UNIT V

[Answer 1]: Computer-aided design (CAD) is a process that involves using computers to create design drawings and models of products (Page 2). CAD is usually associated with interactive computer graphics on a CAD system (Page 2). The designer can conceptualize a part to be designed on a computer monitor and consider alternative designs or modify a particular design to respond quickly to specific design requirements (Page 2).

Effective communication and exchange of data between CAD systems is essential (Page 3). Because there are many CAD systems available, with different characteristics supplied by different vendors, communicating and exchanging data between these systems can be complicated (Page 3). To address this issue, several exchange specifications like Drawing exchange format (DFX), stereolithography (STL) formats, Initial Graphics Exchange Specification (IGES), and Product Data Exchange Specification (PDES) have been developed for translation in two directions and are widely used for the translation of three-dimensional line and surface data between different CAD systems (Page 3).

Therefore, the importance of exchange specifications lies in their ability to establish standards to achieve a common language between different CAD software and facilitate the exchange of data between them. (Pages 2-3)

[Answer 2]: Unfortunately, there is no neat diagram provided in the document that illustrates the different elements of Computer Aided Design systems. However, based on the information provided in the document, the different elements of CAD systems are discussed below:

Geometric Modeling: In geometric modeling, a physical object or any of its parts is described mathematically. The designer constructs a geometric model by giving commands that create or modify lines, surfaces, solids, dimensions, and text. Together, these elements present an accurate and complete two- or three-dimensional representation of the object (Page 4).

Design Analysis and Optimization: After the geometric features of a particular design have been determined, the design is subjected to engineering analysis, such as analyzing stresses, strains, deflections, etc., with the help of sophisticated software packages like ABAQUS, ANSYS, NASTRAN, LS-DYNA, MARQ, and ALGOR (Page 5).

Design Review and Evaluation: The review is done to avoid difficulties either during assembly or in the use of the part. Software is available with animation capabilities to identify potential problems with moving members and other dynamic situations (Page 6).

Database: Many components, such as bolts and gears, are standard components that are mass-produced according to a given design specification or are identical to parts used in previous designs. CAD systems thus have a built-in database management system that allows designers to locate, view, and adopt parts from a stock part library (Page 7).

Therefore, these are the different elements of CAD systems that designers and engineers use to create and analyze models. (Pages 4-7)

[Answer 3]: Computer Aided Manufacturing (CAM) involves the use of computers to assist in all phases of manufacturing a product. It is often combined with computer-aided design (CAD) into CAD/CAM systems (Page 8). The following are applications of CAD/CAM:

Programming for numerical control and industrial robots: In machining operations, CAD/CAM can calculate and describe the tool path. The CAD/CAM system then produces the necessary numerical control (NC) tape or other CNC programs. In machining operations involving industrial robots, a CAD/CAM system generates instructions for the robots based on design specifications (Page 9).

Design of dies and molds: CAD/CAM can automatically produce tool paths for machining dies and molds used for casting for manufacturing operations. The system can take into account special process issues like shrinkage allowances that are preprogrammed (Page 9).

Design of tooling and fixtures and EDM electrodes: CAD/CAM provides automatic tool path generation for tooling and fixtures. The system also can generate tool paths for the electrical discharge machining (EDM) of electrodes, making it easier to create extremely complex geometry (Page 9).

Quality control and inspection: CAD/CAM software provides the ability to program coordinate-measuring machines for inspection of machined parts, align parts and tools correctly, and direct the execution of automated inspection routines, all from the same workstation (Page 9).

Process planning and scheduling: Computer-aided process planning (CAPP) is a subset of CAD/CAM software that links CAD data to the manufacturing process plan. CAPP ensures that all the necessary operations and resources have been planned, scheduled, and assigned based on the updated manufacturing plan (Page 11).

