ME8691 Computer Aided Design and Manufacturing Notes

INDEX

Prepared By: Dr. V.Sathiyamoorthy

Associate professor

ME8691 COMPUTER AIDED DESIGN AND MANUFACTURINGL T P C
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SYLLABUS(REGULATION–2017)

OBJECTIVES:

- To provide an overview of how computers are being used in mechanical component design
- To understand the application of computers in various aspects of Manufacturing viz., Design, Proper planning, Manufacturing cost, Layout & Material Handling system.

UNIT I INTRODUCTION 9

Product cycle- Design process- sequential and concurrent engineering- Computer aided design – CAD system architecture- Computer graphics – co-ordinate systems- 2D and 3D transformations- homogeneous coordinates - Line drawing -Clipping- viewing transformation-Brief introduction to CAD and CAM – Manufacturing Planning, Manufacturing control- Introduction to CAD/CAM –CAD/CAM concepts —Types of production - Manufacturing models and Metrics – Mathematical models of Production Performance

UNIT II GEOMETRIC MODELING 9

Representation of curves- Hermite curve- Bezier curve- B-spline curves-rational curves- Techniques for surface modeling – surface patch- Coons and bicubic patches- Bezier and B-spline surfaces. Solid modeling techniques- CSG andB-rep

UNIT III CAD STANDARDS 9

Standards for computer graphics- Graphical Kernel System (GKS) - standards for exchange images- Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, CALS etc. - communication standards.

UNIT IV FUNDAMENTAL OF CNC AND PART PROGRAMING 9

Introduction to NC systems and CNC - Machine axis and Co-ordinate system- CNC machine tools- Principle of operation CNC- Construction features including structure- Drives and CNC controllers- 2D and 3D machining on CNC- Introduction of Part Programming, types - Detailed Manual part programming on Lathe & Milling machines using G codes and M codes- Cutting Cycles, Loops, Sub program and Macros- Introduction of CAM package.

UNIT V CELLULAR MANUFACTURING AND FLEXIBLE MANUFACTURING SYSTEM (FMS)9

Group Technology(GT),Part Families–Parts Classification and coding–Simple Problems in Opitz Part Coding system–Production flow Analysis–Cellular Manufacturing–Composite part concept–Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control– Quantitative analysis in FMS

TOTAL : 45 PERIODS

OUTCOMES: Upon the completion of this course the students will be able to

CO1	Explain the 2D and 3D transformations, clipping algorithm, Manufacturing models an Metrics
CO2	Explain the fundamentals of parametric curves, surfaces and Solids
CO3	Summarize the different types of Standard systems used in CAD
CO4	Apply NC & CNC programming concepts to develop part programme for Lathe & Milling Machines
CO5	Summarize the different types of techniques used in Cellular Manufacturing and FMS

TEXT BOOKS:

1. Ibrahim Zeid "Mastering CAD CAM" Tata McGraw-Hill PublishingCo.2007
2. Mikell.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, 2008.
3. Radhakrishnan P, SubramanyanS.andRaju V., "CAD/CAM/CIM", 2nd Edition, New Age International (P) Ltd, New Delhi,2000.

REFERENCES:

1. Chris McMahon and Jimmie Browne "CAD/CAM Principles", "Practice and Manufacturing management " Second Edition, Pearson Education, 1999.
2. Donald Hearn and M. Pauline Baker "Computer Graphics". Prentice Hall, Inc,1992.
3. Foley, Wan Dam, Feiner and Hughes - "Computer graphics principles & practice" Pearson Education -2003
4. William M Neumann and Robert F.Sproul "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.

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UNIT I INTRODUCTION

PART –A

1. Why should we go for CAD? (Nov/Dec2015)

There are four fundamental reasons for implementing CAD system which are asfollows

- To increase the Productivity of the designer
- To improve the qualities of the design
- To improve Communications
- To create a database for engineering

2. Mention any four applications of computer aided design in mechanicalengineering?(Nov/Dec 2015)

The applications of computer aided design in mechanical engineering cover alltypes of manufacturing operations such as milling, turning wire cut EDM, punching, etc.

3. List the types of 2D geometric transformation? (Nov/Dec 2015)

- Windowing and viewing transformation, Zooming transformation
- Clipping transformation, Reflection transformation

4. What is the design process? Mention the steps involved in shigley's model for the design process? (May/June 2016)

The engineering design process is a methodical series of steps that engineers usein creating functional products and processes. The process is highly iterative - parts ofthe process often need to be repeated many times before another can be entered – thoughthe part(s) that get iterated and the number of such cycles in any given project can be highly variable.

5. What is Translation?

Translation is one of the important types of transformer. This is used to move theentity after moving all points of new entity are parallel to all points of old entity.

6. Define Concurrent Engineering?

Concurrent Engineering is also known as Simultaneous Engineering. Here whilethe product is designed the design and manufacturing process are carried outsimultaneously this technique facilitates the design engineer to improve the efficiency ofproduct design and process.

7. List out the factor consider for CAD ?

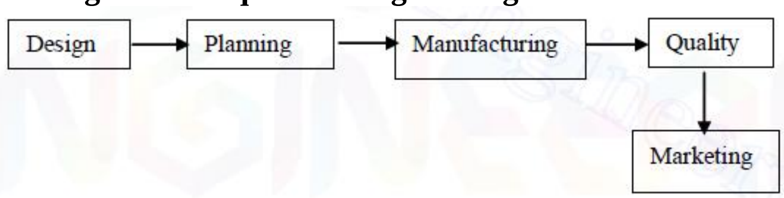
- Reliability, Cost Factor
- Comparability with other system
- Memory Requirements and Storage requirements

8. What is the main drawback of wire frame modeling ?

The main drawback in terms of representation of objects in wireframe model is

- Lack of clarity
- The part geometry model is complex in the case of 3D wireframe system
- Hidden line causes the image to be confused

9. Draw the flow diagram of Sequential Engineering



10. What are the disadvantages of Beizer Curve ?

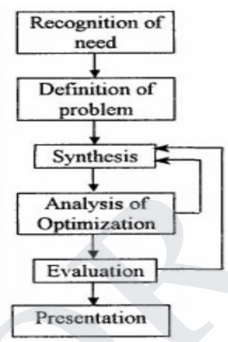
- The Curve does not pass through the control points which may be inconvinient tothe designer
- The Bezier curve lacks control it only has the global control nature
- If one control point is changed the whole curve changes thus the designer cannotselectively change part of the curve

11. What is meant by morphology design?

Morphology design refers the study of the chronological structure of designprojects.

12. List the various stages in the life cycle of a product? (May/June 2016)

- Introduction Stage, Maturity Stage
- Growth Stage, Decline Stage



1) Define computergraphics.

Computer graphics may be defined as the process of creation, storage and manipulation of drawings and pictures with the aid of a number.

2) What are the functions ofIGC?

a. Solid modeling
b. Storage
c. Manipulation
d. Viewing

3) What are the various display control facilities ingraphics?

i. VectorGeneration
ii. Windowing and viewingtransformation.
iii. Clippingtransformation
iv. Zooming
v. Panning
vi. Transmitting information on a network and
vii. Graphicslibraries.

4) What is meant by viewpoint?

The viewpoint is the area on the screen in which the contents of the window are to be displayed as an image.

5) What is viewing transformation and windowing transformation?

The processes of mapping from the model co-ordinate system to the screen co-ordinate system is known as viewing transformation

The viewing transformation in which no rotation is applied is called the windowing transformation.

6) What is meant by Clipping?

Clipping is the process of determining the visible portion of a drawing lying within a window and discarding the rest.

7) State the use of reflection transformation.

It allows a copy of the object to be displayed while the object is reflected about a line or aplane.

8) What is the use shading Technique?

This technique is used to display the images in natural way. It is based on the recognition of distance and shape as a function of illumination.

9) How information is transmitted on a network?

The data must be encoded using a protocol. Protocol is a set of rules that control the exchange of data between the communicatingdevices.

10) What are the main types of 2Dtransformations?

i. Translation
ii. Scaling
iii. Reflection
iv. Rotation
v. Shearing

11) What is meant by concurrent engineering?

The concept and practice of various functions or departments working together, from the beginning, to engineer a product.

12) What are the advantages of Concurrent engineering?

1. The design decisions are taken by a team of multi disciplinaryexperts.
2. Changes and modification on the product design will befaster.
3. Higherquality.

13) What are the characteristics of concurrent engineering?

1. Product responsibilities lies on team of multi disciplinary group.
2. Integration of design, process planning and production will be achieved.
3. Frequent review of design and development process.
4. Rapid prototyping.

14) Define CAD. Mention areas of application of CAD.

The computers help in design and draft is commonly expressed by the term "Computer Aided Design" (CAD). A CAD system helps designer in various ways

1. Invites and promotes interaction through various input/output devices.
2. Allows manipulation of image (such as scalling, translation, rotation) in the computer screen.
3. Enable the designer to carry out the engineering analyses for stress, vibration, noise thermal distortions and more using FEA.
4. Design optimization through simulation and animation.
5. Automated drafting.

15) What is mean by Co-Ordinate Systems?

When a design package is initiated, the display will have a set of co-ordinate values. These are called default co-ordinates. A user co-ordinate system is one in which the designer can specify his own co-ordinates for a specific design application.

PART B

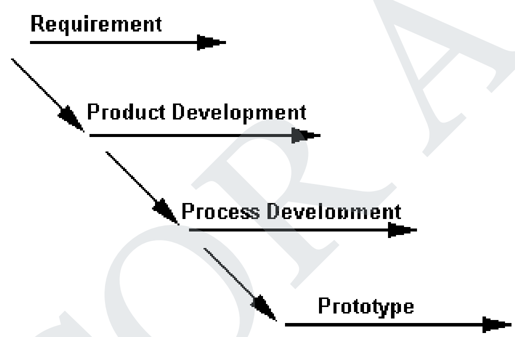
1**. Discuss about Sequential Engineering and Concurrent Engineering (May/June 2016)(Nov/Dec2015)**

Sequential Engineering	**Concurrent Engineering**
Sequential engineering is the term used to explain the method of production in a linear system. The various steps are done one after another, with all attention and resources focused on that single task	In concurrent engineering, various tasks are handled at the same time, and notes sentially in the standard order. This means that info found out later in the course can be added to earlier parts, improving them, and also saving time.
Sequential engineering is a system by which a group within an organization works sequentially to create new products and services.	Concurrent engineering is a method by which work several groups within an organization simultaneously to create new products and services.

The sequential engineering is a linear product design process during which all stages of manufacturing operate in serial.	The concurrent engineering is a non linear Product design process during which all stages of manufacturing operate at the same time.
Both process and product design run in serial and take place in the different time.	Both process and product design run in serial and take place in the different time
Process and Product are not matched to attain optimal matching	Process and Product are co ordinatedto Attain optimal matching of requirements for effective quality and delivery.
Decision making done by only group of experts.	Decision making involves full team Involvement.

Sequential Engineering

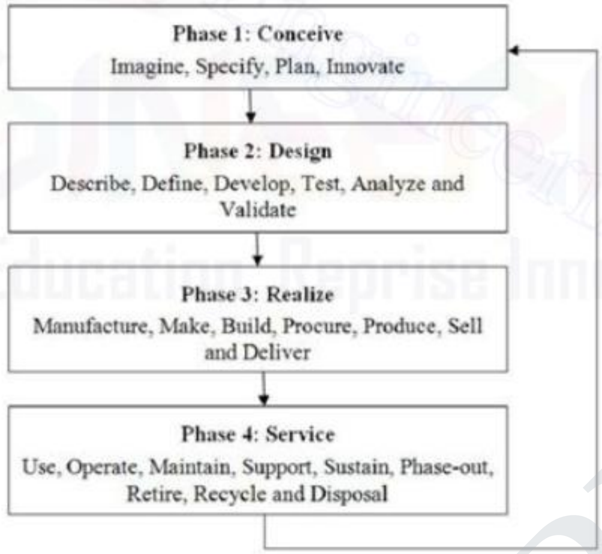
Concurrent Engineering



2. Explain in detailed about product cycle?

Product cycle integrate processes, people, data, and business and gives a product information for industries and their extended activity. Product cycle is the process of managing the entire lifecycle of a product from starting, through design and manufacture, to repair and removal of manufactured products.

There are several Product cycle models in industry to be considered, one of the possible product cycle is given below



Step 1: Conceive

Imagine, Specify, Plan, Innovate

The first step is the definition of the product requirements based on company, market and customer. From this requirement, the product's technical data can be defined. In parallel, the early concept design work is performed defining the product with its main functional features. Various media are utilized for these processes, from paper and pencil to clay mock-up to 3D Computer Aided Industrial Design.

Step 2: Design

Describe, Define, Develop, Test, Analyze and Validate

This is where the completed design and development of the product begins, succeeding to prototype testing, through pilot release to final product. It can also involve improvement to existing products as well as planned obsolescence. The main tool usedfor design and development is CAD. This can be simple 2D drawing / drafting or 3Dparametric feature based solid/surface modeling.

This step covers many engineering disciplines including: electronic, electrical, mechanical, and civil. Besides the actual making of geometry there is the analysis of the components and assemblies.

Optimization, Validation and Simulation activities are carried out using Computer Aided Engineering (CAE) software. These are used to perform various tasks such as: Computational Fluid Dynamics (CFD); Finite Element Analysis (FEA); and Mechanical Event Simulation (MES). Computer Aided Quality (CAQ) is used for activities such as Dimensional tolerance analysis. One more task carried out at this step is the sourcing of bought out components with the aid of procurement process.

Step 3: Realize

Manufacture, Make, Build, Procure, Produce, Sell and Deliver

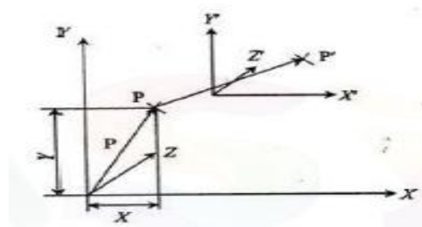
Once the design of the components is complete the method of manufacturing is finalized. This includes CAD operations such as generation of CNC Machining instructions for the product‘s component as well as tools to manufacture those components, using integrated Computer Aided Manufacturing (CAM) software. It includes Production Planning tools for carrying out plant and factory layout and production simulation. Once details components are manufactured their geometrical form and dimensions can be verified against the original data with the use of Computer Aided Inspection Equipment (CAIE). Parallel to the engineering tasks, sales and marketing work take place. This could consist of transferring engineering data to a web based sales configuration.

Step 4: Service

Use, Operate, Maintain, Support, Sustain, Phase-out, Retire, Recycle and Disposal

The final step of the lifecycle includes managing of information related to service for repair and maintenance, as well as recycling and waste management information. This involves using tools like Maintenance, Repair and Operations Management software.

3. Discuss about 2D and 3D transformation?



Translation of the Point

2-D TRANSFORMATION

1. Tranlation
2. Scaling
3. Roration

Translation :-

It is the most common and easily understood transformation in CAD. This moves a geometric entity space in such a way that the new entity is parallel at all points to the old entity.

$$P' = [x' \quad y'] \rightarrow (1)$$

$$x' = x + dx \rightarrow (2)$$

$$y' = y + dy \rightarrow (3)$$

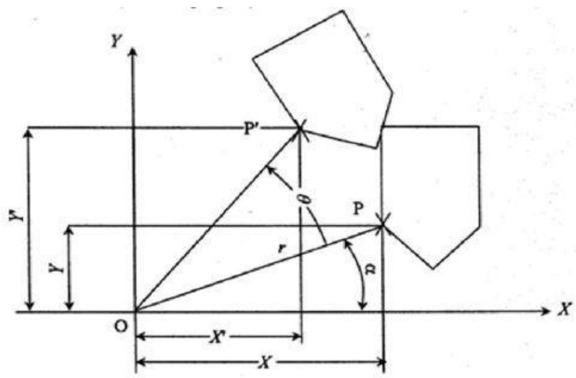
Putting equ (3) back into equ (1)

$$P' = \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x+dx \\ y+dy \end{bmatrix} \rightarrow (4)$$

This can also be written in matrix form as follows

$$P' = \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x+dx \\ y+dy \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} dx \\ dy \end{bmatrix} \rightarrow (5)$$

This is normally the operation used in the CAD System as move command



2. Scaling :-

It is the transformation applied to change the scale of an entity. As shown in following figure this alter the size of the entity by the Scaling factor applied.

$$[P'] = [x' \quad y'] = [S_x \times x_v, S_y \times dy] \rightarrow (6)$$

This can also written as

$$[P'] = \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \rightarrow (7)$$

$$[P'] = [T] \cdot [P] \rightarrow (8)$$

where

$$[T] = \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix} \rightarrow (9)$$

3 Rotation :

It is another important geometric transformation. The final position and orientation of a geometric entity is decided by the angle of rotation (θ) and the base point about which the rotation

To develop the transformation matrix for transformation consider a point p location in xy plane being rotated in ccw to the new position p' by an angle θ

$$[P'] = [x', y']$$

From figure

$$x = r \cos \alpha$$
$$y = r \sin \alpha$$

The new position p' is

$$x' = r \cos(\alpha + \theta)$$
$$= r \cos \theta \cos \alpha - r \sin \theta \sin \alpha$$
$$= x \cos\theta - y \sin\theta$$

$$y' = r \sin(\alpha + \theta)$$
$$= r \sin \theta \cos\alpha + r \cos\theta \sin\alpha$$
$$= x \sin\theta + y \cos\theta$$

This can be written as

$$[P'] = \begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$[P'] = [T_R] \cdot [P]$$

$$[T_R] = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$$

3-D TRNSFORMATION :

1. Translation

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & dx \\ 0 & 1 & 0 & dy \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

2. Scaling

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3. Reflection

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \pm 1 & 0 & 0 & 0 \\ 0 & \pm 1 & 0 & 0 \\ 0 & 0 & \pm 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

4. Rotation about z axis

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

5. Rotation about y axis

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Rotation about x axis

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

4. EXPLAIN IN DETAILED ABOUT DESIGN PROCESS? (May/June 2016)

It is a process in which we initiate the design and come up with a number of design concepts and then narrow down to the single best concept.
This involved the following steps.

