Presentation for

Course: CAD/CAM

Class: VII Semester

Mechanical Engineering

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Computers in Industrial Manufacturing

The role of computer in manufacturing may be broadly classified into two groups:

1. Computer monitoring and control of the manufacturing process.
2. Manufacturing support applications, which deal essentially with the preparations for actual manufacturing and post-manufacture operations.

Computer supports in the areas are :

- Computer aided design and drafting
- Computer aided engineering
- Computer aided manufacturing
- Computer aided process planning
- Computer aided tool design
- Computer aided NC part programming
- Computer aided scheduling
- Computer aided material requirement planning.

Computers in Industrial Manufacturing

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PRODUCT CYCLE

Let us consider the manufacturing environment of a given produce.

How does the product idea originate?

The market forces determine the need for a product. Expertise on the part of the company estimates the likely demand and probable profitability and decides on the best mode of designing and manufacturing the desired product.

The details of such a design and the subsequent manufacturing process are depicted in Fig. 1-2 for the traditional approach and in Fig. 1-3 for computer aided manufacturing

Product Cycle-conventional

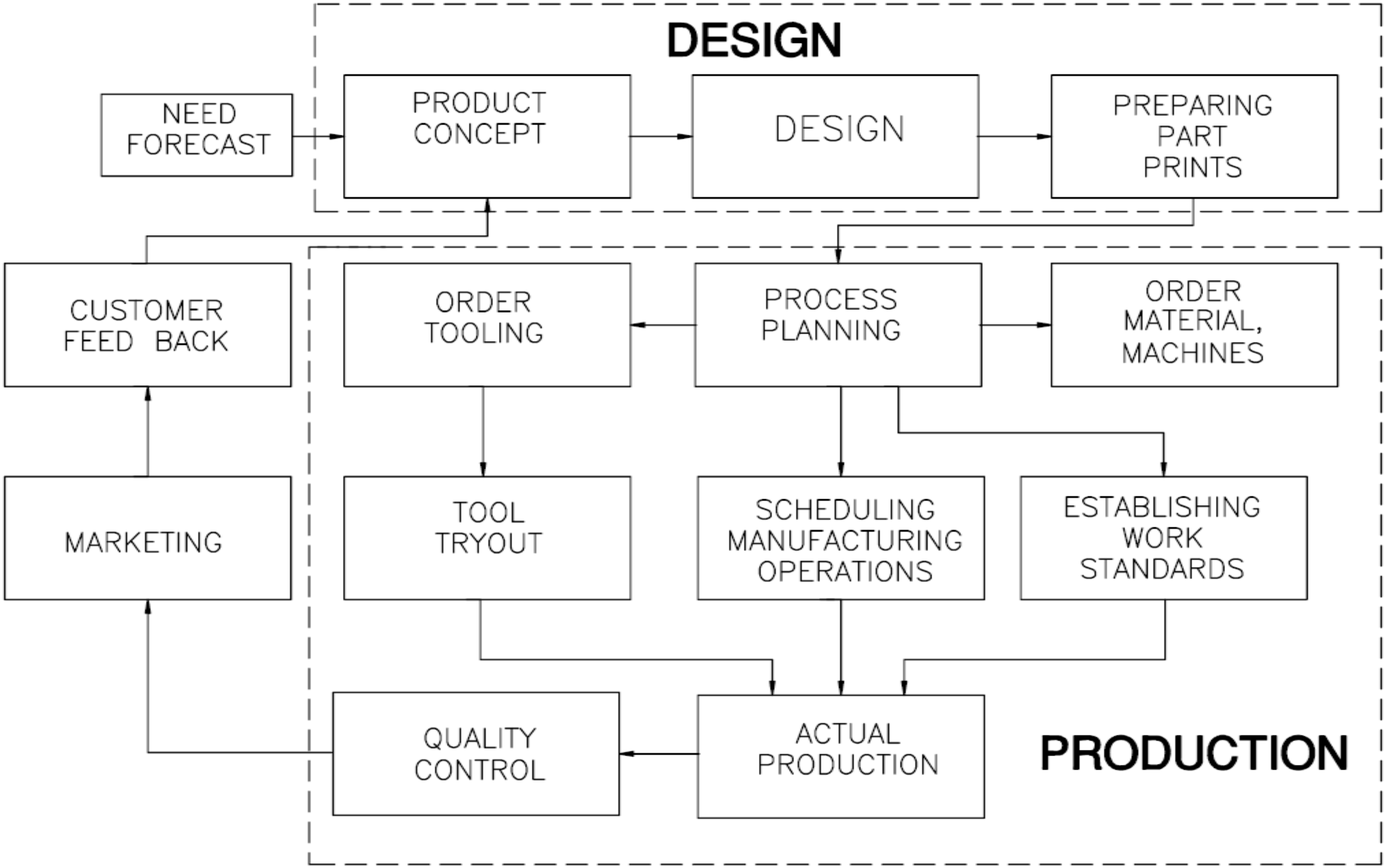


Fig. 1-2 The product cycle in a conventional manufacturing environment