Plant layout: CAD/CAM systems can be used to design factory layouts and then test them without actually building the facilities so that better decisions can be made before the physical layout is finalized. (Page 9)

Therefore, the applications of CAD/CAM in different manufacturing operations are listed above. (Pages 8-11)

[Answer 4]: Computer-aided process planning (CAPP) is a subset of CAD/CAM software that links CAD data to the manufacturing process plan. A routing sheet is a document generated by CAPP that contains information about the operations required to manufacture a part. A sample routing sheet typically includes the following information:

1. The name of the part and its manufacturing code number
2. A sequential listing of the manufacturing operations and the departments where they will be performed, such as machining, quality control or surface finishing
3. The tools required at each workstation
4. Process parameters, such as cutting speeds, feeds and depths of cut
5. Inspection requirements
6. The time required for each operation

Here's a simple example of a routing sheet for a part that is to be produced on a CNC milling machine:

Operation	Department	Tools	Parameters	Inspection	Time
Rough	Machining	Endmill	0.25" DOC, 0.010" IPT	Visual, dimensional	12 min
Finish	Machining	Ball endmill	0.07" IPT	Visual, dimensional	8 min
Inspection	Quality Control	N/A	Visual, dimensional	N/A	5 min
Deburr	Surface Finishing	Deburring tool	N/A	Visual, dimensional	6 min

This table shows the sequence of operations along with the department, tools, parameters, inspection requirements, and time required to manufacture the part. This routing sheet would guide the operator and define the production process, allowing for greater accuracy and repeatability of the part. (Page 10)

[Answer 5]: Group technology (GT) is a methodology that seeks to take advantage of the design and processing similarities among the parts to be produced. An important part of group technology is the classification and coding (C/C) of parts, where parts are identified and grouped into families based on their design and manufacturing attributes.

GT has various advantages, which include:

New part designs can be developed more quickly: GT enables new part designs to be developed from similar, previously used designs. This helps to save significant time.

Manufacturing costs can be more easily estimated: GT allows for relevant statistics on materials, processes, number of parts produced, and other factors to be more easily obtained. This ease of estimation helps in better pricing and budgeting of parts manufacturing.

Standardization of process plans: Process plans can be standardized using GT, leading to efficient scheduling and machine utilization. This reduces setup times, increases productivity, and improves quality.

Sharing of tools, fixtures, and machinery: GT groups similar parts together, allowing for the sharing of tools, fixtures, and machinery. This leads to cost savings, as similar tools, fixtures, and machinery are shared when producing a family of parts.

Greater accuracy in manufacturing: GT leads to more efficient and consistent product manufacturing with better and more consistent product quality.

Reduction in the number of paths and movements: GT simplifies product flow line and takes advantage of group layout, resulting in a decrease in the number of paths, machine movements, and setup times. This also increases machining accuracy and reduces inventory cost.

GT is capable of greatly improving productivity and reducing costs in batch production. Depending on the level of implementation of GT, savings in each of the various design and manufacturing phases can range from 5 to 75%. (Pages 14-16)

[Answer 6]: Flexible Manufacturing Cell (FMC) is a manufacturing system that consists of a group of workstations containing machines such as CNC lathes, mills, and industrial robots. An FMC is designed to handle small to medium lot sizes in a single product family with a short production lead time.

A manufacturing cell can be made flexible by using CNC machines and machining centers, and also with the help of industrial robots or other mechanized systems for handling materials and parts in various stages of completion. An FMC is an unmanned system that is interfaced with a central computer, which can download different instructions for each successive part, passing through a specific workstation.

Flexible manufacturing cells can save on direct labor and inventories and can produce parts in any order or batch size as small as one. The system is self-correcting, which leads to more reliability and uniformity in product quality.

The selection of machines and industrial robots, including the types and capabilities of end effectors and their control systems, is critical to the proper functioning of the FMC. The likelihood of a significant change in demand for part families should be considered during the design of the cell, in order to ensure that the equipment involved has the necessary flexibility and capacity.

However, the cost of implementing an FMC can be high. Nonetheless, this disadvantage is outweighed by increased productivity, flexibility, and controllability. (Pages 19-21)

[Answer 7]: A Flexible Manufacturing System (FMS) is a highly automated production system that integrates all major production elements, such as computer numerically controlled (CNC) machines, work handling systems, and an automated material handling system. It is typically made up of a series of cells, each of which may include CNC machines or robots, and the equipment is often configured in a straight line or in groups, known as flexible manufacturing cells.

A few of the major benefits of flexible manufacturing systems include:

Increased productivity: FMS can operate largely without human intervention, leading to increased productivity and significant reductions in production costs.