- Identification of customer needs
- Problem definition, Gathering Information
- Conceptualization, Concept selection

Feasibility Study

Designs can be futile unless satisfying the original need is feasible

- At this stage, the product appears in abstract forms, but is they feasible?
- Alternative solutions must be subjected to physical and economic analyses and be realizable from both

The Feasibility Study using analysis of several alternatives establishes the design concept as something which can be realized and accepted Some examples
(i) A building must be comfortable to live in:
Heating, ventilation and air conditioning are required. Specify limits of temperature, humidity, velocity and fresh air constituency.
(ii) National fossil fuel supplies are low:
Alternative forms of energy supply are required. Specify amount and where they are needed, and any restrictions of space, time or pollution levels.

Preliminary Design

- Main purpose is selection of the best possible solution from a choice of alternatives Make comparisons against given criteria & constraints
- Must maintain an open mind; use your judgment

Detailed design

- Aim is to produce a complete set of working drawings which are then transmitted to the manufacturer
- This stage of design is far less flexible than those previous
- Design should now reflect all of the planning both for manufacture andconsumption stages Construction/testing of various components may berequired

Production

- Here, the device or system is actually constructed, and planning for this shouldhave been incorporated into the design
- Knowledge of the capability of the machines is required, since it must bepossible to build and assemble the components as specified
- Special jigs, fixtures and even machines may be required

- Planning is vital; including quality control hold points, methods of inspection,standards for comparison etc...
- Timing of construction may be important e.g. Climates

Distribution

- Transportation of the manufactured article, complete or in subassembly formmust be anticipated in the design
- Packaging, availability of vehicles, regulations for use of thoroughfares ,shelf/component life, warehouse storage facilities, special handling,environmental control of temperature and humidity may need to be addressed

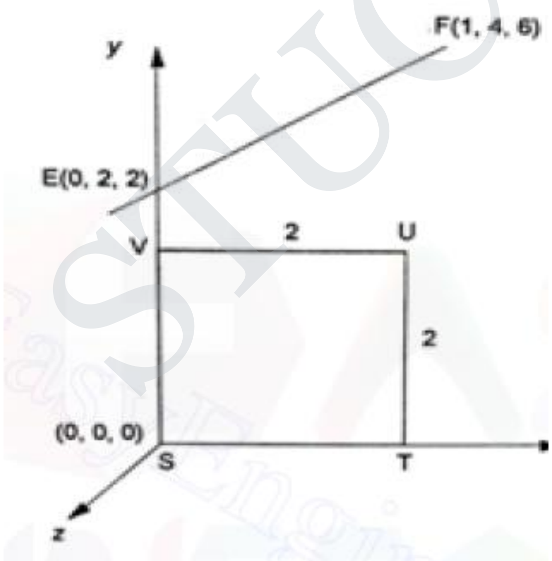
Consumption

- The product is now used by the consumer
- If the design is effect, it will have met the need
- The design may yet not be complete; redesigns and modifications may berequired depending on field trials or consumer feedback
- May need to consider maintenance of components and supply of spare parts orsubassemblies

Retirement

- The product will be discarded as its life cycle terminates
- It may have become obsolete whilst still serviceable and therefore the designmay not have been fully economical
- Disposal and recovery of useful materials should have been included in the design Threats to safety should be guarded against
-

5. Rotate the rectangle shown in fig 300 counter clockwise about the line EF and find new coordinates of the rectangle (Nov/Dec2015)



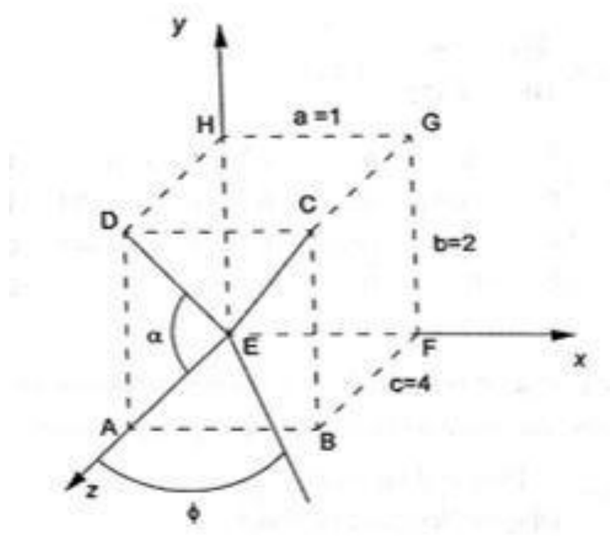


Figure Q9

Solution :

From given Co-ordinates

$$[P] = \begin{bmatrix} S \\ T \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 2 & 0 & 0 & 1 \\ 2 & 2 & 0 & 1 \\ 0 & 2 & 0 & 1 \end{bmatrix}$$

The given rectangle can be rotated about the line EF for 30°

Step 1 :-

The line is ~~translated~~ about the origin to (0 -2 -2)

$$T_{(0,-2,-2)} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & -2 & -2 & 1 \end{bmatrix}$$

Step 2 :

Next the axis is rotated at an angle of α CCW

$$\cos\alpha = \frac{AE}{DE}$$

In cuboid, $AE = c = 4$ $AD = 2$ & $DE = \sqrt{b^2+c^2}$

$$= \sqrt{2^2+4^2}$$

$$= 4.472$$

$$\therefore \cos\alpha = \frac{4}{4.472} = 0.894$$

$$\alpha = 26.57°$$

III'y

$$\sin\alpha = \frac{AD}{DE} = \frac{2}{4.472} = 0.447$$

$$R_{26.57} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha & \sin\alpha & 0 \\ 0 & -\sin\alpha & \cos\alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & .894 & .447 & 0 \\ 0 & -.447 & .894 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Step 3 :

Then the line rotated at an angle of ϕ ccw to axis

$$\cos\phi = \frac{DE}{L}$$

where $AB = a = 1$; $DE = \sqrt{b^2+c^2} = \sqrt{2^2+4^2}$

$= 4.472$

$$L = \sqrt{a^2+b^2+c^2} = \sqrt{1^2+2^2+4^2} = 4.583$$

$$\therefore \cos\phi = \frac{4.472}{4.583} = 0.976$$

$$\phi = 12.58^\circ$$

III'ly $\sin\phi = \frac{AB}{\text{Diagonal length } L} = \frac{1}{4.583}$

$= 0.218$

$$R_{12.58^\circ} = \begin{bmatrix} \cos\phi & 0 & -\sin\phi & 0 \\ 0 & 1 & 0 & 0 \\ \sin\phi & 0 & \cos\phi & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} .976 & 0 & 0.218 & 0 \\ 0 & 1 & 0 & 0 \\ .218 & 0 & 0.976 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Step 4: Next the rectangle is rotated 30° about z

$$R = \begin{bmatrix} \cos\theta & \sin\theta & 0 & 0 \\ -\sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} .866 & .5 & 0 & 0 \\ -.5 & .866 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Step 5:

Next the line is back-rotated at an angle of 12.58°

$$R_{(-12.58)} = \begin{bmatrix} \cos(-\phi) & 0 & -\sin(-\phi) & 0 \\ 0 & 1 & 0 & 0 \\ \sin(-\phi) & 0 & \cos(-\phi) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0.976 & 0 & .218 & 0 \\ 0 & 1 & 0 & 0 \\ -0.128 & 0 & .976 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Step 6: Next the axis back-rotated at angle 26.57°

$$R_{-26.57} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(-\alpha) & \sin(-\alpha) & 0 \\ 0 & -\sin(-\alpha) & \cos(-\alpha) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & .894 & .447 & 0 \\ 0 & .447 & .894 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Step 7: Last the line is back-translated to initial Position.

$$T_{(0,2,2)} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 2 & 2 & 1 \end{bmatrix}$$

$$T_c = T_{(0,-2,-2)} \, R_{26.57°} \, R_{12.58°} \, R_{30°} \, R_{(-12.58°)} \, R_{(-26.57°)} \cdot T_{(0,2,2)}$$

$$T_c = \begin{bmatrix} .9312 & .1634 & -.3256 & 0 \\ -.1743 & .9846 & -.0044 & 0 \\ .3199 & .0609 & .9454 & 0 \\ -.2919 & -.0909 & .1179 & 1 \end{bmatrix}$$

$$[P'] = [P][T_c] = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 2 & 0 & 0 & 1 \\ 2 & 2 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} .9312 & .1634 & -.3256 & 0 \\ -.1743 & .9846 & -0.0044 & 0 \\ .3199 & .0609 & .9454 & 0 \\ -.2919 & -.0909 & .1179 & 1 \end{bmatrix}$$

$$[P'] = \begin{bmatrix} .2913 & -.0989 & .1179 & 1 \\ 1.5712 & .2359 & -.5334 & 1 \\ 1.2226 & 2.2051 & -.5421 & 1 \\ -.6399 & 1.8783 & .1092 & 1 \end{bmatrix}$$

6. Rotate the rectangle (0,0), (2,0), (2,2), (0,2) as shown,300counter clockwise aboutthe centroid and the new co ordinates of the rectangle(Nov/Dec 2015)

From given Co-ordinates

$$\begin{bmatrix} A \\ B \\ C \\ D \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ 2 & 0 & 1 \\ 2 & 2 & 1 \\ 0 & 2 & 1 \end{bmatrix}$$

Step 1: Translation to point (1,1)

$T_x = -1$ & $T_y = -1$

The matrix becomes:-

$$T_{(-1,-1)} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -1 & -1 & 1 \end{bmatrix}$$

Step 2: Rotation by 30° CCW

$$\therefore R = \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \cos 30^\circ & \sin 30^\circ & 0 \\ -\sin 30^\circ & \cos 30^\circ & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} .866 & .5 & 0 \\ -.5 & .866 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Step 3 : Translation to point (1, 1)

$T_x = 1 \quad T_y = 1$

So the back-translation matrix becomes

$$T_{(1,1)} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

The Concatenated Transformation matrix

$$T_{(-1,-1)} R_{30°} T_{(1,1)} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -1 & -1 & 1 \end{bmatrix} \times \begin{bmatrix} .8566 & .5 & 0 \\ -.5 & .866 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} .866 & .5 & 0 \\ -.5 & .866 & 0 \\ .634 & -.366 & 1 \end{bmatrix}$$

Now the transformed matrix is calculated by

$$\begin{bmatrix} A' \\ B' \\ C' \end{bmatrix} = \begin{bmatrix} A \\ B \\ C \end{bmatrix} ; \begin{bmatrix} A' \\ B' \\ C' \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ 2 & 0 & 1 \\ 2 & 2 & 1 \\ 0 & 2 & 1 \end{bmatrix} \begin{bmatrix} .866 & .5 & 0 \\ -.5 & .866 & 0 \\ .634 & -.366 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} .634 & -.366 & 1 \\ 2.366 & .634 & 1 \\ 1.366 & 2.366 & 1 \\ -.366 & 1.366 & 1 \end{bmatrix}$$

∴ New co-ordinates are

$A'(0.634, -0.366)$ $B'(2.366, .634)$ $C'(1.366, 2.366)$

$D'(-0.366, 1.366)$

UNIT II GEOMETRIC MODELING
PART A

1. What are the limitation of Hermite curves?(May/June 2016)

- It is difficult to select the magnitude as well as angle of the tangent vector at thetwo end points of the curve segment
- Curves are difficult to control because of global shape control characteristics.
- The cubic curve never reduces exactly to a conical section and poorlyapproximate asymptotic curve

2. What are the advantage and disadvantage of wire frame model?(May/June2016)

Advantage
- Wire frame models are more clear than 2D representation
- It is widely used method

Disadvantage
- Representation of model in wire frame models is lack in clarity
- During surface definition there might be confusion by eliminating hidden lines
-

3. Difference between analytical curves interpolated curves and approximatedcurves. (Nov/Dec 2015)

S.NO	ANALYTICAL CURVE	INTERPOLATED CURVE	APPROXIMATED CURVE
1.	These curves are represented by a simple mathematical equation	It is drawn by the interpolating thegiven data points	It provides the most flexibility in drawingcurves for complexshapes
2.	They have a fixed form cannot be modified to achieve the shapes that violates the mathematical equations	These curves havelimited flexibility inshape creation	The model of automobile fender can be easily created with the help of approximated curves

4. What are the types of surfaces that CAD/CAM systems use?
- Open and closed surfaces
- Flattening a surface
- Surface patches
- Faces
- Skins and volumes
- Transition to solids

5. What is meant by coon surface?

In mathematics, a Coons patch, is a type of manifold parameterization used incomputer graphics to smoothly join other surfaces together, and in computationalmechanics applications, particularly in finite element method and boundary elementmethod, to mesh problem domains into elements.

6. What do you understand by the form element method of geometricconstruction?

Geometric constructions of figures and lengths were restricted to the use of onlya straightedge and compass (or in Plato's case, a compass only; a technique now calleda Mascheroni construction). Although the term "ruler" is sometimes used instead of"straightedge," the Greek prescription prohibited markings that could be used to make measurements. Furthermore, the "compass" could not even be used to mark offdistances by setting it and then "walking" it along, so the compass had to be consideredto automatically collapse when not in the process of drawing a circle.

7. Specify the applications of this method of modeling in comparison to that of thevariant type?

The finite element method is used to describe the detailed properties of theatmospheric boundary layer by use of a high-resolution model and its bulk properties byuse of a simple vertically integrated model. Features of the finite element method thatcan be exploited for applications to the atmospheric boundary layer include thecapability to use different basis functions in different parts of the domain, ability to gridover irregular terrain, ease of using time-dependent basis functions and the natural waythat surface boundary conditions and vertically integrated properties enter the model.

8. What are the limitations in utilizing the sweep method for geometric?

- In computational geometry, a sweep line algorithm or plane sweep algorithm is atype of algorithm that uses a conceptual sweep line or sweep surface to solve variousproblems in Euclidean space.
- The idea behind algorithms of this type is to imagine that a line (often a verticalline) is swept or moved across the plane, stopping at some points. Geometricoperations are restricted to geometric objects that either intersect or are in theimmediate vicinity of the sweep line whenever it stops, and the complete solution isavailable once the line has passed over all objects

9. Generate the conical surface obtained by rotation of the line segment AB aroundthe z-axis with A= (1,0,1) and B= (7,0,7)(Nov/Dec 2015)

Solution

From the given coordinates, the coordinate's matrix can be written by

$$\begin{bmatrix} A \\ B \end{bmatrix} = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 7 & 0 & 7 & 1 \end{bmatrix}$$

$$[R_{xy}] = [R_z] = \begin{bmatrix} \sin\theta & -\cos\theta & 0 & 0 \\ \cos\theta & \sin\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The resultant matrix after rotation is calculated by

$$\begin{bmatrix} A' \\ B' \end{bmatrix} = \begin{bmatrix} A \\ B \end{bmatrix} [R_z]$$

$$\begin{bmatrix} A' \\ B' \end{bmatrix} = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 7 & 0 & 7 & 1 \end{bmatrix} \begin{bmatrix} \sin\theta & -\cos\theta & 0 & 0 \\ \cos\theta & \sin\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} A' \\ B' \end{bmatrix} = \begin{bmatrix} \sin\theta & -\cos\theta & 1 & 1 \\ 7\sin\theta & -7\cos\theta & 7 & 1 \end{bmatrix}$$

10. For a cubic Bezier curve, carry a similar matrix formulation to a cubic spline?

A Bézier curve is a parametric curve frequently used in computer graphics andrelated fields. Generalizations of Bézier curves to higher dimensions are called Béziersurfaces, of which the Bézier triangle is a special

PART – B

1. Discuss in detail about approximate synthetic curve representation? (Nov/Dec2015)

Hermite curve:

It is determined by defining positions and tangent vectors at the data points. It is also known "CUBIC CURVE" Hermite curve passes through the end points of the curve segment

The parametric equation of a cubic spline segment is given by

$$p(s) = \sum_{i=0}^{3} c_i s^i, \quad 0 \le s \le 1 \quad \rightarrow (1)$$

Here
$s \longrightarrow$ Parameter
$c_i \Rightarrow$ The polynomial co-efficient

equation (1) is written as

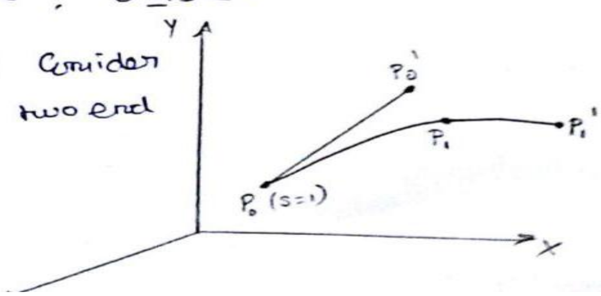
$$p(s) = c_3 s^3 + c_2 s^2 + c_1 s + c_0 \quad \rightarrow (2)$$

The (2) written as $p(s) = s^T c$ where $s = (s^3\, s^2\, s)^T$
$\hookrightarrow 2 \cdot 1$ $\quad c = [c_3\ c_2\ c_1\ c_0]^T$

The tangent vector of the curve at any point is given by differentiating equ (1)

$$p'(s) = \sum_{i=0}^{3} c_i\, i\, s^{i-1}, \quad 0 \le s \le 1 \quad \rightarrow (3)$$

To find the co-efficient c_i consider the cubic spline curve with two end points P_0 & P_1



Applying the boundry conditions (P_0 P_0' at $s=0$ & P_1 P_1' at $s=1$)

$\therefore$ $P_0 = C_0$; $P_0' = C_1$; $P_1 = C_3 + C_2 + C_1 + C_0$

$P_1' = 3C_3 + 2C_2 + C_1 \rightarrow (4)$

Sub eqn (4) in (2)

$\therefore$ $P(s) = (2s^3 - 3s^2 + 1)P_0 + (-2s^3 + 3s^2)P_1 + (s^3 - 2s^2 + s)P_0'$
$+ (s^3 - s^2)P_1$; $0 \le s \le 1 \rightarrow (5)$

Tangent vectors becomes

$P'(s) = (6s^2 - 6s)P_0 + (-6s^2 + 6s)P_1 + (3s^2 - 4s + 1)P_0'$
$+ (3s^2 - 2s)P_1'$; $0 \le s \le 1 \rightarrow (6)$

The function 's' in eqn (5) & (6) are belding functions

writing eqn (5) in matrix form

$p(s) = s^T [M_H] V \quad 0 \le s \le 1$ $\quad M_H$ – Hermite matrix

V – Geomatry matrix

$$[M_H] = \begin{bmatrix} 2 & -2 & 1 & 1 \\ -3 & 3 & -2 & -1 \\ 0 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \quad V = [P_0\ P_1\ P_0'\ P_1']^T$$

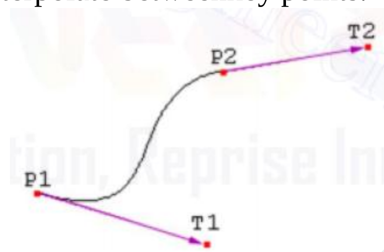
Compare (2.1) & (2.6) $\quad C = [M_H] V$ (or) $V = [M_H]^T C$

where $$[M_H]^{-1} = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 0 \\ 3 & 2 & 1 & 0 \end{bmatrix}$$

$|||$'ly $p'(s) = s^T . [M_H]^S V$

$$[M_H]^S = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 6 & -6 & 3 & 3 \\ -6 & 6 & -4 & -2 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

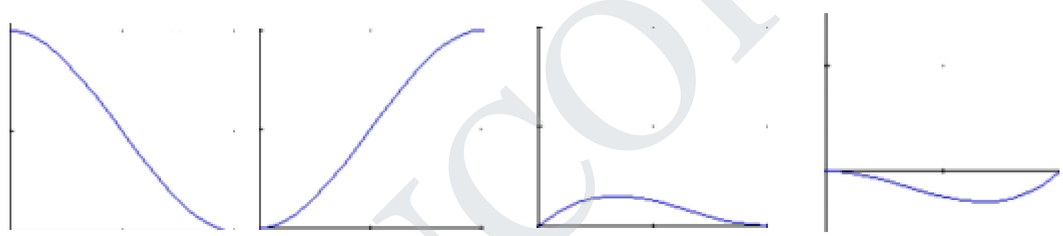
A Hermite curve is a spline where every piece is a third degree polynomialdefined in Hermite form: that is, by its values and initial derivatives at the end points ofthe equivalent domain interval. Cubic Hermite spines are normally used forinterpolation of numeric values defined at certain dispute values x1x2x3, ….., xn toachieve a smoothcontinuous function. The data should have the preferred functionvalue and derivative at each Xk. The Hermite formula is used to every interval (Xk,Xk+1)individually. The resulting spline become continuous and will have first derivative.Cubic polynomial splines are specially used in computer geometric modeling toattain curves that pass via defined points of the plane in 3D space. In these purposes,each coordinate of the plane is individually interpolated by a cubic spline function of adivided parameter_t‗.Cubic splines can be completed to functions of different parameters, in severalways. Bicubic splines are frequently used to interpolate data on a common rectangulargrid, such as pixel values in a digital picture. Bicubic surface patches, described bythree bicubic splines, are a necessary tool in computer graphics. Hermite curves aresimple to calculate but also more powerful. They are used to well interpolate betweenkey points.



