondary handling system is provided at each workstation to separate most of the parts from the primary line. Material handling equipment used: in-line transfer system; conveyor system; or rail-guided vehicle system.

![Figure 1 in line FMS layout](image)

**Loop FMS layout**

Workstations are organized in a loop that is served by a looped parts handling system. In Figure 2, parts usually flow in one direction around the loop with the capability to stop and be transferred to any station.
Figure 2: Loop FMS layout

Figure 2: Loop FMS layout Each station has secondary handling equipment so that part can be brought-to and transferred from the station work head to the material handling loop. Load/unload stations are usually located at one end of the loop.

**Rectangular FMS layout**

This arrangement allows for the return of pallets to the starting position in a straight line arrangement.

Figure 3: Rectangular FMS layout

**Ladder FMS layout**

This consists of a loop with rungs upon which workstations are located. The rungs increase the number of possible ways of getting from one machine to the next, and obviate the need for a secondary material handling system. It reduces average travel distance and minimizes congestion in the handling system, thereby reducing transport time between stations. See Figure 4.
Open field FMS layout
It consists of multiple loops and ladders, and may include sidings also. This layout is generally used to process a large family of parts, although the number of different machine types may be limited, and parts are usually routed to different workstations depending on which one becomes available first. See Figure 5.
Robot centered FMS layout

This layout uses one or more robots as the material handling system. See figure 6.

![Robot centered FMS layout](image)

b) Explain the computer controlled functions in FMS. (6)

Answer: Simulation-based Control

The simulation-based control system was implemented using a modified version of the SIMAN simulation language. The modification allows delay-type blocks to function either in simulation mode or in real-time control mode. In simulation mode, entities coming into the delay block are held for the specified delay time. In real-time control mode, the task message associated with the delay block is sent to the execution function and the entity waits at the delay block until a completion message is received from the execution function. The ability to run in either simulation model or real-time mode allows the same simulation to be used as a predictive analysis tool and a real-time controller (Smith et al., 1994). The SIMAN modifications for implementing real-time control have now been included in the commercial versions of the Arena simulation package.

Factory Resource Model

The controller class identifies common equipment behavior and control requirements and describes a corresponding C++ class hierarchy for use in controller development. Although the equipment classification provides the information necessary to operate individual pieces of equipment, the classification does not describe how the individual pieces of equipment interact.
with one another within the control system. For example, although the ability of an industrial robot to move components between different points in space is captured in the Material Handling class, the use of the robot to load and unload a specific NC machine in the facility is not described in either class. These types of interactions are described by using a graph-based connectivity model (Wysk et al., 1995). The resource model graph for the TAMCAM facility is illustrated in Figure 2.

Decision Maker

The decision maker is responsible for routing parts through the system and setting priorities between individual parts at the processing stations. In the example system, these decisions translate to prioritizing the loading of parts from the load/unload station onto the Shuttleworth conveyor system and setting the queue priorities for each of the Pro Lights, the Hercus, and the inspector. The Shuttleworth conveyor itself is responsible for tracking empty pallets, avoiding congestion, and determining the specific routes that parts take from a source port to a destination port. As such, the decision maker is does not make decisions regarding specific part routing on the conveyor. Instead, it simply instructs the Shuttleworth controller to move parts from a source port to a destination port, and the conveyor controller decides on the path and sets priorities between carts already on the system.
Execution System

The execution system is also generated from the resource model instance. The execution system is based on the three-level hierarchical control architecture described by Smith et al. (1994). The example implementation uses only the bottom two levels in the hierarchy. Each piece of equipment (MP, MH, and MT) has an associated equipment level controller. These controllers provide the interface between the shop floor control system and the device-specific controller provided by the equipment vendor.

9.a) Explain the concept of CAPP. Elaborate it's advantages over traditional process planning system.

Answer: Computer Aided Process Planning (CAPP)

- To overcome the drawbacks of manual process planning, the computer-aided process planning (CAPP) is used. With the use of computers in the process planning, one can reduce the routine clerical work of manufacturing engineers.
- It provides the opportunity to generate, rational consistent and optimal plans. In addition CAPP provides the interface between CAD and CAM.

Benefits of CAPP over traditional process planning

The benefits of implementing CAPP include the following:
- **Process rationalization and standardization:** CAPP leads to more logical and consistent process plans than manual process planning.

- **Productivity improvement:** As a result of standard process plan, the productivity is improved.

- **Product cost reduction:** Standard plans tend to result in lower manufacturing costs and higher product quality.

- Elimination of human error.

- **Reduction in time:** As a result of computerized work, a job that used to take several days, is now done in a few minutes.