Ability to manufacture products of different designs: With the help of a computer-aided system, the FMS can be programmed to produce different parts with varying designs. This ability to quickly adjust production can save time and money and increase the competitiveness of the manufacturer.

Lower inventory costs: An FMS can operate with relatively small buffer inventories of raw materials and finished goods, which can save on both space and money.

Reduced lead times: FMS can dramatically decrease the time needed to complete production runs and can increase the speed of delivery to market.

Improved quality control: FMS machines can produce parts with very high levels of accuracy.

Flexibility to handle changes in production demand: By being configured in cells, FMS is highly adaptable to changes in demand, allowing manufacturers to more easily change production lines and reduce overall production costs.

Cost savings: Using an FMS can lead to cost savings in labor, material costs, and more efficient use of factory space.

The FMS is a highly sophisticated and complex production process, and its implementation can be expensive. However, the benefits can lead to higher profitability, increased efficiency, and improved competitiveness in the marketplace, which provide a significant return on investment over the long term. (Pages 22-24)

[Answer 8]: Holonic Manufacturing is a manufacturing technique in which independent manufacturing cells, called holons, are combined to create a highly flexible and adaptable manufacturing system. Each holon represents a building block for production, storage, and transfer of objects or information. They are autonomous, self-contained, and are capable of functioning independently, but they can also interact with other holons to achieve manufacturing goals.

The general sequence of events for a holonic manufacturing system can be outlined as follows:

A factory consists of a pool of resource holons, available as separate entities in the pool. These holons can include CNC machines, milling machines, grinders, and more.

Upon receipt of an order or a directive from higher levels in the factory hierarchical structure, an order holon is formed and begins communicating and negotiating with other available resource holons.

The negotiations result in a self-organized grouping of resource holons based on product requirements, resource holon availability, and customer requirements. For example, a given product may require a CNC lathe, a CNC grinder, and an automated inspection station to organize it into a production holon.

In case of breakdown, the unavailability of a particular machine, or changing customer requirements, other holons from the resource pool can be added or subtracted as needed, allowing for the reorganization of the production holon.

Holonic Manufacturing combines the flexibility and adaptability of a holonic approach with the power and intelligence of a computer network. By utilizing independent, autonomous cells, Holonic Manufacturing is able to handle a wide variety of production runs, changing production needs, and other factors that would interfere with traditional manufacturing processes.

The hierarchy of the holonic system allows for better coordination and communication between the cells, which leads to greater efficiency, speed, and accuracy in the manufacturing process.

Holonic Manufacturing is a highly sophisticated production process that is still evolving and changing. However, its ability to adapt to changing conditions and to handle a wide variety of production runs make it an attractive option for many manufacturers. (Pages 24-26)

[Answer 9]: A local area network (LAN) is a network of computers and devices connected together within a limited area, such as a building, office, or campus. There are three basic types of topology for a local area network (LAN):

Star Topology: In star topology, all nodes connect to a central hub or switch. When one node sends data, the hub or switch forwards it to all other nodes on the network. This topology is suitable for situations that are not subject to frequent configuration changes. All messages pass through a central station. Applications include small offices, homes, and schools.

Ring Topology: In ring topology, all individual user stations are connected in a continuous ring. The message is forwarded from one station to the next until it reaches its assigned destination. Although the wiring is relatively simple, the failure of one station shuts down the entire network. The ring topology is suitable for applications with high data transfer requirements, such as videoconferencing and file transfers.

Bus Topology: In the bus topology, all stations have independent access to the bus. This system is reliable and easier than the other two to service. Because its arrangement is similar to the layout of the machines in the factory, its installation is relatively easy, and it can be rearranged when the machines are rearranged. The bus topology is suitable for small networks such as offices and homes.

The basic types of LAN topology can be used in a variety of applications, such as:

Data transfer: Networks can be used for transferring data between different computers on the network. This can include sending files, sharing printers, and exchanging emails.

Collaboration: Networks can be used to allow team members to communicate and collaborate on projects. This can include shared documents, real-time communication, and conferencing.

Internet and networking: With the help of LANs, organizations can establish high-speed internet connections, email communication, and web access for employees.

Videoconferencing: Videoconferencing enables meetings to take place without all participants needing to be in the same room. This functionality relies on a stable, high-speed LAN.