The following vectors needs to compute a Hermite curve:

- P1: the start point of the Hermite curve
- T1: the tangent to the start point
- P2: the endpoint of the Hermite curve
- T2: the tangent to the endpoint

Figure shows the functions of Hermite Curve of the 4 functions (from left to right:h1, h2, h3, h4).



Functions of Hermite Curve

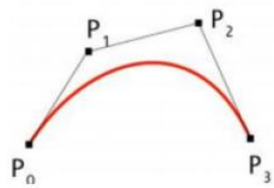
A closer view at functions _h1‗ and _h2‗, the result shows that function _h1‗ startsat one and goes slowly to zero and function _h2‗ starts at zero and goes slowly to one.At the moment, multiply the start point with function _h1‗ and the endpoint withfunction _h2‗. Let s varies from zero to one to interpolate between start and endpoint of

Hermite Curve. Function _h3‗ and function _h4‗ are used to the tangents in the similarway. They make confident that the Hermite curve bends in the desired direction at thestart and endpoint.

2. Write short notes on Bezier and B-spline curve? (May/June 2016)

Bezier curve

Bezier curves are extensively applied in CAD to model smooth curves. As thecurve is totally limited in the convex hull of its control points P0, P1,P2 & P3, the pointscan be graphically represented and applied to manipulate the curve logically. Thecontrol points P0 and P3 of the polygon lie on the curve .The other two verticesdescribed the order, derivatives and curve shape. The Bezier curve is commonly tangentto first and last vertices.Cubic Bezier curves and Quadratic Bezier curves are very common. Higherdegree Bezier curves are highly computational to evaluate. When more complex shapesare required, Bezier curves in low order are patched together to produce a compositeBezier curve. A composite Bezier curve is usually described to as a _path‗ in vectorgraphics standards and programs. For smoothness assurance, the control point at whichtwo curves meet should be on the line between the two control points on both sides.



A general adaptive method is recursive subdivision, in which a curve's controlpoints are verified to view if the curve approximates a line segment to within a lowtolerance. If not, the curve is further divided parametrically into two segments, $0 \leq t \leq 0.5$ and $0.5 \leq t \leq 1$, and the same process is used recursively to each half. There arefuture promote differencing techniques, but more care must be taken to analyze errortransmission.Analytical methods where a Bezier is intersected with every scan line engagefinding roots of cubic polynomials and having with multiple roots, so they are not oftenapplied in practice. A Bezier curve is described by a set of control points P0 through Pn,where _n' is order of curve. The initial and end control points are commonly the endpoints of the curve; but, the intermediate control points normally do not lie on the curve.

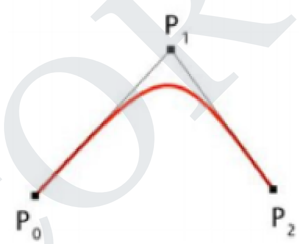
(i) Linear Bezier curves

Linear Bezier Curve

As shown in the figure the given points P0 and P1, a linear Bezier curve is merelya straight line between those two points. The Bezier curve is represented by

$$\mathbf{B}(t) = \mathbf{P}_0 + t(\mathbf{P}_1 - \mathbf{P}_0) = (1-t)\mathbf{P}_0 + t\mathbf{P}_1 \text{ , } t \in [0,1]$$

(ii) Quadratic Bezier curves



Quadratic Bezier Curve

As shown in the figure, a quadratic Bezier curve is the path defined by thefunction B(*t*), given points P0, P1, and P2

$$\mathbf{B}(t) = (1-t)[(1-t)\mathbf{P}_0 + t\mathbf{P}_1] + t[(1-t)\mathbf{P}_1 + t\mathbf{P}_2] \text{ , } t \in [0,1],$$

This can be interpreted as the linear interpolate of respective points on the linear Beziercurves from P0 to P1 and from P1 to P2 respectively. Reshuffle the preceding equationgives:

$$\mathbf{B}(t) = (1-t)^2\mathbf{P}_0 + 2(1-t)t\mathbf{P}_1 + t^2\mathbf{P}_2 \text{ , } t \in [0,1].$$

The derivative of the Bezier curve with respect to the value_t' is

$$\mathbf{B}'(t) = 2(1-t)(\mathbf{P}_1 - \mathbf{P}_0) + 2t(\mathbf{P}_2 - \mathbf{P}_1).$$

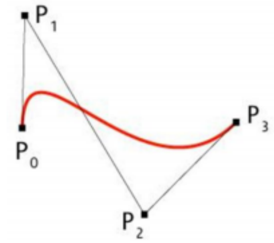
From which it can be finished that the tangents to the curve at P0 and P2intersect at P1. While_t' increases from zero to one, the curve departs from P0 in the direction of P1, thenturns to land at P2 from the direction of P1.

The following equation is a second derivative of the Bezier curve with respect to _t':

$$\mathbf{B}''(t) = 2(\mathbf{P}_2 - 2\mathbf{P}_1 + \mathbf{P}_0).$$

A quadratic Bezier curve is represent a parabolic segment. Since a parabolacurve is a conic section, a few sources refer to quadratic Beziers as _conic arcs'.

(iii) Cubic Bezier curves



The function **B** **P**i, **P**j, **P**k (t) for the quadratic Bezier curve written by points **P**i, **P**j, and **P**k,the cubic Bezier curve can be described as a linear blending of two quadratic Beziercurves:

$$\mathbf{B}(t) = (1-t)^3\mathbf{P}_0 + 3(1-t)^2 t\mathbf{P}_1 + 3(1-t)t^2\mathbf{P}_2 + t^3\mathbf{P}_3 \ , \ t \in [0,1].$$

The open form of the curve is:

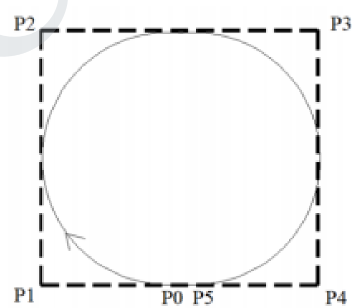
$$\mathrm{B}(t) = (1-t)^3\mathrm{P}_0 + 3(1-t)^2 t\mathrm{P}_1 + 3(1-t)t^2\mathrm{P}_2 + t^3\mathrm{P}_3 \ , \ t \in [0,1].$$

For several choices of P1 and P2 the Bezier curve may meet itself.Any sequence of any four dissimilar points can be changed to a cubic Beziercurve that goes via all four points in order. Given the beginning and ending point of a
few cubic Bezier curve, and the points beside the curve equivalent to t = 1/3 and t =2/3, the control points for the original Bezier curve can be improved.
The following equation represent first derivative of the cubic Bezier curve with respectto t:

$$\mathrm{B}'(t) = 3(1-t)^2(\mathrm{P}_1 - \mathrm{P}_0) + 6(1-t)t(\mathrm{P}_2 - \mathrm{P}_1) + 3t^2(\mathrm{P}_3 - \mathrm{P}_2).$$

Properties Bezier curve

- The Bezier curve starts at P0 and ends at P*n*; this is known as _endpointinterpolation‘ property.
- The Bezier curve is a straight line when all the control points of a cure arecollinear.
- The beginning of the Bezier curve is tangent to the first portion of the Bezierpolygon.
- A Bezier curve can be divided at any point into two sub curves, each of whichis also a Bezier curve.
- A few curves that look like simple, such as the circle, cannot be expressedaccurately by a Bezier; via four piece cubic Bezier curve can similar a circle,with a maximum radial error of less than one part in a thousand (Fig.2.8).



Circular Bezier Curve

Each quadratic Bezier curve is become a cubic Bezier curve, and morecommonly, each degree 'n' Bezier curve is also a degree 'm' curve for any $m > n$.

- Bezier curves have the different diminishing property. A Bezier curves does not_ripple‘ more than the polygon of its control points, and may actually _ripple‘less than that.
- Bezier curve is similar with respect to t and (1-t). This represents that thesequence of control points defining the curve can be changes without modify ofthe curve shape.
- Bezier curve shape can be edited by either modifying one or more vertices ofits polygon or by keeping the polygon unchanged or simplifying multiplecoincident points at a vertex.

B-Spline Surfaces

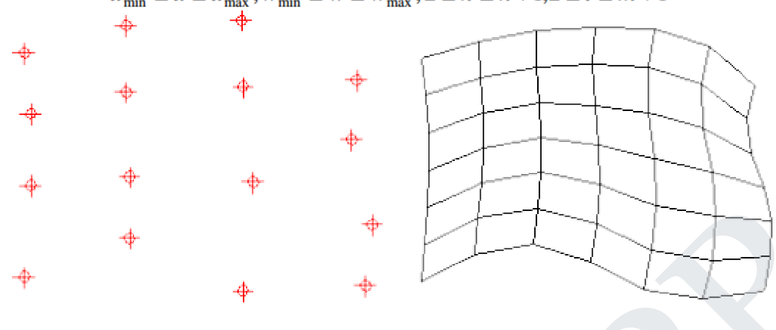
- The B-spline surface approximates a characteristics polygon as shown andpasses through the corner points of the polygon, where its edges are tangentialto the edges of the polygon

- This may not happen when the control polygon is closed
- A control point of the surface influences the surface only over a limited portionof the parametric space of variables u and v.

  The expression for the B-spline surfaces is given by

$$Q(u,w)=\sum_{i=1}^{n+1}\sum_{j=1}^{m+1}B_{i,j}N_{i,k}(u)M_{j,l}(w)$$

$$u_{\min}\le u\le u_{\max};w_{\min}\le w\le w_{\max};2\le k\le n+1,2\le l\le m+1$$



(a) Data points (b) B-spline

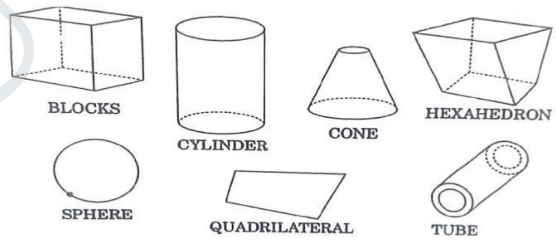
3. Briefly explain the different scheme used to generate a solid model? (Nov/Dec2015)

TECHNIQUES IN SURFACE MODELLING

- Constructive solid geometry (CSG and C-rep)
- Boundary representation method (B-rep)

CONSTRUCTIVE SOLID GEOMETRY (CSG and C-rep)

- Constructive solid geometry (CSG) (formerly called computational binary solidgeometry) is a technique used in solid modeling.
- Constructive solid geometry allows a modeler to create a complex surface orobject by using Boolean operators to combine objects.
- Often CSG presents a model or surface that appears visually complex, but isactually little more than cleverly combined or de-combined objects
- The simplest solid objects used for the representation are called primitives. Typically they are the objects of simple shape.



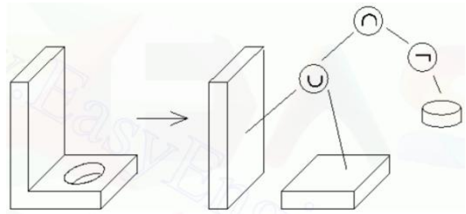
Solid primitives.

The set of allowable primitives is limited by each software package. Some softwarepackages allow CSG on curved objects while other packages do not.

- It is said that an object is constructed from primitives by means of allowableoperations, which are typically Boolean operations on sets :Union, intersectionand difference as well as geometric transformations of those sets

Boolean Operations

The CSG is constructed by the following Boolean operation



4. What do you understand by boundary representation technique in solidmodeling, explain briefly the structure of B-rep technique (May/June 2016)

Boundary representation method (B-rep)

- In solid modeling and computer-aided design, boundary representation oftenabbreviated as B-rep or BREP is a method for representing shapes using thelimits.
- Consisting of two parts: topological description of connectivity and orientation ofvertices, edges and faces, and geometric description for embedding theseelements in space
- The topological description specifies vertices, edges and faces abstractly, andindicates their incidences and adjacencies.
- The geometric representation specifiessurface equations, edge equations, andvertices coordinates.
- A vertex is a unique point in space
- An edge is a finite, non-self-intersecting, directed space curve bounded by twovertices that are not necessarily distinct.
- A face is a finite connected, nonself-intersectingregion of a closed orientedsurface bounded by one or more loops.
- A loop is an ordered alternating sequence ofedges and vertices.

The Euler-Poincar´e Formula - necessary conditions for consistency

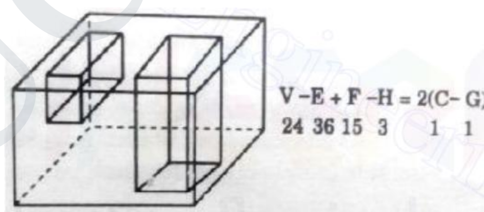
(1).For solids that have a closed, orientable surface and no holes or no interiorvoids:

$$V - E + F = 2$$

(2).For solids bounded by a single connected surface and with holes, but eachface ishomeomorphic to a disk:

$V - E + F = 2(1 - G)$

where G is the number of handles, called genus



Advantages of b-rep

- Appropriate to construct solid models of unusual shapes
- Relatively simple to convert a b-rep model to wireframe model

Disadvantages of b-rep

- Requires more storage
- Not suitable for applications like tool path generation
- Slow manipulation

5. Discus the various methods in surface modeling?

i. Surface Patch

ii. Coons Patch

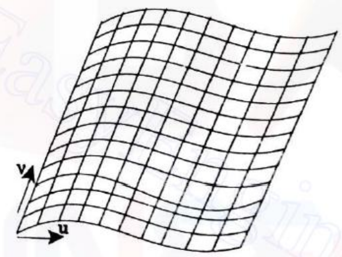
iii. Bicubic Patch

iv. Be‘zier Surface

v. B-Spline Surface

i. Surface Patch

The patch is the fundamental building block for surfaces. The twovariables *u* and *v* vary across the patch; the patch may be termed *biparametric*.The parametric variables often lie in the range 0 to 1. Fixing the value of one ofthe parametric variables results in a curve on the patch in terms of the othervariable (*Isoperimetric curve*). Figure shows a surface with curves at intervalsof *u* and *v* of 0 : 1.



Surface patch.

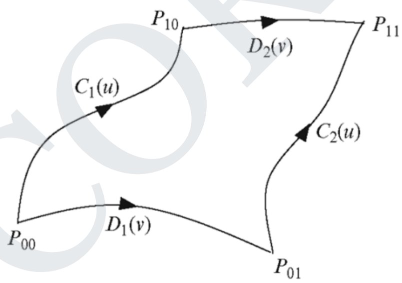
ii. Coons Patch

The sculptured surface often involve interpolation across an intersecting mesh ofcurves that in effect comprise a rectangular grid of patches, each bounded by fourboundary curves. The linearly blended coons patch is the simplest for interpolatingbetween such boundary curves. This patch definition technique blends for fourboundary curves C*i*(*u*) and D*j*(*v*) and the corner points p*ij* of the patch with the linearblending functions,

$$f(t) = 1 - t$$
$$g(t) = t$$

Using the expression

$$\vec{p}(u, v) = \vec{C_0}(u)\, f(v) + \vec{C_1}(u)\, g(v) + \vec{D_0}(v)\, f(u) + \vec{D_1}(v)\, g(u) - \vec{p_{00}}\, f(u)\, f(v) - \vec{p_{01}}\, f(u)\, g(u) - \vec{p_{10}}\, g(u)\, f(v) - \vec{p_{11}}\, g(u)\, g(v)$$

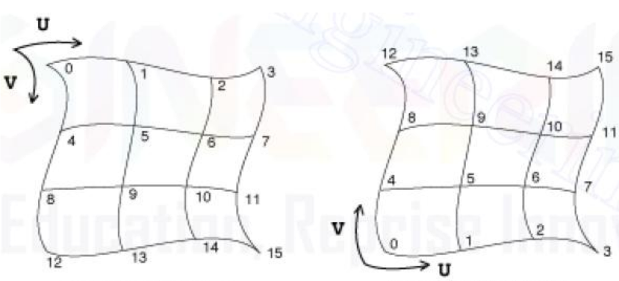


iii. Bicubic Patch

The bi-cubic patch is used for surface descriptions defined in terms ofpoint and tangent vector information. The general form of the expressions for abi-cubic patch is given by:

$$\vec{p}(u, v) = \sum_{i=0}^{3} \sum_{j=0}^{3} \vec{k_{ij}}\, u^i\, v^j$$

This is a vector equation with 16 unknown parameters *kij* which can be foundby Lagrange interpolation through 4 x 4 grid.