- Reduced clerical effort and paper work

- Improved legibility: Computer-prepared route sheets are neater and easier to read than manually prepared route sheets.

- Faster response to engineering changes: Since the logic is stored in the memory of the Computer, CAPP becomes more responsive to any changes in the production parameters than the manual method of process planning.

- Incorporation of other application programs: The CAPP program can be interfaced with other application programs such as cost estimating and work standards.

### Approaches of CAPP

The two basic approaches or types of CAPP system are:

1. Retrieval (or variant) CAPP system.
2. Generative CAPP system.

A CAPP tool can be represented as having three separate functions:

1. Retrieval
2. Technological analysis
3. Computational
b) Discuss in detail with neat sketch "Retrieval CAPP System".

Answer: Retrieval (or Variant) CAPP System

- It is also called a variant CAPP system and has been widely used in machining applications.
• Basic idea behind the retrieval CAPP is that similar parts will have similar process plans.
• A process plan for a new part is created by recalling, identifying and retrieving an existing plan for a similar part and making the necessary modifications for the new part.
• Variant CAPP is a computer-assisted extension of the manual approach.

**Advantages of Retrieval CAPP System**

• Once a standard plan has been written, a variety of parts can be planned.
• Comparatively simple programming and installation (compared with generative CAPP systems) is required to implement a planning system.
• Efficient processing and evaluation of complicated activities and decisions, thus reducing the time and labour requirements.
• Standardized procedures by structuring manufacturing knowledge of the process planners to company’s needs.
• Lower development and hardware costs.
• Shorter development times.
• The system is understandable and the planner has control of the final plan.
• It is easy to learn and easy to use.

**Disadvantages of Retrieval CAPP System**

• The components to be planned are limited to similar components previously planned.
• Maintaining consistency in editing is difficult.
• Experienced process planners are still required to modify the standard plan for the specific component.

10.a) Explain the concept of Master Production Schedule (MPS). Describe Inputs & Outputs of MPS. (7)

**Answer: Master Production Schedule (MPS)**

It is a detailed plan that states how many end items (i.e. the final product to be sold to the customer) will be available for sale or distribution during specific periods.

**Purpose of the master production schedule:**

(i) To set due dates for the availability of end items.
(ii) To provide information regarding resources and materials required to support the aggregate plan.

(iii) Input to MRP will set specific production schedules for parts and components used in end items.

**Inputs to MPS:**

The MPS inputs are:

1. Market requirements.
2. Production plan from aggregate planning
3. Resources available.

b) Discuss the terms in detail.

(6)

i) Material Requirement Planning (MRP).

**Answer:** Manufacturing Resource Planning (MRP-I)

- It represents the natural evolution of closed-loop MRP (materials requirements planning).
- It is an integrated information system that synchronizes all aspects of the business.
- It coordinates sales, purchasing, manufacturing, finance, and engineering by adopting a focal production plan and by using one unified database to plan and update the activities in all the systems.
- MRP II consists of virtually all the functions in the PPC system (presented in Figure) plus additional business functions that are related to production.

ii) Manufacturing Resource Planning (MRP-II)

**Answer:** Manufacturing Resource Planning (MRP-II)

Important MRP II system functions include:

1. Management planning—business strategy, aggregate production planning, master production scheduling, rough-cut capacity planning and budget planning.
2. Customer services—sales forecasting, order entry, sales analysis and finished goods inventory.
3. Operations planning—purchase order and work order release.
4. Operations execution — purchasing, product scheduling and control, work-in-process inventory control, shop floor control and labour hour tracking.

5. Financial functions — cost accounting, accounts receivable, accounts payable, general ledger and payroll.

Now-a-days many commercial software are available incorporating MRP II functions with more features.

Some of them include:

- Enterprise Resource Planning (ERP)
- Customer-Oriented Manufacturing Management Systems (COMMS)
- Manufacturing Execution Systems (MES)
- Customer-Oriented Management Systems (COMS).

11.a) Explain with neat sketch "Shop Floor Control". (6)

**Answer: Shop Floor Control**

- This control manages the detailed flow of materials inside the production facility.
- It Encompasses the principles, approaches and techniques needed to schedule, control, measure and evaluate the effectiveness of production operations.
- Is an activity of production control one of the activity of process planning and control (PPC).
- To understand the significance of the shop floor control, it is essential to have the basic knowledge of various activities of PPC and their relations to shop floor control.
- It is defined as a system for utilizing data from the shop floor as well as data processing files to maintain and communicate status information on shop orders and work centre.
Shopfloor control (SFC) is concerned with:

(i) The release of production orders to the factory.
(ii) Monitoring and controlling the progress of the orders through the various work centres.
(iii) Acquiring information on the status of the orders.
(iv) Shop floor control deals with managing the work-in-process.