Data storage and backup: Networks can be used to store and back up important data. This allows for automatic backups and easy retrieval of data even in case of a system failure.

The type of topology chosen for a LAN network will depend on the specific requirements of the organization and the applications being used. Regardless of the topology type, LANs provide a way for organizations to communicate, collaborate, and transfer data with ease. (Pages 26-28)

[Answer 10]: An expert system (ES) comprises three main components: a knowledge base, an inference engine, and a user interface. The diagram below briefly describes the components of an expert system:

The Knowledge base serves as a repository for all of the knowledge that is required to solve a given problem domain. This knowledge may take various forms, such as rules, decision trees, or other expert heuristics. The knowledge base is developed by experts in the given domain and is updated in order to reflect new discoveries or changes in the problem domain.

The Inference engine is the brain of the expert system. It uses the knowledge base to reason about a given problem, applying rules and heuristics to deduce the best solution for that situation. Once a solution is found, it is presented to the user through the user interface.

The User interface lets the user interact with the expert system. In general, the user interface must be designed to facilitate the interaction between the expert system and the user. User-friendly interfaces allow users to provide input to the system, interact with the system, and receive output from the system.

Expert systems are widely used in various applications such as problem diagnosis, modeling and simulation of production facilities, computer-aided design, process planning, and production scheduling, and management of a company’s manufacturing strategy.

Expert systems have short reaction times and their ability to provide rapid responses to problems makes them suitable for use in real-time decision-making. They are designed to help organizations solve specific problems and to ensure that expert knowledge is accurately captured and utilized. (Page 30)

[Answer 11]: Artificial Neural Networks (ANN) and Fuzzy Logic are two important concepts in Artificial Intelligence (AI) that have many real-world applications.

Artificial Neural Networks:

Artificial Neural Networks (ANN) attempt to simulate the functioning of a biological brain by creating a system of interconnected processing elements, called neurons.

A trained artificial neural network can recognize complex patterns in input data, classify new data, and make predictions to support decision-making.

ANNs are very effective for applications such as speech recognition, image processing, natural language processing, and process control, and are increasingly used for applications such as fraud detection, spam filtering and recommendation systems.

Fuzzy Logic:

Fuzzy Logic is an approach to reasoning that allows for imprecision in the data and decision-making.

Fuzzy Logic-based systems are designed to deal with complex and uncertain situations and are hence suitable for problems where clear-cut, precise solutions are impossible to obtain.

With Fuzzy Logic applications, terms such as “near,” “far,” “big,” and “small” can be utilized instead of precise numerical values. Fuzzy Logic can be used to make decisions and to control systems, and it has various applications such as automatic transmission in automobiles, washing machines, and helicopters.

Some of the common applications of ANNs and Fuzzy Logic include:

Robotics and Motion Control: ANN and Fuzzy Logic-based algorithms have been used in robotics to improve object recognition, path planning, and control of robotic systems.

Image Processing and Machine Vision: ANNs and Fuzzy Logic are helpful for recognizing patterns and detecting objects in images.

Process Control: ANNs and Fuzzy Logic are utilized in manufacturing processes for control and monitoring of different parameters.

Security and Surveillance: ANNs and Fuzzy Logic are employed in systems for face and fingerprint identification, speech recognition, and biometric authentication.

In summary, ANNs and Fuzzy Logic are widely used in various fields for pattern recognition, image processing, and control systems, among others. Their ability to handle imprecise or uncertain data makes them valuable tools in decision-making processes. (Pages 33-34)

[Answer 12]: Flexible Fixturing is a method for holding irregular-shaped or curved workpieces with the two main methods of hard tooling and using phase-change materials. Phase change materials (PCM) are thermally conductive materials that change their state, for example, from a solid to a liquid when heated and back to a solid when cooled. PCMs, therefore, offer significant potential to enhance the flexibility and versatility of manufacturing systems without the need to use hard tooling fixtures.

PCM can be used for Flexible Fixturing in two ways:

Low-melting-point metal: A low-melting-point metal such as lead is used as the medium for clamping the workpiece. An irregular-shaped workpiece is dipped into the molten lead, and after it sets, the solidified lead block is clamped in a simple fixture which provides a perfect fit of the workpiece while holding it firmly. This approach is suitable for small batch, high geometric variation workpieces.