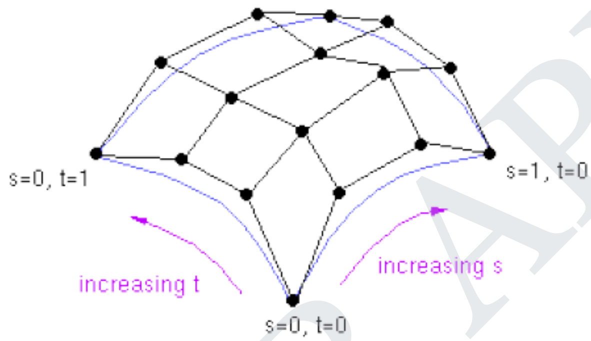


iv. Bezier Surface

A Bézier surface patch is defined by its 4 x 4 Bézier geometry matrix **GB,** whichspecifies the control points of the surface. As in the case of Bézier curves, the cornerpoints of **GB** specify actual points on the edge of the interpolated surface, while the―inner‖ points are intermediate points which indirectly specify the tangent vectors to thesurface. The x, y, and z directions of the surface are calculated independently; thus, for a3D surface patch. there will actually be separate geometry matrices **GB***x*, **GB***y* and **GB**zone for each direction.

The geometry matrix **GB***k* is given by

$$G_{Bk} = \begin{bmatrix} P_{00} & P_{01} & P_{02} & P_{03} \\ P_{10} & P_{11} & P_{12} & P_{13} \\ P_{20} & P_{21} & P_{22} & P_{23} \\ P_{30} & P_{31} & P_{32} & P_{33} \end{bmatrix}$$



Advantages of Surface Modeling

- It is less ambiguous.
- Complex surfaces can be easily identified.
- It removes hidden line and adds realism.

Disadvantages of Surface Modeling:

- Difficult to construct.
- Difficult to calculate mass property.
- More time is required for creation.
- Requires high storage space.
- Also requires more time for manipulation.

Representation of curves- Hermite curve- Bezier curve- B-spline curves-rational curves-Techniques for surface modeling – surface patch- Coons and bicubic patches- Bezier and B-spline surfaces. Solid modeling techniques- CSG and B-rep

UNIT III CAD STANDARDS

1. Write any three CAD standards for exchange of modeling data. (May/June 2016)

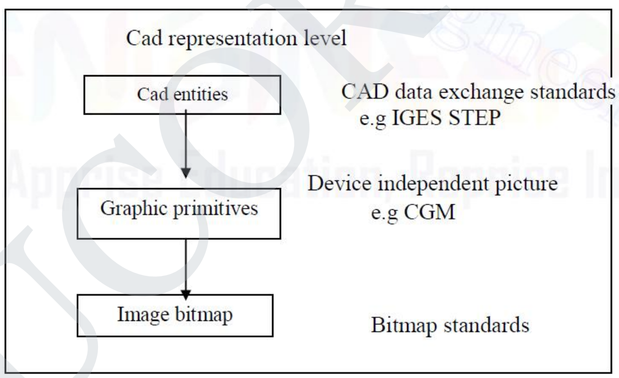
- IGES (Initial Graphics Exchange Specification)
- DXF (Drawing / Data Exchange Format)
- STEP (Standard for the Exchange of Product model data)

2. What is the importance of standards in CAD? (May/June 2016)

- To save the time of drafting.
- To make training easier.
- To make outsourcing more efficient

3. What is meant by CAD data exchange? Mention its importance. (Nov/Dec 2015)

CAD data exchange involves a number of software technologies and methodsto translate data from one Computer-aided design system to another CAD file format.This PLM technology is required to facilitate collaborative work (CPD) between OEMs andtheir suppliers.



4. Compare the shape based and the product data based exchange standards. (Nov/Dec 2015)

S.NO	SHAPE BASED EXCHANGE STANDARDS	PRODUCT DATA BASED EXCHANGE STANDARDS
1	All data exchange data are neutral file	It has a specific file format
2	It has section of header table block entities and ends	It has a three layered architecture such as application logical and physical layer
3	These file do not have any software specific function	The file must have any software specific function
4	EX : DXE & IGES	Example STEP,SDF,EDIF &PDES

5. Give the requirements of product data exchange between dissimilar CAD/CAMsystems?

CAD data exchange involves a number of software technologies and methodsto translate data from one Computer-aided design system to another CAD file format.This PLM technology is required to facilitate collaborative work (CPD) between OEMs andtheir suppliers.
The main topic is with the translation of geometry (wireframe, surface and solid) but alsoof importance is other data such as attributes; metadata, assembly structure and feature data.

6. Compare IGES, PDES?

The Initial Graphics Exchange Specification (IGES) (pronounced eye-jess) is a vendorneutralfile format that allows the digital exchange of information among computer-aideddesign (CAD) systems. Using IGES, a CAD user can exchange product data models in theform of circuit diagrams, wireframe, freeform surface or solid modeling representations.Standards for The Exchange of Product model data (STEP) is also called as ProductDesign Exchange Specification (PDES). This is the standard data format used to store all thedata relevant to the entire life cycle of the product including design, analysis, manufacturingquality assurance, testing and maintenance, in addition to the simple product definition data.

7. Write the scan-conversion process of a straight line in terms of pixel position.

- Digital Differential Analyzer (DDA)
- Floating Point Algorithms

8. Write the mathematical expression to scale a straight line about a fixed point.

I have a log-log graph with a straight line on it, and I want to find the line's equation.The x-axis is scaled as 0.01, 0.1, 1, 10, 100and the y-axis is 10, 100, 1000, 10000.
9. Write any 2 properties of bezier curves.

Bezier curves exhibit a symmetry property: The same Bezier curve shape is obtained ifthe control points are specified in the opposite order. The only difference will be theparametric direction of the curve. The direction of increasing parameter reverses when thecontrol points are specified in the reverse order. Bezier curves are invariant under affinetransformations, but they are not invariant under projective transformations.

10. What is composite transformation?

A composite transformation (or composition of transformations) is two or moretransformations performed one after the other. Sometimes, a composition of transformationsis equivalent to a single transformation.

11. What are the types of parallel projection?

- Isometric projection
- Diametric projection
- Trimetric projection

12. What is color model?

A color model is a system for creating a full range of colors from a small set ofprimary colors. There are two types of color models: additive and subtractive.

13. What is color gamut?

While pure red can be expressed in the RGB color space, it cannot be expressed in theCMYK color space; pure red is out of gamut in the CMYK color space. A device that is ableto reproduce the entire visible color space is an unrealized goal within the engineeringof color displays and printing processes.

Part B

1. Explain about exchanging images?

There are basically three methods of transferring data from one CAD system toanother.

- Direct CAD system export/import
- Direct 3rd party translators.
- Intermediate data exchange formats

Direct internal

Some CAD systems can directly read and/or write other CAD formats, simply byusing file open and file save as options. As most CAD file formats are not open, this option islimited to either system owned by the same company or via hacking of competitor's fileformat.

Direct external

There are a number of companies that specialize in CAD data translation software,providing software that can read one system and write the information in another CADsystem format. These systems have their own proprietary intermediate format some of whichwill allow reviewing the data during translation. Some of these translators work stand-alonewhile others require one or both of the CAD packages installed on the translation machine asthey use code (APIs) from these systems to read/write the data.

Data translation formats

A common method of translation is via an intermediary format. The sending CADsystem exports out to this format and the receiving CAD system reads in this format. Someformats are independent of the CAD vendors being defined by standards organizations whileothers, although owned by a company, are widely used and are regarded as quasi industrystandards. It is becoming increasingly common for companies owning these quasi industrystandards to further the use of their formats by openly publishing these data formats.

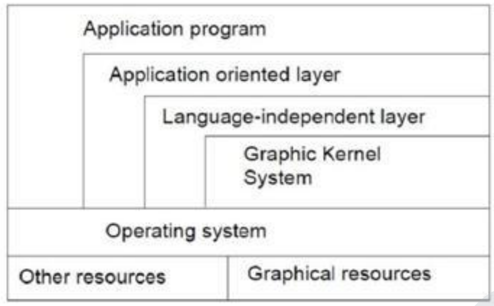
Bitmaps:-

FORMAT NAMES	FILE SUFFIX	COMPRESSED	NOTES
Window bitmap format	BMP	NO	Propriety came into use with window 3
Soft file format	Pcx	YES	Proprietary one of the oldest and most common formats
Tagged image file format	Tifs/tif	OPTIONAL	Widely used especially for desktop publishing
Graphics interchange format	Gif	YES	Widely used in world wide web
Joint photography	Jpeg	YES	Iso/iec 10918 user lossy image compression for max image compression
TARGA file format	TGA	NO	Propriety from true vision the first popular format for high resolution image

2. Graphics Kernel System (GKS)? (May/June 2016)

Graphics Kernal System is the first proposed standard for computer graphics by ISOand ANSI. GKS was developed in to need for a standardized method of developing graphicsprogram. The main objective of the

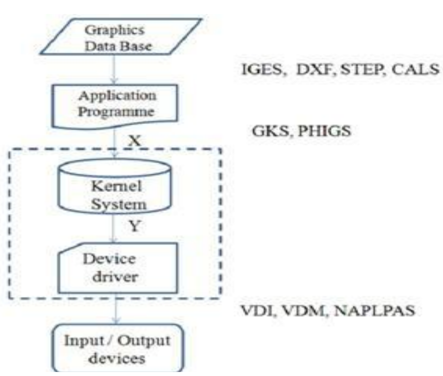
Graphical Kernel System, GKS, is the production andmanipulation of pictures (in a way that does not depend on the computer or graphical devicebeing used). Such pictures vary from simple line graphs (to illustrate experimental results, for
example), to engineering drawings, to integrated circuit layouts (using colour to differentiatebetween layers), to images representing medical data (from computerised tomography (CT)scanners) or astronomical data (from telescopes) in grey scale or colour. Each of these variouspictures must be described to GKS, so that they may be drawn.



In GKS, pictures are considered to be constructed from a number of basic buildingblocks. These basic building blocks, or primitives as they are called, are of a number of typeseach of which can be used to describe a different component of a picture. The five mainprimitives in GKS are:
1. polyline: which draws a sequence of connected line segments.
2. polymarker: which marks a sequence of points with the same symbol.
3. fill area: which displays a specified area.
4. text: which draws a string of characters.
5. cell array: which displays an image composed of a variety of colours or grey scales.
Basic set of primitives
POLYLINE
POLYMARKER
FILLAREA
Example:
X= (2, 5, 3.5, 2) Y= (2, 2, 5, 2)

3. Standards for Computer Graphics?(Nov/Dec 2015)
The following international organizations involved to develop the graphics standards:

- ACM (Association for Computer Machinery)
- ANSI (American National Standards Institute)
- ISO (International Standards Organization)
- GIN (German Standards Institute)



As a result of these international organization efforts, various standard functions atvarious levels of the graphics system developed. These are:

- **IGES** (Initial Graphics Exchange Specification) enables an exchange of model databasis among CAD system.
- **DXF** (Drawing / Data Exchange Format) file format was meant to provide anexact representation of the data in the standard CAD file format.
- **STEP** (Standard for the Exchange of Product model data) can be used to exchangedata between CAD, Computer Aided Manufacturing (CAM) , Computer AidedEngineering (CAE), product data management/enterprise data modeling (PDES) andother CAx systems.
- CALS (Computer Aided Acquisition and Logistic Support) is an US Department ofDefense initiative with the aim of applying computer technology in Logistic support.
- GKS (Graphics Kernel System) provides a set of drawing features for two-dimensionalvector graphics suitable for charting and similar duties.
- PHIGS (Programmer‘s Hierarchical Interactive Graphic System) The PHIGS standarddefines a set of functions and data structures to be used by a programmer tomanipulate and display 3-D graphical objects.
- VDI (Virtual Device Interface) lies between GKS or PHIGS and the device drivercode. VDI is now called CGI (Computer Graphics Interface).
- VDM (Virtual Device Metafile) can be stored or transmitted from graphics device toanother. VDM is now called CGM (Computer Graphics Metafile).
- NAPLPS (North American Presentation- Level Protocol Syntax) describes text andgraphics in the form of sequences of bytes in ASCII code.

4. Write short notes on Drawing exchange format (DXF) standard? (May/June 2016)

Drawing exchange format (DXF) is a file format for graphics information. It is anASME/ANSI standard that is used for PC-based CAD/CAM platforms. DXF enables vectordata exchange as well as 2D and 3D graphics drawing.AutoCAD DXF (Drawing Interchange Format, or Drawing Exchange Format) is a CADdata file format developed by Autodesk for enabling data interoperability between AutoCADand other programs.DXF was originally introduced in December 1982 as part of AutoCAD 1.0, and wasintended to provide an exact representation of the data in the AutoCAD native file format,DWG (Drawing), for which Autodesk for many years did not publish specifications. Becauseof this, correct imports of DXF files have been difficult. Autodesk now publishes the DXF
specifications as a PDF on its website version of AutoCAD from Release 10 (October 1988)and up support both ASCII and binary forms of DXF. Earlier versions support only ASCII.

As AutoCAD has become more powerful, supporting more complex object types, DXFhas become less useful. Certain object types, including ACIS solids and regions, are notdocumented. Other object types, including AutoCAD 2006's dynamic blocks, and the entireobjects specific to the vertical market versions of AutoCAD, are partially documented, butnot well enough to allow other developers to support them. For these reasons many CAD
applications use the DWG format which can be licensed from Autodesk or non-natively fromthe Open Design Alliance.DXF coordinates are always without dimensions so that the reader or user needs to knowthe drawing unit or has to extract it from the textual comments in the sheets.

DXF: Units

DXF file format does not store any information on units. Coordinates are just numbers.So a scaled import can easily be happened. The Layout Editor will assume that the currentsetting of user units had to be used to import/export the DXF. So please adjust the user unitsbefore storing and loading it. Also there a macro to load DXF files, this will ask you for thecorrect units before importing it. Starting with version 20130904 DXF units can be set in theSetup Dialog.

DXF: Handling of layer names

The DXF file format only knows layer names. A numbering of layer like in the GDS format does not exist. By opening a DXF file the Layout Editor analyzed the used layers. If aused layername already exist in the current setup, this layer is used. If the layer name startswith a number, this number is used. Otherwise the first unused layer is renamed.

DXF: save regular polygon as circle

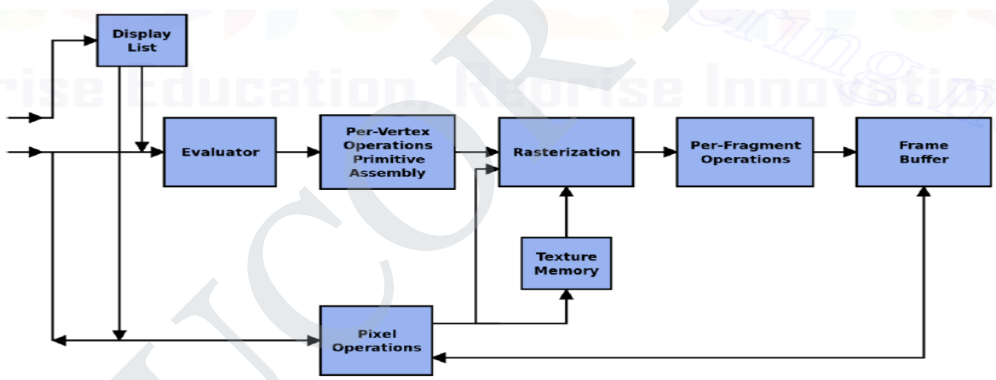
The DXF file format allows handling circles. Circles are not supported by the LayoutEditor as basic elements; circles are stored as regular polygons. By activating this option anyregular polygon with more than 8 points will be saved as a circle element and not as apolygon.

5. Write short notes on (Nov/Dec 2015)

(I) Open GL (ii) IGES (iii) STEP (iv) CALS

(i) Open GL(Nov/Dec 2015)

Open Graphics Library (OpenGL) is a cross-language, cross-platform applicationprogramming interface (API) for rendering 2D and 3D vector graphics. The API is typicallyused to interact with a graphics processing unit (GPU), to achieve hardware-acceleratedrendering.The OpenGL specification describes an abstract API for drawing 2D and 3D graphics.Although it is possible for the API to be implemented entirely in software, it is designed to be implemented mostly or entirely in hardware. Applications use it extensively in the fields ofcomputer-aided design (CAD), virtual reality, scientific visualization, informationvisualization, flight simulation, and video games.



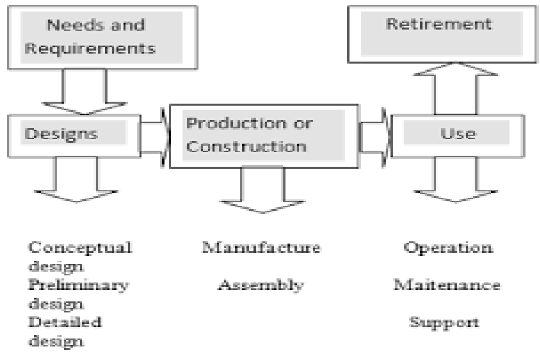
(ii) IGES

Initial Graphics Exchange Specification (**IGES**) is a neutral file format designed totransfer 2D and 3D drawing data between dissimilar CAD systems. The **IGES** standarddefines two file formats: fixed-length ASCII, which stores information in 80-characterrecords, and compressed ASCII.