Functions of Shop Floor Control

The major functions of shop floor control are:

1. Assigning priority of each shop order (Scheduling).
3. Conveying shop-order status information to the office (Follow up).
4. Providing actual output data for capacity control purposes.
5. Providing quantity by location by shop order for work-in-process inventory and accounting purposes.
6. Providing measurement of efficiency, utilization and productivity of manpower and machines.

The functions of SFC are:

1. Scheduling
2. Dispatching and
3. Follow-up or Expediting.
Phases of SFC

The three important phases of SFC are:

1. Order release
2. Order scheduling and
3. Order progress.

- It depicts the three phases and their relationship to other functions in the Production management system.
- In a computer integrated manufacturing system these phases are managed by computer software.
- In a typical factory which works on manual processing of data, the above documents move with the production order and are used to track the progress through the shop.
- In a CIM factory, more automated methods are used to track the progress of the production orders

i) The first input is the authorization to produce (that derives from master schedule). This authorization proceeds through MRP which generates work orders with scheduling information.

(ii) The second input is the engineering and manufacturing database. This database contains engineering data (such as the product design, component material specifications, bills of materials, process plans, etc.) required to make the components and assemble the products. Database input provides the product structure and process planning
information needed to Prepare the various documents that accompany the order through the shop.

11.b) Explain importance of Inspection system. Discuss Computer Aided Quality Control. State Objectives & benefits of CAQC. (7)

Answer: Inspection is an important tool to achieve quality concept. It is necessary to assure confidence to manufacturer and aims satisfaction to customer. Inspection is an indispensable tool of modern manufacturing process. It helps to control quality, reduces manufacturing costs, eliminate scrap losses and assignable causes of defective work.

Inspection only measures the degree of conformance to a standard in the case of variables. In the case of attributes inspection merely separates the nonconforming from the conforming.

Inspection does not show why the nonconforming units are being produced.

**Objectives of Inspection in Production Management**

**Objectives of Inspection**

To detect and remove the faulty raw materials before it undergoes production.

To detect the faulty products in production whenever it is detected.

To bring facts to the notice of managers before they become serious to enable them discover weaknesses and over the problem.

To prevent the substandard reaching the customer and reducing complaints.

To promote reputation for quality and reliability of product.

**Purpose of Inspection**

To distinguish good lots from bad lots.

To distinguish good pieces from bad pieces.

To determine if the process is changing.

To determine if the process is approaching the specification limits.

To rate quality of product.

To rate accuracy of inspectors.

To measure the precision of the measuring instrument.

To secure products-design information.

To measure process capability.

**Computer Aided Quality Control.**
The use of the computers for quality control of the product is called as the computer aided quality control or CAQC. The two major parts of quality control are inspection and testing, which are traditionally performed manually with the help of gages, measuring devices and the testing apparatus. The two major parts of computer aided quality control are computer aided inspection (CAI) and computer aided testing (CAT). CAI and CAT are performed by using the latest computer automation and sensor technology. CAI and CAT are the standalone systems and without them the full potential of CAQC cannot be achieved.

1) **100% testing and inspection:** In the traditional manual process the testing and inspection is done by the sampling process out of the hundreds and thousands of products or parts manufactured by the company since it is not feasible to check each and every product.

2) **Inspection integrated with manufacturing process:** In the traditional process there is separate quality control department where the manufactured product is taken for the inspection and testing. In CAQC the inspection process is integrated with the manufacturing process and it is located along the production line.

3) **Use of non-contact sensors:** In the traditional process the product or the part to be inspected is handled manually since it has to be positioned properly for inspection on the desk or suitable location. In CAQC non-contact sensors are used for the inspection purpose and they inspect the product without coming in contact with the product. The non-contact sensors operated by the computer are kept along the production line and they can check the product very quickly in the fraction of seconds.

4) **Computerized feedback control system:** The data collected by the non-contact sensors is sent as the feedback to the computerized control systems. These systems would carry out the analysis of the data including statistical trend analysis. This helps in identifying the problem going on in the manufacturing line and find appropriate solution to it.

5) **Computer aided quality control and CAD/CAM integration:** Apart from inspection and testing, computers are used in a number of other areas of the quality control. All the applications of CAQC can be integrated with CAD/CAM to make the whole process of designing and manufacturing controlled by the computers converted into fully automated process.
12. Write short notes on following any four.  
   i) Shop floor Data Collection Techniques.  