Magnetorheological (MR) or electrorheological (ER) fluid: The supporting medium in this approach is a fluid that changes from a liquid to that of a solid when immersed into a workpiece, an external magnetic/electric field is applied that polarizes the particles and aligns with an external magnetic/electric field. This process provides a flexible fixturing system that can rapidly accommodate a range of part shapes and dimensions without requiring extensive changes, adjustments or operator intervention.

Overall, PCM can be used to increase the flexibility and versatility of a manufacturing system by providing a flexible alternative to hard tooling fixtures. However, they require a special setup and dye and so are best used for critical flexible fixturing applications (Pages 25-26).

[Answer 13]: Different types of assembly systems used in manufacturing are-

Manual Assembly: It uses simple tools and is economical for small lots. Workers can manually assemble even complex parts without much difficulty. In spite of the use of sophisticated mechanisms, robots, and computer controls, aligning and placing of a simple square peg into a square hole involving small clearances can be difficult in automated assembly.

High-Speed Automated Assembly: It utilizes special transfer mechanisms designed for assembly. Individual assembly is carried out on products that are indexed for proper positioning.

Robotic Assembly: One or two general-purpose robots operate at a single workstation, or the robots operate at a multi station assembly system.

Flexible Assembly Systems (FAS): These utilize computer controls, interchangeable and programmable workheads and feeding devices, coded pallets, and automated guiding devices. FAS is capable of assembling up to a dozen different transmission and engine combinations and power steering and air-conditioning units.

Overall, these different assembly systems offer different advantages and drawbacks, and their implementation in a particular manufacturing process depends on the product line, manufacturing process, and the production level required. (Pages 26-30)

[Answer 14]: Design for flexible fixturing involves the creation of work-holding devices that can handle complex geometries, changeover quickly from one part to another, and require little or no operator intervention. Some of the main design considerations that need to be addressed for flexible fixturing are stated below:

Automatic positioning and accurate workpiece clamping: Work-holding devices must position the workpiece automatically and accurately.

Sufficient stiffness: The fixtures must have sufficient stiffness to resist, without excessive distortion, normal and shear stresses developed at the workpiece–fixture interfaces. For heavy cutting, high accuracy positioning requirements, and/or high-production needs, more extensive fixturing can be employed.

Accommodation of different part models: A flexible fixture should be able to accommodate parts to be made by different processes and with different dimensions and surface features that vary from part to part.

Low profiles of clamps and fixtures: Clamps and fixtures should have low profiles to avoid collision with cutting tools.

Overall, the design of flexible fixturing requires a delicate balance between providing adequate strength and rigidity for accurate workpiece holding and leaving sufficient room for adaptability, rapid changeover, and economical manufacture. Modern design techniques, such as modular fixturing, can help in the rapid design of fixtures, but the quality of the final product ultimately depends on the engineer's knowledge and experience. (Pages 30-31)

[Answer 15]: The design for assembly involves various considerations to achieve the efficient assembly of components in a manufacturing process. Below are some key considerations:

Reduce part count: Reduction of the number and variety of parts in a product reduces assembly complexity and shortens assembly time and cost. By simplifying the product design and giving priority to the ease of assembly, there is a reduction in assembly errors and costs.

Parts symmetry: To avoid the need for locating, aligning, or making adjustments to parts, they should have a high degree of symmetry, making their installation foolproof. Symmetry can help shorten assembly time and eliminate human error.

Design for automation: Designing parts for easy handling by robots or other automated devices also makes the assembly process more straightforward and efficient. For example, designing parts that can be manipulated by the same gripper of the robot can make the assembly a much smoother process. Additionally, designing the parts to insert in one direction eases the assembly process.

Avoid extraneous fasteners: Avoiding the need for redundant hardware, such as bolts, nuts, and screws, can reduce the cost of assembly as well as the overall equipment costs while also contributing to faster product assembly. Considerations should also be taken to ensure the avoidance of fasteners between limited access components.

Color codes: Using color codes on parts that may appear similar, but are different, can help reduce the likelihood of errors and replace slow part identification methods during manufacturing.

Overall, the design considerations for assembly are aimed at standardizing quality control and increasing production efficiency. Careful consideration of these factors in the product design process can help reduce assembly times, minimize human error, and optimize the assembly process. (Page 31)