(iii) STEP

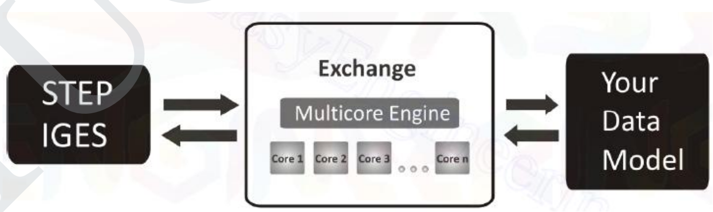
STEP file is a CAD file format, usually used to share 3D models between users withdifferent CAD systems. Standard ISO 10303 is informally known as ―STEP‖, which stands for ―Standard forthe Exchange of Product model data‖. STEP-file (ISO 10303-21) is implementation methodof STEP standard that can represent 3D object in Computer-aided design (CAD) and relatedinformation.

(iv)CALS



"CALS" means "computer-aided logistics support", the word can be an extension of otherwords such as CAD (computer-aided design), CAE (computer-aided engineering), CAM(computer-aided manufacturing), and CIM (computer-integrated manufacturing). All of thosewords contains a word "computer-integrated" or "computer-integrated" before the words thatindicate business processes and very easy to understand together with "CALS". The words"design", "engineering", "manufacturing", and "logistics" are all expressions of businessprocesses, and the aim of CAD, CAE, CAM, CIM, and CALS is to support those businessprocesses by computers to shorten lead times and reduce costs through automation. Comparedto "design", "engineering", and "manufacturing", "logistics" has a broader meaning thatencompasses not only distribution but also functions such as procurementand manufacturing.For that reason, the concept of "CALS" is expanded and regarded as a definitive methodologyfor electronically conducting transactions between companies and some compare "CALS" to"Black Boat" by the image of dominating world industries by the U.S. However, I think that"CALS" strongly indicates "multimedia corporate society in the 21st century", "creation ofnew industrial policies", and "technical infrastructures forcommunications".
Supply Chain Management (SCM) aims to "improvement of corporate management toincrease cash flow" that is built on those technical infrastructures and so it is rathermanagement oriented than technology oriented. Management of throughput improvementthrough improving lead times and service levels of a supply chain includes improvement ofcompany quality to increase company profitability.

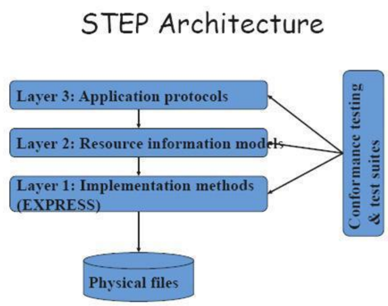
STEP (Standard for the Exchange of Product model Data)



Standard for Exchange of Product Model Data

- Uses a formal model f or data exchange
- Information is modeled using the EXPRESS language
- EXPRESS has elements of Pascal, C, and other languages
- It contains constructs for defining data types and structures, but not fo r processingdata
- EXPRESS describes geometry and other information in a standard, unambiguousWay

Classes of STEP Parts



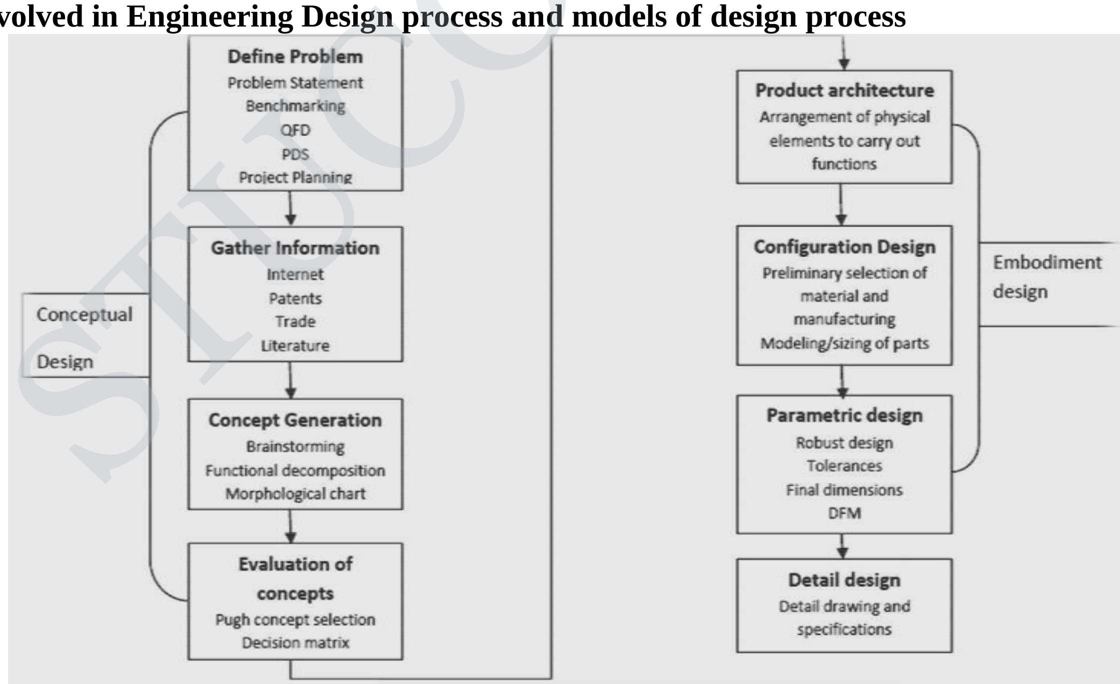
•Introductory

- Description methods
- Implementation methods
- Conformance testing methodology and framework
- Integrated resources
- Application protocols
- Abstract test suites
- Application interpreted constructs

Status of STEP

- STEP has been under development for many years, and willcontinue for many more
- Over a dozen STEP parts have been approved as internationalstandards
- Many others are under development.

1. Steps involved in Engineering Design process and models of design process



Conceptual Design

It is a process in which we in itiate the design and come up with a number of design conceptsand then narrow down to the singl e best concept. This involved the following step s.

(1) *Identification of customer needs*: The mail objective of this is to completely understand the customers‘ needs and to c ommunicate them to the design team
(2) *Problem definition*: The mail goal of this activity is to create a statement that describes what all needs to be accomplished to meet the needs of the customers‘ requirem ents.
(3) *Gathering Information*: In this step, we collect all the information that can be helpful for developing and translating the customers‘ needs into engineering design.
(4) *Conceptualization*: In thi s step, broad sets of concepts are generated th at can potentially satisfy the problem statem ent
(5) *Concept selection*: The main objective of this step is to evaluate the various concepts, modifying and evolving into a single preferred concept.

Embodiment Design

It is a process where the structured development of the design concepts takes place. It is in this phase that decisions are made on strength, material selection, size shape and spatial compatibility. Embodiment design is concerned with three major tasks – product architecture, configuration design, and parametric design.
(1) *Product architecture*: It is concerned with dividing the overall design system in to small subsystems and modules. It is in this step we decide how the physical components of the design are to be arranged in order to combine them to carry out the functional duties of the design.
(2) *Configuration design*: In this process we determine what all features are required in the various parts / components and how these features are to be arranged in space relative to each other.
(3) *Parametric design*: It starts with information from the configuration design process and aims to establish the exact dimensions and tolerances of the product. Also, final decisions on the material and manufacturing processes are done if it has not been fixed in the previous process. One of the important aspects of parametric designs is to examine if the design is robust or not.

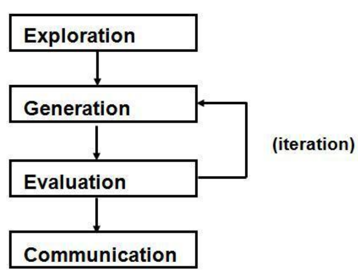
Detail Design

It is in this phase the design is brought to a state where it has the complete engineering description of a tested and a producible product. Any missing information about the arrangement, form, material, manufacturing process, dimensions, tolerances etc of each part is added and detailed engineering drawing suitable for manufacturing are prepared.

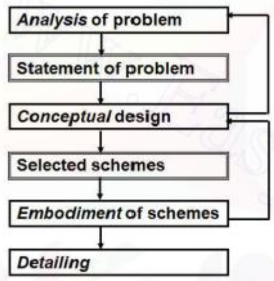
II) Models of the Design Process

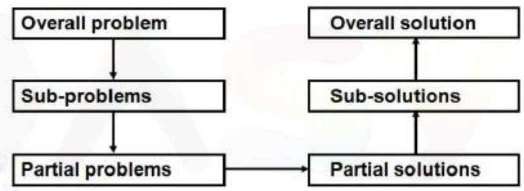
Designers have to:
Explore - the problem ‘territory’
Generate - solution concepts
Evaluate - alternative solution concepts
Communicate - a final proposal

A simple model of the design process, derived from what designers have to do

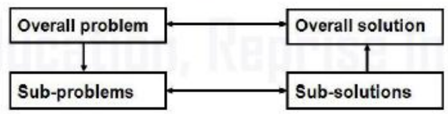


French's model
VDI model





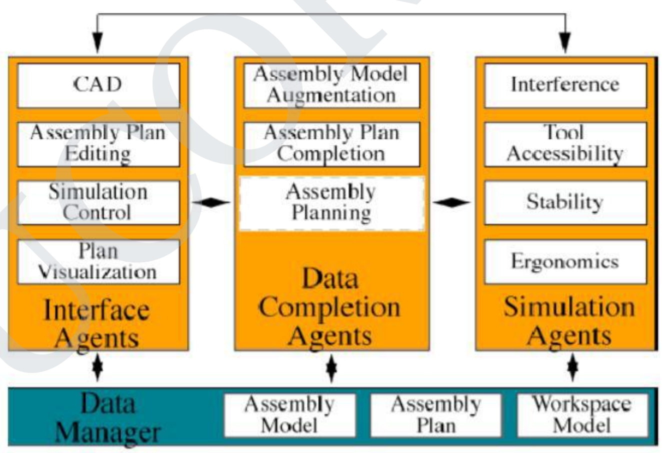
Cross's basic model



2. Draw the layout of Intelligent Assembly modeling and Simulation

The goal of IAM S is to avoid this expensive and time-consuming process byfacilitating semblability checking in a virtual, simulated environment. In addition to par t-part interference checking, the IAMS tool will check for tool accessibility, stability, and ergonomics.

Intelligent Assembly Modeling and Simulation



3. Given the triangle, described by the homogenous points matrix below scale is by afactor ¾ keeping the centroid in the same location use (i) separate matrix method(Nov/Dec2015)

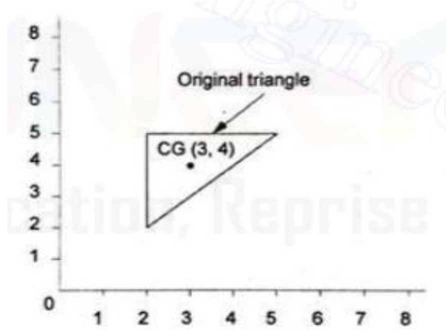


Figure Q3

$$[P] = \begin{bmatrix} 2 & 2 & 0 & 1 \\ 2 & 5 & 0 & 1 \\ 5 & 5 & 0 & 1 \end{bmatrix}$$

The Centroid of the triangle

$x = (2+2+5)/3 = 3$

$y = (2+5+5)/3 = 4$

$z = (0+0+0)/3 = 0$

$\therefore C = (3, 4, 0)$

(i) Seperate matrix method

First the triangle is ~~transfer~~ translated origin (-3 -4)

$$\left.\begin{matrix} \text{Translation matrix} \\ T_{(-3,-4,0)} \end{matrix}\right\} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -3 & -4 & 0 & 1 \end{bmatrix}$$

After translation the given homogenous points

$$[P_1] = [P]\left[T_{(-3,-4,0)}\right]$$

$$[P_1] = \begin{bmatrix} 2 & 2 & 0 & 1 \\ 2 & 5 & 0 & 1 \\ 5 & 5 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -3 & -4 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} -1 & -2 & 0 & 1 \\ -1 & 1 & 0 & 1 \\ 2 & 1 & 0 & 1 \end{bmatrix}$$

b) Second the translated triangle is scale to 3/4

Scaling matrix

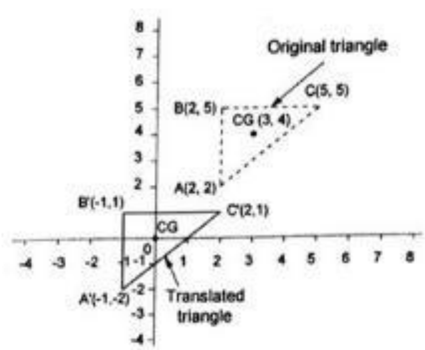
$$= \begin{bmatrix} 0.75 & 0 & 0 & 0 \\ 0 & .75 & 0 & 0 \\ 0 & 0 & 0.75 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

After Scaling the translated triangle matrix becomes

$$[P_2] = [P_1] \left[S_{(.75,\ .75,\ .75)} \right]$$

$$= \begin{bmatrix} -1 & -2 & 0 & 1 \\ -1 & 1 & 0 & 1 \\ 2 & 1 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} .75 & 0 & 0 & 0 \\ 0 & .75 & 0 & 0 \\ 0 & 0 & .75 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} -0.75 & -1.5 & 0 & 1 \\ -0.75 & 0.75 & 0 & 1 \\ 1.5 & .75 & 0 & 1 \end{bmatrix}$$



4. Explain Monte Carlo method in detail?

Monte Carlo methods (or Monte Carlo experiments) are a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results. Their essentiall idea is using randomness to solve problems that might be deterministic in principle. They are often used in physical and mathematical problems and are most useful when it is difficult or impossible to use other approaches. Monte Carlo methods are mainly used in three distinct problem classes optimization, numerical integration, and generating draws from a probability distribution.

In physics-related problems, Monte Carlo methods are useful for simulating systems with many

coupled degrees of freedom, such as fluids, disordered materials, strongly coupled solids, and cellular structures (see cellular Potts model, interacting particle systems, McKean-Vlasov processes, kinetic models of gases). Other examples include modeling phenomena with significant uncertainty in inputs such as the calculation of risk in business and, in math, evaluation of multidimensional definite integrals with complicated boundary conditions. In
application to space and oil exploration problems, Monte Carlo–based predictions of failure, cost overruns and schedule overruns are routinely better than human intuition or alternative "soft" methods.In principle, Monte Carlo methods can be used to solve any problem having a probabilistic interpretation.
The Monte Carlo simulation procedure is described below

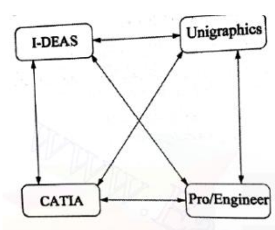
1. Specify the statistical distribution for the variation in each component dimention. The distribution may be described algebraically or empirically.
2. Generate the random number r1
3. Find X1 correspond to r1
4. Repeat step 1 to 3 for all other parts, say n number of parts, in the assembly.
5. Calculate the assembly function Xo=X1 + X2 + X3 + ….+ Xn
6. Calculate mean, standard deviation, median, variance, skewness, kurtosis, max, min, etc.
7. Draw histogram and check the acceptance criteria of assembly.

This simulation can be applied to the solid model of a mechanical assembly. Here, the solid model is used as the assembly function to calculate the assembly resultants. This approach provides the user with a tool for 2D and 3D tolerance simulation. Widely used in tolerance analysis for assemblies which have linear or explicit non linear function.
Limitation:
Large computation time, for the simulation of above three technique are adequate and haveacceptable precision.
Requires explicit assembly function, each assemble variable must be expressed as a singlealgebraic function of the manufactured dimensions of the components in the assembly.

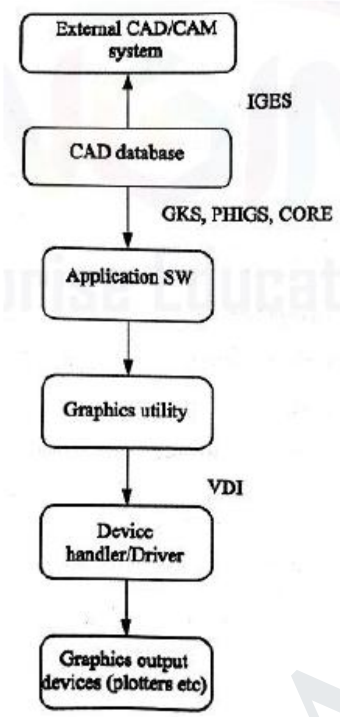
5. Explain communication standards in detail?

Communication standards

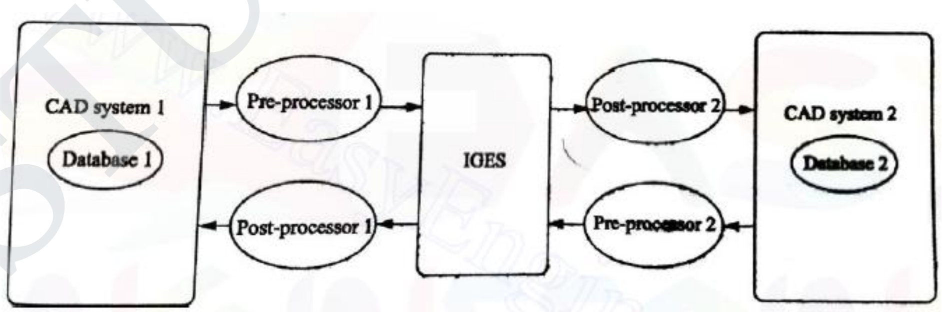
In local area network (LAN) and wide area network (WAN) there are wide variation in physicalmeans such as twisting pairs and coaxial cables, optical fiber links, microwave links in formatused in encoding the data. For successful communication, standards should be well definedLevel of graphics standards communication



Level of graphics standards communication



Level 1: The data is communicated between graphics utility SW and graphics output device.VDI(Virtual Device Interface) or CGI(Computer Graphics Interface) is the most important standard in this category. VDI specified a standard format for transferring GD between graphic sutility and device drives.
Level 2: The data is communicated between applied SW and graphics utility. GKS most universally accepted standard development in W. Germany in 1979. GKS provides interface between application package and graphics utility programs for any CAD system through CORE(American software equivalent to GKS). PHIGS (Programmers Hierarchical Interface for Graphics) has been proposed to eliminate restrictions of GKS
Level 3: The data is communicated between different CAD system such as IGES (Initial Graphics Exchange Specification) and ANSI. Standard format of codes is for CADCAM data. It is completely independent of any system supplier. It enables both graphical and manufacturing data to be transferred between dissimilar systems.