Introduction  
Raw data are at the heart of all information systems. In a manufacturing environment, a large amount of data is generated on the shop floor itself, and shop-floor data collection represents the way this data is to be collected in order to improve shop-floor performance. After examining exactly what is meant by shop-floor data collection and why we would wish to do it, the technologies used in this area will be examined in detail, from bar codes to voice recognition systems, finishing off by looking at how people may react to the introduction of this technology.

Definition of shop-floor data collection  
A sample of manufacturing managers' definitions of shop-floor data collection (SFDC), collected by the IB Consulting group survey, included replies such as collecting data from the factory floor, collecting and presenting information on machine status, staff attendance, quality losses, scrap, etc. and networked information system available to management and operators and providing real-time and historical process data (Quinn, 1994). In essence, SFDC is about finding out exactly what is happening on the factory floor as a starting point for improving manufacturing performance. Shop-floor information includes:

- process yield and scrap;
- machine performance and usage parameters;
- operations time;
- order status;
- inventory and product traceability;
- quality data;
- personnel.
ii) Pull System of Production Control.

Pull System of Production Control.
The pull inventory control system begins with a customer's order. With this strategy, companies only make enough product to fulfill customer's orders. One advantage to the system is that there will be no excess of inventory that needs to be stored, thus reducing inventory levels and the cost of carrying and storing goods.

An example of a pull inventory control system is the just-in-time, or JIT system. The goal is to keep inventory levels to a minimum by only having enough inventory, not more or less, to meet customer demand. The JIT system eliminates waste by reducing the amount of storage space needed for inventory and the costs of storing goods.

**Disadvantages of the Pull System**

One major disadvantage to the pull system is that it is likely that a company will run into ordering dilemmas, such as a supplier not being able to get a shipment out on time. This leaves the company unable to fulfill the order and contributes to customer dissatisfaction.

iii Inventory Control / Management.

**Inventory Control**

Inventory Management:
It is defined as the scientific method of determining what to order, when to order and how much to order and how much to stock so that costs associated with buying and storing are optimal without interrupting production and sales.

**Objective of Inventory Control**

The main objectives of inventory control are:

(i) To ensure continuous supply of materials so that production should not suffer at any time.

(ii) To maintain the overall investment in inventory at the lowest level, consistent with operating requirements.
(iii) To minimize holding, replacement and shortage cost of inventories and maximize the efficiency in production and distribution.

(iv) To keep inactive, waste, surplus, scrap and obsolete items at the minimum level.

(v) To supply the product, raw material, WIP, etc., to its users as per their requirements at right time and at right price.

(vi) To ensure timely action for replenishment.

(vii) To maintain timely record of inventories of all the items and to maintain the stock within the desired limits.

(viii) To avoid both over-stocking and under-stocking of inventory costs Associated with Inventory (What are Inventory Costs?)

The major costs associated with procuring and holding inventories are:

1. Ordering costs
2. Carrying (or holding) costs
3. Shortage (or stock out) costs and
4. Purchase costs

- It is Refer to the managerial and clerical costs to prepare the purchase or production order.
- It is also known by the names procurement costs, replenishment costs and acquisition costs

These costs include:

1. Ordering costs
   (i) Costs of staff of purchase department,
   (ii) Costs of stationery consumed for ordering, postage, telephone bills, etc.
   (iii) Depreciation costs and expenses for maintaining equipment required for ordering, receiving and inspecting incoming items.
   (iv) Inspection costs of incoming materials.
2) Holding (or inventory carrying) costs

- Inventory carrying costs are the costs associated with holding a given level of inventory on hand.
- It varies in direct proportion to the amount of holding and period of holding the stock in stores. This cost will not occur if inventory is not carried out.

**The holding costs include:**

(i) Costs for storage facilities.
(ii) Handling costs.
(iii) Depreciation, taxes and insurance.
(iv) Costs on record keeping.
(v) Losses due to pilferage, spoilage, deterioration and obsolescence.
(vi) Opportunity cost of capital.

3) Shortage (or stock-out) costs

When the stock of an item is depleted and there is a demand for it, then the shortage cost will occur.

Shortage cost is the cost associated with stock-out.

The shortage costs include:

(i) Back order costs.
(ii) Loss of future sales.
(iii) Loss of customer goodwill.
(iv) Loss of profit contribution by lost sales revenue.
(v) Extra cost associated with urgent, small quantity ordering costs.

4) Purchase (or production) costs

These are the costs incurred to purchase/or produce the item. This Costs include the price paid or the labour, material and overhead charges necessary to produce the item.
b) Explain the computer controlled functions in FMS.

6

9. a) Explain the concept of CAPP. Elaborate its advantages over traditional process planning system.

7

b) Discuss in detail with neat sketch "Retrieval CAPP System".