UNIT IV

FUNDAMENTAL OF CNC AND PART PROGRAMMING

1. Define NC system?

NC is defined as a form of programmable automation in which the process iscontrolled by alphanumeric data.

2. What isMCU?

MCU is a hardware system which reads, interprets and translates the programof instructions into mechanical action of machine tool.

3. Define CNC?

CNC is defined as a NC system that utilizes a dedicated, stored computer program to perform some or the entire basic NC functions.

4. Write any four application of NCsystem?

Application are in aero equipment; printed circuit boards; coil winding; automobile parts; and blue print of complex shapes.

5. Define DNC?

Direct numerical control system is defined as a manufacturing system in which a number of machine tools are controlled by a computer through direct connection and in real time.

PART B

1. Write brief notes on NCprocedure

To utilize numerical control in manufacturing, the following steps must be accomplished.

Process Planning: The engineering drawing of the workpart must be interpreted in terms of the manufacturing processes to be used. this step is referred to as process planning and it is concerned with the preparation of a route sheet. The route sheet is a listing of the sequence of operations which must be performed on the work part. It is called a route sheet because it also lists the machines through which the part must be routed in order to accomplish the sequence of operations. We assume that some of the operations will be performed on one or more NC machines.

Part programming: A part programmer plans the process for the portions of the job to be accomplished by NC. Part programmers are knowledgeable about the machining process and they have been trained to program for numerical control. They are responsible for planning the sequence of machining steps to be performed by NC and to document these in a special format. There are two ways to program for NC.

Manual part programming

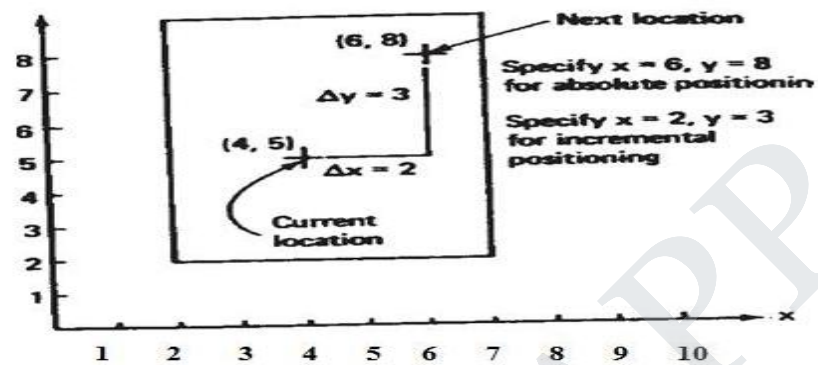
In manual programming, the machining instructions are prepared on a form called a part program manuscript. The manuscript is a listing of the relative cutter/work piece positions which must be followed to machine the part. In computer-assisted part programming, much of the tedious computational work required in manual part programming is transferred to the computer. This is especially appropriate for complex work piece geometries and jobs with many machining steps. Use of the computer in these situations results in significant savings in part programming time.

2. Answer in brief about Fixed zero and floating zero:

The programmer must determine the position of the tool relative to the origin (zero point) of the coordinate system. NC machines have either of two methods for specifying the zero point. The first possibility is for the machine to have a fixed zero. In this case, the origin is always located at the same position on the machine. Usually, that position is the southwest comer (lower left-hand comer)of the table and all tool locations will be defined by positive x and y coordinates.

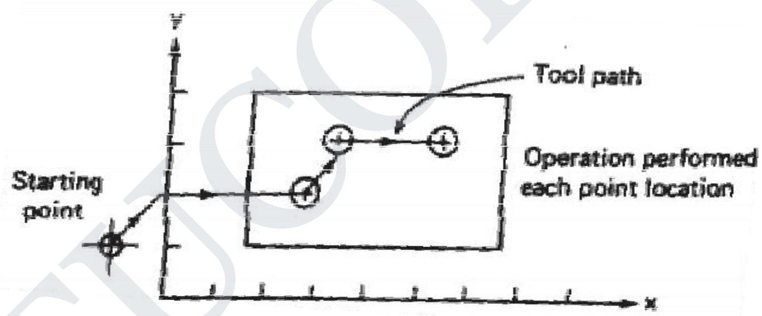
The second and more common feature on modern NC machines allows the machine operator to set the zero point at any position on the machine table. This feature is called floating zero. The part programmer is the one who decides where the zero point should be located. The decision is based on part programming convenience. For example, the work part may be symmetrical and the zero point should be established at the center of symmetry.

Absolute versus incremental positioning



3. Give an brief notes on Straight-cutNC

Straight-cut control systems are capable of moving the cutting tool parallel to one of the major axes at a controlled rate suitable for machining. It is therefore appropriate for performing



Milling operations to fabricate work pieces of rectangular configurations. With this type of NC system it is not possible to combine movements in more than a Single axis direction. Therefore, angular cuts on the work piece would not be possible. An example of a straight-cut operation is shown in Figure

4. Write down the application of Numerical control systems.

Numerical control systems are widely used in industry today, especially in the metalworking industry. By far the most common application of NC is for metal cutting machine tools. Within this category, numerically controlled equipment has been built to perform virtually the entire range of material removal processes, including: Milling, Drilling and related processes Boring, Turning, Grinding, Sawing

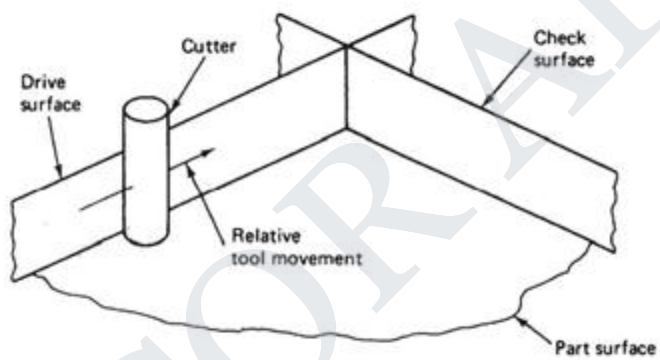
Within the machining category, NC machine tools are appropriate for certain jobs and inappropriate for others. Following are the general characteristics of production jobs in metal machining for which numerical control would be most appropriate:

- Parts are processed frequently and in small lot sizes.
- The part geometry is complex.
- Many operations must be performed on the part in its processing.

- Much metal needs to be removed.
- Engineering design changes are likely.
- Close tolerances must be held on the work part.
- It is an expensive part where mistakes in processing would be costly.
- The parts require l00% inspection

5. Write a short notes on Contouring motions.

Contouring commands are somewhat more complicated because the tool's position must be continuously controlled throughout the move. To accomplish this control, the tool is directed along two intersecting surfaces as shown in Figure 8.lO. These surfaces have very specific names in APT:
l. Drive surface. This is the surface (it is pictured as a plane in Figure 8.lO) that guides the side of the cutter.
Part surface. This is the surface (again shown as a plane in the figure) on which the bottom of the cutter rides. The reader should note that the "part surface" mayor may not be an actual surface of the work part. The part programmer must define this plus the drive surface for the purpose of maintaining continuous path control of the tool. There is one additional surface that must be defined for APT contouring motions.



Three surfaces in APT contouring motions which guide the cutting tool.

6. What are the steps involved in NC procedure. NC procedure

To utilize numerical control in manufacturing, the following steps must be accomplished.

- ***Process Planning.*** The engineering drawing of the work part must be interpreted in terms of the manufacturing processes to be used. This step is referred to as process planning and it is concerned with the preparation of a route sheet. The route sheet is a listing of the sequence of operations which must be performed on the work part. It is called a route sheet because it also lists the machines through which the part must be routed in order to accomplish the sequence of operations. We assume that some of the operations will be performed on one or more NC machines.
- ***Part programming.*** A part programmer plans the process for the portions of the job to be accomplished by NC. Part programmers are knowledgeable about the machining process and they have been trained to program for numerical control. They are responsible for planning the sequence of machining steps to be performed by NC and to document these in a special format. There are two ways to program for NC:

Manual part programming

Computer-assisted part programming

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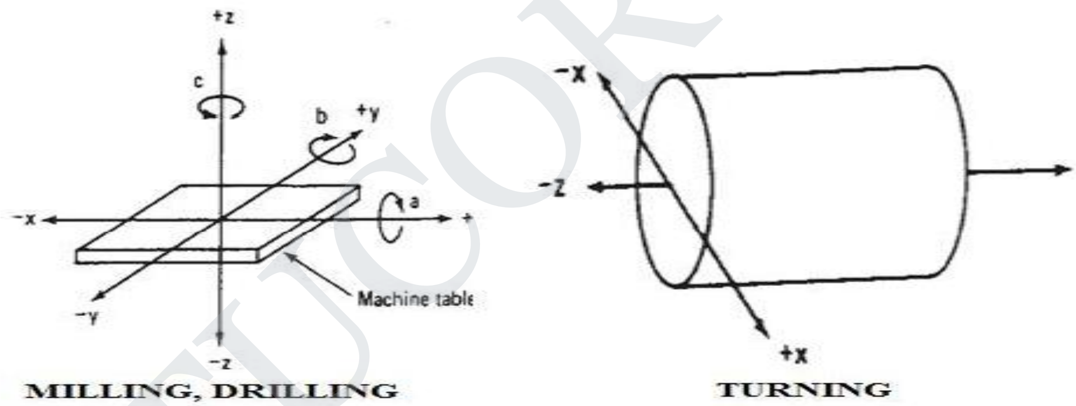
***Tape preparation*:** A punched tape is prepared from the part programming NC process plan in manual part programming, the punched tape is prepared directly from the part program manuscript on a type writerlike device equipped with tape punching capability. In computer-assisted part programming, the computer interprets the list of part programming instructions, performs the necessary calculations to convert this into a detailed set of machine tool motion commands, and then controls a tape punch device to prepare the tape for the specific NC machine.

Tape verification. After the punched tape has been prepared, a method is usually provided for checking the accuracy of the tape. Sometimes the tape is checked by running it through a computer program which plots the various tool movements (or table movements) on paper. In this way, major errors in the tape can be discovered. The "acid test" of the tape involves trying it out on the machine tool to make the part. A foam or plastic material is sometimes used for this tryout. Programming errors are not uncommon, and it may require about three attempts before the tape is correct and ready to use.

Production. The final step in the NC procedure to use the NC tape in production. This involves ordering the raw workparts specifying and preparing the tooling and any special fixturing that may be required, and setting up The NC machine tool for the job. The machine tool operator's function during production is to load the raw workpart in the machine and establish the starting position of the cutting tool relative to the workpiece. The NC system then takes over and machines the part according to the instructions on tape. When the part is completed, the operator removes it from the machine and loads the nextpart.

8. With neat diagram draw andexplain

NC COORDINATE SYSTEMS



The programmer must determine the position of the tool relative to the origin (zero point) of the coordinate system. NC machines have either of two methods for specifying the zero point. The first possibility is for the machine to have a fixed zero. In this case, the origin is always located at the same position on the machine. Usually, that position is the southwest comer (lower left-hand comer) of the table and all tool locations will be defined by positive x and y coordinates.

The second and more common feature on modern NC machines allows the machine operator to set the zero point at any position on the machine table. This feature is called **floating zero**. The part programmer is the one who decides where the zero point should be located. The decision is based on part programming convenience. For example, the work part may be symmetrical and the zero point should be established at the center of symmetry.

Another option sometimes available to the part programmer is to use either an absolute system of tool positioning or an incremental system. Absolute positioning means that the tool locations are always defined in relation to the zero point. If a hole is to be drilled at a spot that is 8 in. above the x axis and 6in. to the right of the y axis, the coordinate location of the bole would be specified as x = +6.OOO and y = +8.OOO. By contrast, incremental positioning means that the next tool location must be defined with reference to the previous tool location. If in our drilling example, suppose that the previous hole had been drilled at an absolute position of x = +4.OOO and y=+5.OOO. Accordingly, the incremental position instructions would be specified as x = +2.OOO and y= +3.OOO in order to move the drill to the desired spot. Figure illustrates the difference between absolute and incremental positioning.

9. What are the various types of motion control system

In order to accomplish the machining process, the cutting tool and workpiece must be moved relative to each other. In NC, there are three basic types of motion control systems: -

- Point-to-point
- Straight cut
- Contouring

Point-to-point NC

Point-to-point (PTP) is also sometimes called a positioning system. In PTP, the objective of the machine tool control system is to move the cutting tool to a predefined location. The speed or path by which this movement is accomplished is not import in point-to-point NC. Once the tool reaches the desired location, the machining operation is performed at that position.

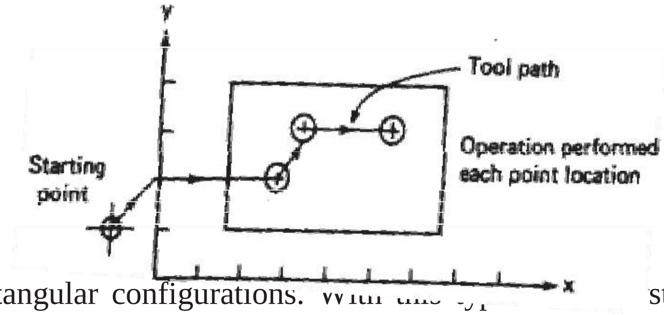
NC drill presses are a good example of PTP systems. The spindle must first be positioned at a particular location on the work piece. This is done under PTP control. Then the drilling of the hole is performed at the location, and so forth. Since no cutting is performed between holes, there is no need for controlling the relative motion of the tool and work piece between hole locations. Figure illustrates the point-to-point type of control.

Positioning systems are the simplest machine tool control systems and are therefore the least expensive of the three types. However, for certain processes, such as drilling operations and spot welding, PIP is perfectly suited to the task and any higher level of control would be unnecessary.

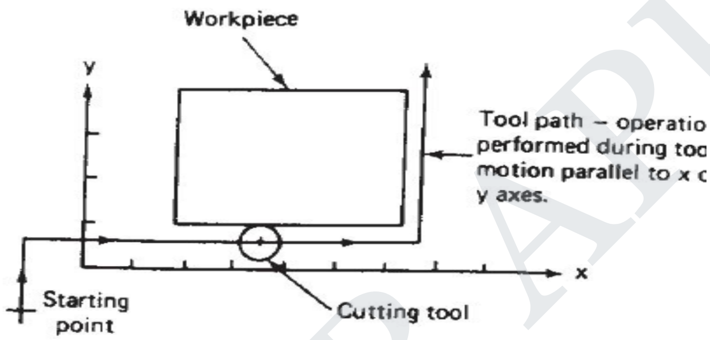
Straight-cut NC

Straight-cut control systems are capable of moving the cutting tool parallel to one of the major axes at a controlled rate suitable for machinin to fabricate workpieces of rectangular configurations. With this type of NC system it is not possible to combine movements in more than a Single axis direction. Therefore, angular cuts on the workpiece would not be possible. An example of a straight-cut operation is shown in Figure

Straight-cut system



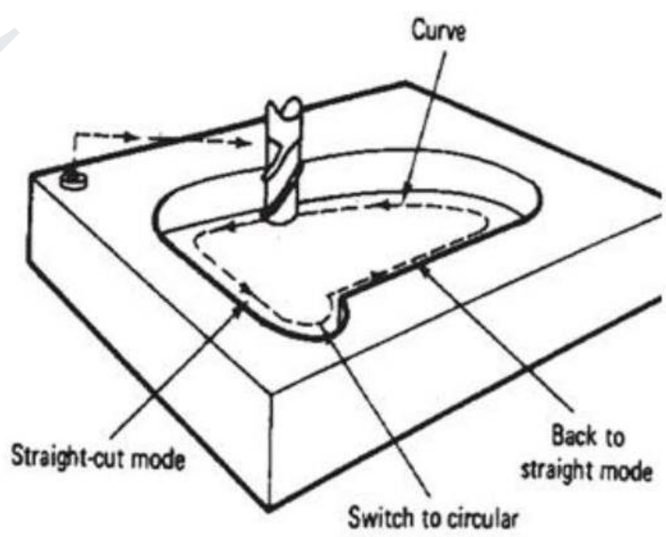
To fabricate work pieces of rectangular configurations. With this type of system it is not possible to combine movements in more than a Single axis direction. Therefore, angular cuts on the work piece would not be possible. An example of a straight-cut operation is shown in Figure



Straight-cut system

Contouring NC

Contouring is the most complex, the most flexible, and the most expensive type of machine tool control. It is capable of performing both PTP and straight-cut operations. In addition, the distinguishing feature of contouring NC systems is their capacity for simultaneous control of more than one axis movement of the machine tool. The path of the cutter is continuously controlled to generate the desired geometry of the work piece. For this reason, contouring systems are also called continuous-path NC systems.



Straight or plane surfaces at any orientation, circular paths, conical shapes, or most any other mathematically definable form are possible under contouring control. Figure illustrates the versatility of continuous path NC.

10. Write down the application of the numerical control

APPLICATIONS OF NUMERICAL CONTROL

Numerical control systems are widely used in industry today, especially in the metalworking industry. By far the most common application of NC is for metal cutting machine tools. Within this category, numerically controlled equipment has been built to perform virtually the entire range of material removal processes, including:

Milling, Drilling and related processes Boring, Turning, Grinding, Sawing Within the machining category, NC machine tools are appropriate for certain jobs and inappropriate for others. Following are the general characteristics of production jobs in metal machining for which numerical control would be most appropriate:

Parts are processed frequently and in small lot sizes.

The part geometry is complex.

Many operations must be performed on the part in its processing.

Much metal needs to be removed.

Engineering design changes are likely.

Close tolerances must be held on the workpart.

It is an expensive part where mistakes in processing would be costly.

The parts require lOO% inspection

It has been estimated that most manufactured parts are produced in lot sizes of 5O or fewer. Small-lot and batch production jobs represent the ideal situations for the application of NC. This is made possible by the capability to program the NC machine and to save that program for subsequent use in future orders. If the NC programs are long and complicated (complex part geometry, many operations, much metal removed), this makes NC all the more appropriate when compared to manual methods of production. If engineering design changes or shifts in the production schedule are likely, the use of tape control provides the flexibility needed to adapt to these changes. Finally, if quality and inspection are important issues (close tolerances, high part cost, lOO% inspection required), NC would be most suitable, owing to its high accuracy and repeatability.

In order to justify that a job be processed by numerical control methods, it is not necessary that the job possess every one of these attributes. However, the more of these characteristics that are present, the more likely it is that the part is a good candidate for NC.

In addition to metal machining, numerical control has been applied to a variety of other operations. The following, although not a complete list, will give the reader an idea of the wide range of potential applications of NC Press working machine tools Welding machines Inspection machines Automatic drafting Assembly machines. Tube bending Flame cutting Plasma arc cutting Laser beam processes Automated knitting machines Cloth cutting Automatic riveting Wire-wrap machine.

Advantages of NC

Following are the advantages of numerical control when it is utilized in the type of production jobs described.

l. *Reduced nonproductive time*. Numerical control has little or no effect on the basic metal, cutting (or other manufacturing) process. However; NC can increase the proportion of time the machine is engaged in the actual process. It accomplishes this by means of fewer setups, less time in setting up, reduced work piece handling time, automatic tool changes on some machines, and so on.

In a University of Michigan survey reported by Smith and Evans, a comparison was made between the machining cycle times for conventional machine tools versus the cycle times for NC machines. NC cycle times, as a percentage of their conventional counterparts, ranged from 35% for five-axis machining centers to 65% for presswork punching. The advantage for numerical control tends to increase with the more complex processes.

Reduced fixturing. NC requires fixtures which are simpler and less costly to fabricate because the positioning is done by the NC tape rather than the jig or fixture

Reduced manufacturing lead time. Because jobs can be set up more quickly with NC and fewer setups are generally required with NC, the lead time to deliver a job to the customer is reduced.

Greater manufacturing flexibility. With numerical control it is less difficult to adapt to engineering design changes alterations of the production schedule, changeovers in jobs for rush orders, and so on.

Improved quality control. NC is ideal for complicated workparts where the chances of human mistakes are high. Numerical control produces parts with greater accuracy, reduced scrap, and lower inspection requirements. Reduced inventory. Owing to fewer setups and shorter lead times with numerical control, the amount of inventory carried by the company is reduced.

Reduced floor space requirements. Since one NC machining center can often accomplish the production of several conventional machines, the amount of floor space required in an NC shop is usually less than in a conventionalshop.

Disadvantages of NC

Along with the advantages of NC, there are several features about NC which must be considered disadvantages:

Higher investment cost. Numerical control machine tools represent a more sophisticated and complex technology. This technology costs more to buy than its non-NC counterpart. The higher cost requires manufacturing managements to use these machines more aggressively than ordinary equipment.

High machine utilization is essential on order to get reasonable returns on investment. Machine shops must operate their NC machines two or three sifts per day to achieve this high machine utilization.

Higher maintenance cost. Because NC is a more complex technology and because NC machines are used harder, the maintenance problem becomes more acute. Although the reliability of NC systems has been improved over the years, maintenance costs for NC machines will generally be higher than for conventional machine tools.

Finding and/or training NC personnel. Certain aspects of numerical control shop operations require a higher skill level than conventional operations. Part programmers and NC maintenance personnel are two skill areas where available personnel are in short supply. The problems of finding, hiring, and training these people must be considered a disadvantage to the NC shop.

11. Explain detailly about NC part programming methods

Following is a list of the different types of words in the formation of a block. Not very NC machine uses all the words. Also, the manner in which the words are expressed will differ between machines. By convention, the words in a block are given in the following order:

SEQUENCE NUMBER (n-words): This is used to identify the block.

PREPARATORY WORD (g-words): This word is used to prepare the controller for instructions that are to follow. For example, the word gO2 is used to prepare the C controller unit for circular interpolation along an arc in the clockwise direction. The preparatory word l& needed S9 that the controller can correctly interpret the data that follow it in the block.

COORDINATES (x-, y-, and z-words): These give the coordinate positions of the tool. In a two-axis system, only two of the words would be used. In a four- or five- axis machine, additional a- words and V or b-words would specify the angular positions.

Although different NC systems use different formats for expressing a coordinate, we will adopt the convention of expressing it in the familiar decimal form: For example, x + 7.235 ory-O.5ao. Some formats do not use the decimal point in writing the coordinate. The + sign to define a positive coordinate location is optional. The negative sign is, of **FEED RATE** (f-word): This specifies the feed in a machining operation. Units are inches per minute (ipm) by convention.

CUTTING SPEED (s-word): This specifies the cutting speed of the process, the rate at which the spindle rotates.

TOOL SELECTION (t-word): This word would be needed only for machines with a tool turret or automatic tool changer. The t-word specifies which tool is to be used in the operation. For example, tO5 might be the designation of a l/2-in. drill bit in turret position 5 on an NC turret drill.

MSCELLANEOUS FUNCTION (m-word): The m-word is used to specify certain miscellaneous or auxiliary functions which may be available on the machine tool.

UNIT-V
CELLULAR MANUFACTURING AND FLEXIBLE MANUFACTURING SYSTEMS (FMS)

PART –A

1. What are the activities of CAM?

   A CAM activity includes process planning, NC part programming, production scheduling, and computer production monitoring and computer process control.

2. In what way CIM differs from CAD/CAM?

   A CIM includes all of the engineering function of CAD/CAM, but it also includes the firm"sbusiness functions that are related to manufacturing.

3. What is group technology?

   Group technology is a manufacturing philosophy in which similar parts are identified and grouped together to get the advantages of similarities in both design and manufacturing attributes.

4. What is meant by part family?

   Part family is a collection of parts which are similar either because of geometric shape or because of similar steps that are required in their manufacture.

5. What is meant by PFA method?

   Production flow analysis is a method for identifying part families and associated machine groupings that uses the information contained on production route sheets rather than on part drawings.

6. What is FMS?

   FMS is a manufacturing system based on multi-operation machine tools, incorporating (automatic part handling and storage).

7. What is Process planning?

   Process planning consists of preparing a set of instructions that describe how to fabricate a part or build an assembly which will satisfy engineering design specifications. Process planning is the systematic determination of the methods by which product is to be manufactured, economically and competitively.

8. Which is ideal state in computer based manufacturing applications?

   Computer Integrated Manufacturing (CIM) is an ideal state in which computer based manufacturing applications communicate information to coordinate design, planning and manufacturing processes.

9. What is the role of process planning in CIM architecture?

   The process planning function can ensure the profitability or non profitability of a part being manufactured because of the myriad ways in which apart can be produced.

10. List the applications of FMSs.

    Applications of FMS installations are in the following areas.

    Machining Assembly

Sheet-metal press-working Forging

Plastic injection molding

PART –B

1. Give an brief account on partfamily.

A part family is a collection of parts which are similar either because of geometric shape and size or because similar processing steps are required in their manufacture. The parts within a family are different, but their similarities are close enough to merit their identification as members of the part family.

The various machine tools are arranged by function. There is a lathe section, milling machine section, drill press section, and so on. During the machining of a given part, the workpiece must be moved between sections, with perhaps the same section being visited several times. This results in a significant amount of material handling, a large in-process inventory, usually more setups than necessary, long manufacturing lead times, and high cost. Figure shows a production shop of supposedly equivalent capacity, but with the machines arranged into cells. Each cell is organized to specialize in the manufacture of a particular part family.

2. Describe automated process planning.

Because of the problems encountered with manual process planning, attempts have been made in recent years to capture the logic, judgment, and experience required for this important function and incorporate them into computer programs. Based on the characteristics of a given part, the program automatically generates the manufacturing operation sequence. A computer-aided process planning (CAPP) system offers the potential for reducing the routine clerical work of manufacturing engineers. At the same time, it provides the opportunity to generate production routings which are rational, consistent, and perhaps even optimal. Two alternative approaches to computer-aided process planning have been developed. Thes eare:

- Retrieval-type CAPP systems (also called variant systems)
- Generative CAPP systems

3. What are the BENEFITS OF CAPP?

Whether it is a retrieval system or a generative system, computer-aided process planning offers a number of potential advantages over manually oriented process planning.

Process rationalization. Computer-automated preparation of operation routings is more likely to be consistent, logical, and optimal than its manual counterpart. The process plans will be consistent because the same computer software is being used by all planners. The process plans tend to be more logical and optimal because the company has presumably incorporated the experience and judgment of its best manufacturing people into the process planning computer software.

Increased productivity of process planners. With computer-aided process planning, there is reduced clerical effort, fewer errors are made, and the planners have immediate access to the process planning data base. These benefits translate into higher productivity of the process planners. One system was reported to increase productivity by 6OO% in the process planning function.

Reduced turnaround time. Working with the CAPP system, the process planner is able to prepare a route sheet for a new part in less time compared to manual preparation. "Ibis leads to an overall reduction in manufacturing lead time.

Improved legibility. The computer-prepared document is neater and easier to read than manually written route sheets. CAPP systems employ standard text, which facilitates interpretation of the process plan in the factory.

In corporation of other application programs. The process planning system can be designed to operate in conjunction with other software packages to automate many of the time- consuming manufacturing support functions.

4. Write a short notes on aggregate planning.

It is a high-level corporate planning activity. The aggregate production plan indicates production output levels for the major product lines of the company. The aggregate plan must be coordinated with the plans of the sales & marketing departments. Because the aggregate production plan includes products that are currently in production, it must also consider the present & future inventory levels of those products & their component parts. Because new products currently being developed will also be included in the aggregate plan, the marketing plans & promotions for current products & new products must be reconciled against the total capacity resources available to the company.

The production quantities of the major product lines listed in the aggregate plan must be converted into a very specific schedule of individual products, known as the master production schedule (MPS). It is a list of products to be manufactured, when they should be completed & delivered, &it what quantities. A hypothetical MPS for a narrow product set is presented in the table, showing how it is derived from the corresponding aggregate plan in the 2nd table. The master schedule must be based on an accurate estimate of demand & a realistic assessment of the company’s production schedule.

5. How MRP Works?

The MRP processor operates on data contained in the MPS, the BOM file, and the inventory record file. The master schedule specifies the period-by period list of final products required. The BOM define what material and components are needed for each Product and inventory record files gives the current and future inventory status of each product, component, and material. The MRP processor computers how many of each component and raw material are needed each period by " exploding " the end product requirements into successively lower levels in the product structure.

Several complicating factors must be considered during the MRP computations. First the quantities of component and subassemblies listed in the solution of Example 25.1 do not account for any of those items that may already be stocked in inventory or are expected to be received as future order. Accordingly, the computed quantities must be adjusted for any inventories on hand or on order, a procedure called netting. For each time bucket, net requirements = gross requirements less on hand inventories and less quantities on order.

Second, quantities of common use items must be combined during parts explosion to determine the total quantities required for each component and raw material in the schedule. Common use items are raw materials and components that are used on more than one product. MRP collects these common use items from different products to achieve economics in ordering the raw materials and producing the components.

6. Give an detail account on Group technology layout.

The set of similar components can be called as a part family. Since all family members require similar processes, a machine cell can be built to manufacture the family. This makes production planning and control much easier because only similar components are considered for each cell. Such a cell-oriented layout is called a group-technology layout or cellular layout.

Advantages are gained in group-technology layout Reduced work piece handling

- Lower setup times.
- Less in-process inventory.
- Less floor space, and shorter lead times.

Some of the manufacturing cells can be designed to form production flow lines, with conveyors used to transport work parts between machines in the cell.

The three methods for grouping parts into families are:

1. Visual inspection method. 2.Production flow analysis (PFA). 3.Parts classification and codingsystem.

Visual inspection method:

It is the least sophisticated and least expensive method. It involves the classification of parts into families by looking at either the physical parts or photographs and arranging them into similar groupings. This method is generally considered to be the least accurate of the three.

Production flow analysis (PFA):

The second method, production flow analysis, was developed by J. L. Burbidge. PFA is a method of identifying part families and associated machine tool groupings by analyzing the route sheets for parts produced in a given shop. It groups together the parts that have similar operation sequences and machine routings.

The disadvantage of PFA is that it accepts the validity of existing route sheets, with no consideration given to whether these process plans are logical or consistent. The production flow analysis approach does not seem to be used much at all in the United States.

Parts classification and coding

This method of grouping parts into families involves an examination of the individual design and/or manufacturing attributes of each part. The attributes of the part are uniquely identified by means of a code number. This classification and coding may be carried out on the entire list of active parts of the firm, or a sampling process may be used to establish the partfamilies.

Many parts classification and coding systems have been developed throughout the world, and there are several commercially available packages being sold to industrial concerns.

7.Explain the MICLASS System?

MICLASS stands for Metal Institute Classification System and was developed by TNO, the Netherlands Organization for Applied Scientific Research. It was started in Europe about five years before being introduced in the United States in l974. Today, it is marketed in the United States by the Organization for Industrial Research in Waltham, Massachusetts. The MICLASS system was developed to help automate and standardize a number of design, production, and management functions. These include:

Standardization of engineering drawings

Retrieval of drawings according to classification number Standardization of process routing

Automated process planning

Selection of parts for processing on particular groups of machine tools Machine tool investment analysis

The MICLASS classification number can range from l2 to 3O digits. The first l2 digits are a universal code that can be applied to any part. Up to l8 additional digits can be used to code data that are specific to the particular company or industry. For example, lot size, piece time, cost data, and operation sequence might be included in the l8 supplementary digits.

The CODE system

The CODE system is a parts classification and coding system developed and marketed by Manufacturing Data Systems, Inc. (MDSI), of Aim Arbor, Michigan. Its most universal application is in design engineering for retrieval of part design data, but it also has applications in manufacturing process planning, purchasing, tool design, and inventory control.

The CODE number has eight digits. For each digit there are l6 possible values (zero through 9 and A through F) which are used to describe the part's design and manufacturing characteristics. The initial digit position indicates the basic geometry of the part and is called the Major Division of the CODE system. This digit would be used to specify whether the shape was a cylinder, flat piece, block, or other. The interpretation of the remaining seven digits depends on the value of the first digit, but these remaining digits form a chain-type structure. Hence the CODE system possesses a hybrid structure.

8. Explain various types of planning function?

Process planning is concerned with determining the sequence of individual manufacturing operations needed to produce a given part or product. The resulting operation sequence is documented on a form typically referred to as a route sheet. The route sheet is a listing of the production operations and associated machine tools for a work part or assembly.

Traditional process planning

There are variations in the level of detail found in route sheets among different companies and industries.

The following steps describing each operation and identifying each work center. In any case, it is traditionally the task of the manufacturing engineers or industrial engineers in an organization to write these process plans for new part designs to be produced by the shop. The process planning procedure is very much dependent on the experience and judgment of the planner. It is the manufacturing engineer's responsibility to determine an optimal routing for each new part design. However, individual engineers each have their own opinions about what constitutes the best routing. Accordingly, there are differences among the operation sequences developed by various planners. We can illustrate rather dramatically these differences by means of an example.

In one case cited, a total of 42 different routings were developed for various sizes of a relatively simple part called an "expander sleeve." There were a total of 64 different sizes and styles, each with its own part number. The 42 routings included 2O different machine tools in the shop.

The reason for this absence of process standardization was that many different individuals had worked on the parts: 8 or 9 manufacturing engineers, 2 planners, and 25 NC part programmers. Upon analysis, it was determined that only two different routings through four machines were needed to process the 64 part numbers. It is clear that there are potentially great differences in the perceptions among process planners as to what constitutes the "optimal" method of production.

In addition to this problem of variability among planners, there are often difficulties in the conventional process planning procedure. New machine tools in the factory render old routings less than optimal. Machine breakdowns force shop personnel to use temporary routings, and these become the documented routings even after the machine is repaired. For these reasons and others, a significant proportion of the total number of process plans used in manufacturing are not optimal.

Automated process planning

Because of the problems encountered with manual process planning, attempts have been made in recent years to capture the logic, judgment, and experience required for this important function and incorporate them into computer programs. Based on the characteristics of a given part, the program automatically generates the manufacturing operation sequence. A computer-aided process planning (CAPP) system offers the potential for reducing the routine clerical work ofmanufacturingengineers. At the same time, it provides the opportunity to generate production routings which are rational, consistent, and perhaps even optimal. Two alternative approaches to computer-aided process planning have been developed. These are:

Retrieval-type CAPP systems (also called variant systems)
Generative CAPP systems

9. Draw and explain Retrieval type CAPP system and Generative CAPPsystem?

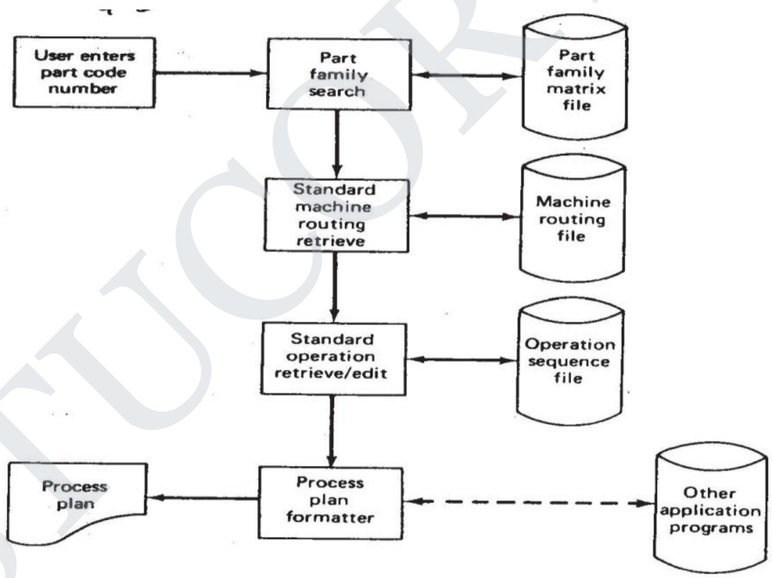
RETRIEVAL - TYPE PROCESS PLANNING SYSTEMS

Retrieval-type CAPP systems use parts classification and coding and group technology as a foundation. In this approach, the parts produced in the plant are grouped into part families, distinguished according to their manufacturing characteristics. For each part family, a standard process plan is established. The standard process plan is stored in computer files and then retrieved for new work parts which belong to that family. Some form of parts classification and coding system is required to organize the computer files and to permit efficient retrieval of the appropriate process plan for a new work part. For some new parts, editing of the existing process plan may be required. This is done when the manufacturing requirements of the new part are slightly different from the standard. The machine routing may be the same for the new part, but the specific operations required at each machine may be different. The complete process plan must document the operations as well as the sequence of machines through which the part must be routed. Because of the alterations that are made in the retrieved process plan, these CAPP systems are sometimes also called by the name' 'variant system."

Figure will help to explain the procedure used in a retrieval process planning system. The user would initiate the procedure by entering the part code number at a computer terminal. The CAPP program then searches the part family matrix file to determine if a match exists. If the file contains an identical code number, the standard machine routing and operation sequence are retrieved from the respective computer files for display to the user. The standard process plan is examined by the user to permit any necessary editing of the plan to make it compatible with the new part design. After editing, the process plan formatter prepares the paper document in the properform.

If an exact match cannot be found between the code numbers in the computer file and
The code number for the new part, the user may search the machine routing file and the operation sequence file for similar parts that could be used to develop the plan for the new part. Once the process plan for a new part code number has been entered, it becomes the standard process for future parts of the same classification.

GENERATIVE PROCESS PLANNING SYSTEMS



Information flow in a retrieval-type computer-aided process planning system.

Generative process planning involves the use of the computer to create an individual process plan from scratch, automatically and without human assistance. The computer would employ a set of algorithms to progress through the various technical and logical decisions toward a final plan for manufacturing. Inputs to the ~ tern would include a comprehensive description of the work part. This may involve the use of some form of part code number to summarize the work part data, but does not involve the retrieval of existing standard plans. Instead, the general CAPP system synthesizes the design of the optimum process sequence, based an analysis of part geometry, material, and other factors which would influence manufacturing decisions.

In the ideal generative process planning package, any part design could presented to the system for creation of the optimal plan. In practice, cu generative- type systems are far from universal in their applicability. They after fall short of a truly generative capability, and they are developed for a some limited range of manufacturing processes.

10. Explain machinability data system?

A machinability data base system, which forms a part of the common manufacturing data base and is also capable of adapting and optimizing the machining data, is an important component of automated manufacturing systems. A generative type machinability data base system is proposed for automating the adaptation and optimization of the machining data. A typical machining problem is formulated and analyzed to illustrate the proposed adaptive optimization methodology.

Aggregate planning: It is a high-level corporate planning activity. The aggregate production plan indicates production output levels for the major product lines of the company. The aggregate plan must be coordinated with the plans of the sales & marketing departments. Because the aggregate production plan includes products that are currently in production, it must also consider the present & future inventory levels of those products & their component parts. Because new products currently being developed will also be included in the aggregate plan, the marketing plans & promotions for current products & new products must be reconciled against the total capacity resources available to the company.

The production quantities of the major product lines listed in the aggregate plan must be converted into a very specific schedule of individual products, known as the master production schedule (MPS). It is a list of products to be manufactured, when they should be completed & delivered, &it what quantities.

Master Production Schedule

Products included in the MPS divide into 3 categories: (1) firm customer orders, (2) forecasted demand, & (3) spare parts. Proportions in each category vary for different companies, &in some cases one or more categories are omitted. Companies producing assembled products will generally have to handle all three types. In the case of customer orders for specific products, the company is usually obligated to deliver the item by a particular date that has been promised by the sales department. In the second category, production output quantities are based on statistical forecasting techniques applied to previous demand patterns, estimates by the sales staff, & other sources. For many companies forecasted demand constitutes the largest portion of the master schedule. The third category consists of repair parts that eithe will be stocked in the companys servies department or sent directly to the customer. Some companies exclude this third category from the master schedule since it does not represent end products.

The MPS is generally considered to be a medium-range plan since it must take into account the lead times to order raw materials & components, produce parts in the factory, & then assemble the end products. Depending on the product, the lead times can range from several weeks to many months; in some cases, more than a year. The MPS is usually considered to be fixed in the near term. This means that changes are not allowed within about a six week horizon because of the difficulty in adjusting production schedules within such a short period. However, schedule adjustments are allowed beyond six weeks to cope with changing demand patterns or the introduction of new products. Accordingly, we should note that the aggregate production plan is not the only input to the master schedule. Other inputs that may cause the master schedule to depart from the aggregate plan include new customer orders & changes in sales forecast over the near term.

11. Give an detail account of Flexible manufacturing system and FMS components.

Group of processing stations inter connected by means of a automated material handling and storage system, and controlled by an integrated computer system.

The guided vehicles are used as the materials handling system in the FMS. The vehicles deliver work from the staging area (where work is placed on pallet fixtures, usually, manually) to the individual workstations in the system. The vehicles also move work between stations in the manufacturing system. At a workstation, the work is transferred from the vehicle platform into the work area of the station (usually, the table of a machine tool) for processing. At the completion of processing by that station a vehicle returns to pick up the work and transport it to the next area. AGV systems provide a versatile material handling system to complement the flexibility of the FMS operation.

A flexible manufacturing system is a configuration of processing workstations interconnected with computer terminals that process the end-to-end manufacturing of a product, from loading/unloading functions to machining and assembly to storing to quality testing and data processing.

The system can be programmed to run a batch of one set productsinaparticularquantityandthenautomaticallyswitchovertoanothersetofproducts.

The main benefit is the enhancement of production efficiency, whereby downtime is reduced because the need to shut down the production line to set up for a different product is eliminated. One disadvantage of FMS is its higher up-front cost and the time required to carefully preplan the system specifications. Another possible drawback is the higher cost associated with the need for specialized labor to run, monitor and maintain the FMS; however, since the FMS is meant to increase production automation (i.e., reduce labor input), the result is typically a net benefit in terms of cost. Common FMS layouts take the form of line, loop, ladder, and open field.

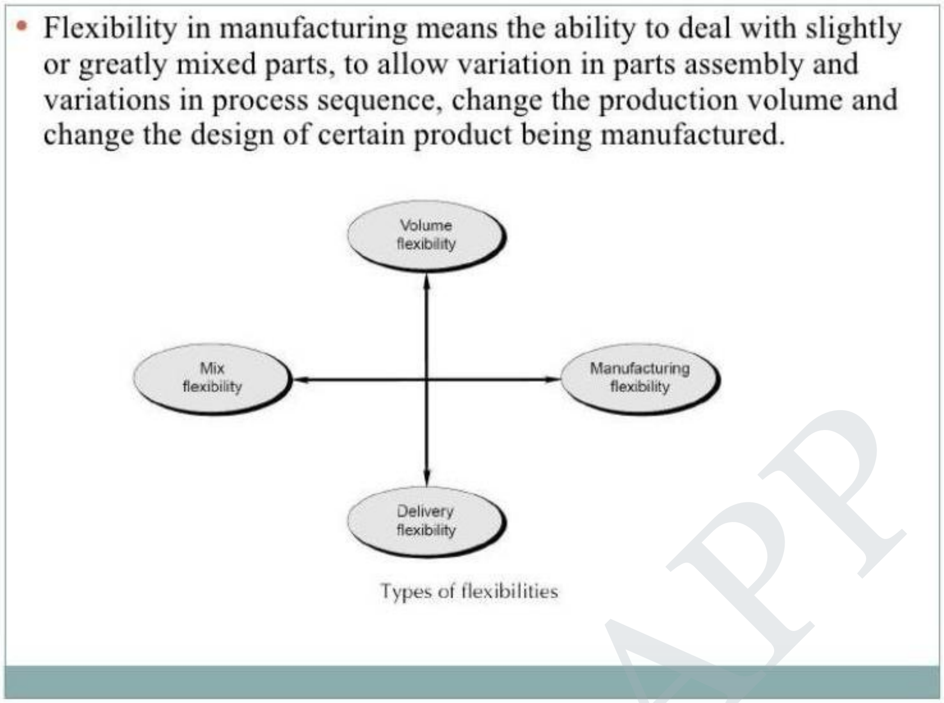
FMS components

BASIC COMPONENTS OF FMS Workstations- They are typically CNC machine tools that perform machining operation on families of parts. Automated Material Handling and Storage system- They are used to transport work parts and subassembly parts between the processing stations, sometimes incorporating storage into function. The processing or assembly equipment used in an FMS depends on the type of work accomplished by the system.

In a system designed for machining operations, the principle types of processing station are CNC machine tools. However, the FMS concept is also applicable to various other processes as well. Following are the types of workstations typically found in an FMS.

Load/Unload Stations. The load/unload station is the physical interface between the FMS and the rest of the factory. Raw work-parts enter the system at this point, and finished parts exit the system from here. Loading and unloading can be accomplished either manually or by automated handling systems. Manual loading and unloading is prevalent in most FMSs today. The load/unload station should be ergonomically designed to permit convenient and safe movement of work parts. For parts that are too heavy to lift by the operator, mechanized cranes and other handling devices are installed to assist the operator.

A certain level of cleanliness must be maintained at the workplace. and air hoses or other washing facilities are often required to flush away chips and ensure clean mounting and locating points. The station is often raised slightly above floor level using an open-grid platform to permit chips and cutting fluid to drop through the openings for subsequent recycling or disposal



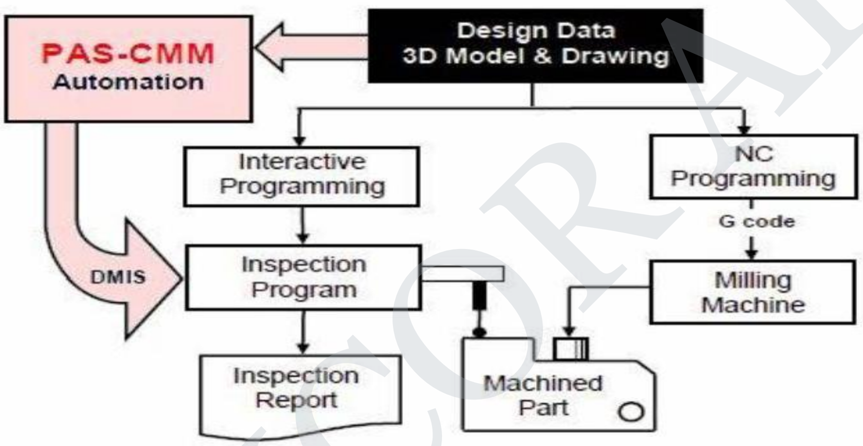
12. What is Computer Aided Quality Control or CAQC?

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.

Traditionally, quality control is carried out using manual inspection methods. It is a system in which standards are maintained on manufactured products through testing a sample of the items made against the original specification. Because of the fact it is manual, quality control can be a time-consuming andpreciseprocedurethatisopentohumanerror.Onoccasionitcancausedelaystothe -letter acronym essentially stands for CAQ. Computer-aided quality assurance is when computers are used to inspect and test products that are being manufactured. It is an engineering application that can oversee the operations of machinery and ensure everything is being produced as required.

It allows for a digital inspection of the quality of the products being produced. This includes measuring the equipment and its management/handling, producing a vendor rating, conducting a goods inward inspection, creating an attribute chart, putting in place statistical process control (SPC) and producing necessary documentation. Computer-aided quality assurance can also ensure a failure mode and effects analysis, otherwise known as FMEA, is put into action. Additionally, it can allow for advanced product quality planning and a dimensional tolerance stack-up analysis on computer-aided design models using the product and manufacturing information. On top of this, it also encompasses a computer-aided inspection with coordinate-measuring machines and can compare data that has been gathered through the 3D scanning of the physical elements of computer-aided design (CAD) models.



13. Draw and explain working of CMM.

In the world of digital manufacturing, where machines are capable of making parts to micron accuracies, being able to measure precisely and reliably is essential to qualifying every part that we make. *Let's* take a closer look at one of our important measurement tools, the CMM, and how it works for you. At its most basic a coordinate is a point, a fixed singular location in three- dimensional space. A series of points can be used to define the parameters of a complex shape. Therefore a coordinate measuring machine (CMM) is any device that is able to collect this set of points for a given object and to do so with an acceptable degree of accuracy and repeatability.

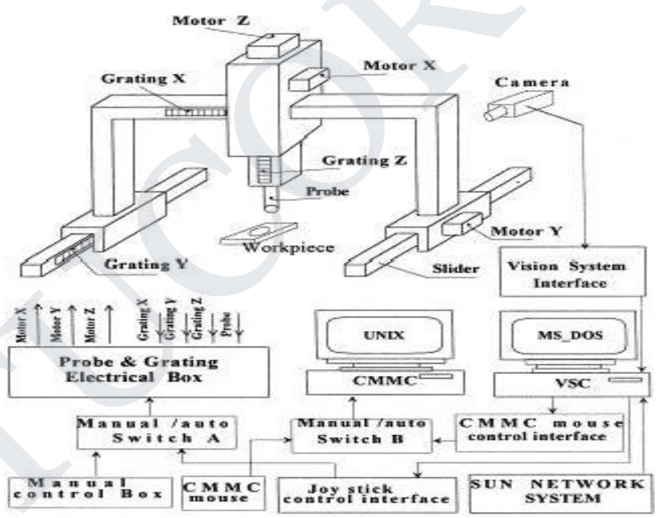
The foundation of the system is just that: a heavy base plate or table which serves as the foundation for an object placed on it to be measured. This is often a massive slab of granite or some other dense material that is stable, rigid, immune to fluctuations caused by the environment, and ground with a very flat top face.

To this table is mounted a moveable bridge or gantry. Vertical posts support a horizontal beam, and on this beam will be suspended another vertical column that holds the measuring probe. The bridge or gantry is able to move along the X-axis. The vertical spindle can move along the bridge thus defining the Y axis. And the probe on the vertical column can move up and down which defines the Z- axis over the table.

At the end of the spindle is the probe. There are different technologies available that can be used as a probe, partly depending on the objects to be measured and the degree of accuracy required. In our case, a precise sphere of ruby is mounted on the tip of the stylus.

Finally, the tip of the probe communicates its information to a computer which interprets the data with specialized software to create a 3D map of the part in question from the cumulative set of points. The exact size and position of the tip must be precisely known in advance to establish the "zero" point for all subsequent measurements. That is one of the reasons for using a ruby sphere, since it is a hard substance that does not fluctuate in size due to temperature or humidity. The tip is mounted on a spring-loaded stylus. That stylus in turn has an angular rotation of 105° and a circular rotation of 360°.

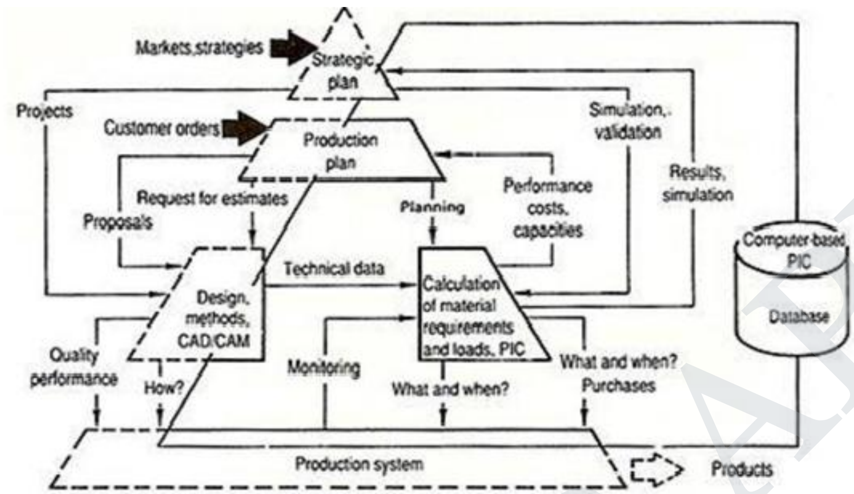
As a result, the entire machine is considered a 5-axis CMM. The stylus is connected to exquisitely



sensitive electronics that detect even the slightest deviation in electrical resistance coming from the probe. Each time the spherical tip contacts a solid object and is forced to deflect, that generates an electrical pulse which is sent to the computer which maps out a point on our imaginary X-Y-Z space. Hundreds or thousands of such points are collected, depending on the geometry and size of the part.

14. Draw and explain CIM

Computer-integrated manufacturing (CIM) is the manufacturing approach of using computers to control the entire production process. This integration allows individual processes to exchange information with each other and initiate actions.



This integration allows individual processes to exchange information with each other and initiate actions. It is a way of thinking and solving problems. CIM is not a product that can be purchased and installed. It is the use of integrated systems and data communications coupled with new managerial philosophies. CIM is the integration of all enterprise operations and activities around a common corporate data repository. What is CIM?

Decrease in work-in process inventory Increase in manufacturing productivity Shorter customer lead time Lower total cost Improved competitiveness Greater flexibility and responsiveness Improved schedule performance Reduced inventory levels Shorter vendor lead time Shorter flow time Shorter time to market with new products Improved quality Improved customer service Potential Benefits of CIM Better product quality, reduction of scrap 20-50%. Increase of productivity by 40- 70%; Reduction of the in-shop time of a part by 30-60%; Reduction of design costs by 15- 30%; Role of Computer in Manufacturing The computer has had a substantial impact on almost all activities of factory. The operation of a CIM system gives the user substantial benefits:

CIM is an example of the implementation of Information and Communication Technologies (ICTs)in manufacturing. Algorithms for uniting the data processing component with the sensor/modification component. Mechanisms for sensing state and modifying processes; Means for data storage, retrieval, manipulation and presentation; Manufacturing Method As a method of manufacturing, three components distinguish

CIM from other manufacturing methodologies:

CIM & Production Control System Process control: Computers may be used to assist the human operators of the manufacturing facility, but there must always be a competent engineer on hand to handle circumstances which could not be foreseen by the designers of the control software. Data integrity: The higher the degree of automation, the more critical is the integrity of the data used to control the machines. While the CIM system saves on labor of operating the machines, it requires extra human labor in ensuring that there are proper safeguards for the data signals that are used to control the machines. Integration of components from different suppliers: When different machines, such as CNC, conveyors and robots, are using different communications protocols. In the case of AGVs (automated guided vehicles), even differing lengths of time for charging the batteries may cause problems. Key challenges.

There are three major challenges for the development of a smoothly operating computer-integrated manufacturing system:

CAPP (Computer-Aided Process Planning) is the use of computer technology to aid in the process planning of apart or product, in manufacturing. CAM (Computer-Aided Manufacturing) is the use of computer software to control machine tools and related machinery in the manufacturing of work pieces. CAE (Computer-Aided Engineering) is the broad usage of computer software to aid in engineering tasks. CAD (Computer-Aided Design) involves the use of computers to create design drawings and product models. Sub systems in computer-integrated manufacturing.