Product Cycle-with Computer applications

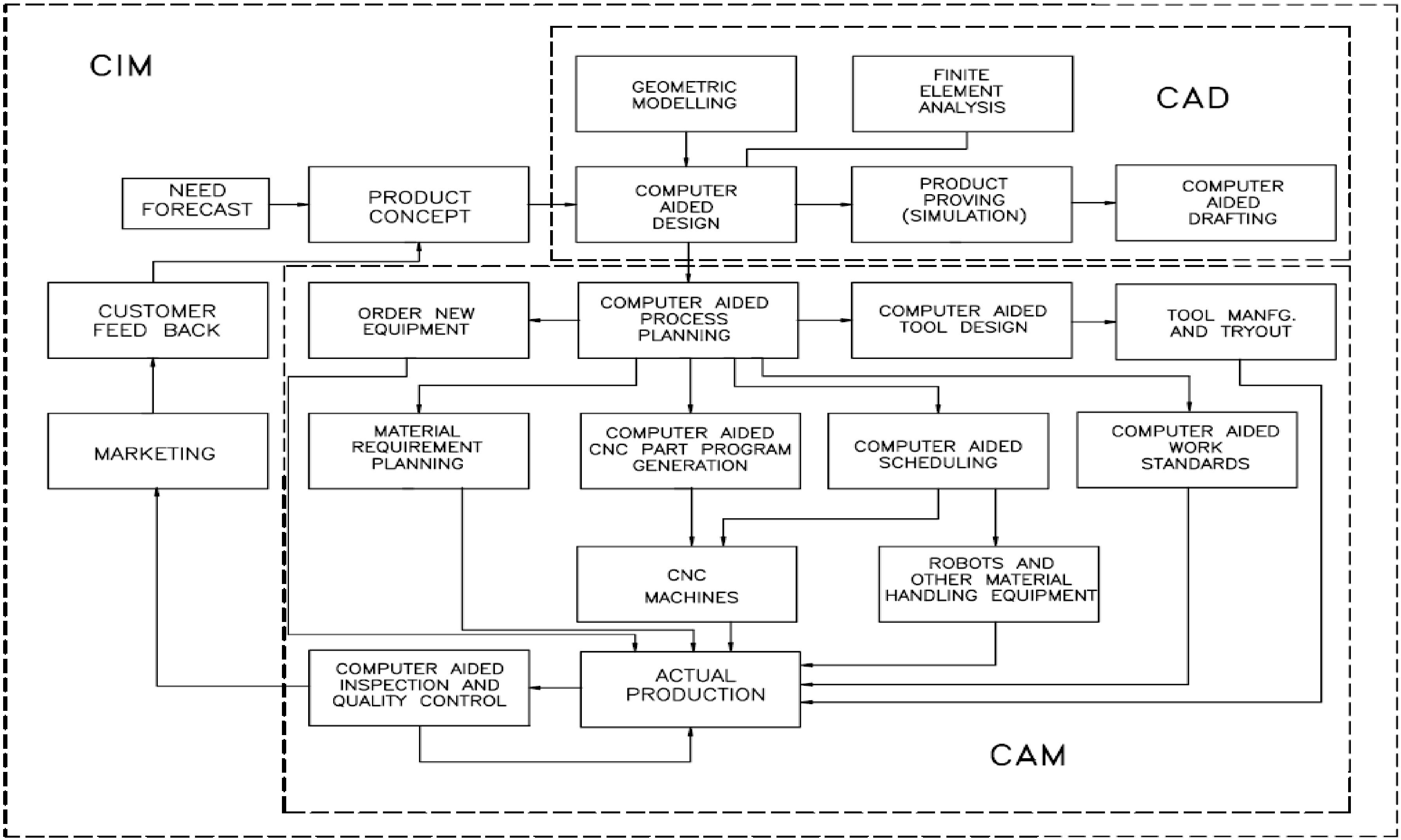


Fig. 1-3 The product cycle in a computerised manufacturing environment

Computer Aided Design (CAD)

Is a TOOL to aid designer/engineer Classified under 2 categories:

1.Product Engineering

- Product functions
- Product Specifications
- Conceptual design
- Ergonomics and Aesthetics
- Standards
- Detailed Design
- Prototype development
- Testing

- **Simulation**
- **Analysis**
- **Strength**
- **Kinematics, Dynamics**
- **Heat, Flow**
- **Design for Manufacture**
- **Design for Assembly**
- **Drafting**

2.Manufacturing Engineering

- Process planning
- Process sheets
- Route sheets
- Tooling
- Cutting tools
- Jigs and Fixtures
- Dies and Moulds
- Manufacturing Information Generation

- CNC Part programmes
- Robot Programmes
- Inspection (CMM) programmes
- Production Organisation
- Bill of Materials
- Material Requirement Planning
- Production Planning
- Shop Floor Control
- Plant Simulation
- Packaging
- Distribution, Marketing

Hardware Components

- **Central processing unit (CPU)**

  A hardware component that performs computing functions utilizing the ALU, control unit, and registers.

- **Arithmetic/logic unit (ALU)**

  Performs mathematical calculations and makes logical comparisons.

- **Control unit**

  Sequentially accesses program instructions, decodes them, coordinates flow of data in/out of ALU, registers, primary and secondary storage, and various output devices.

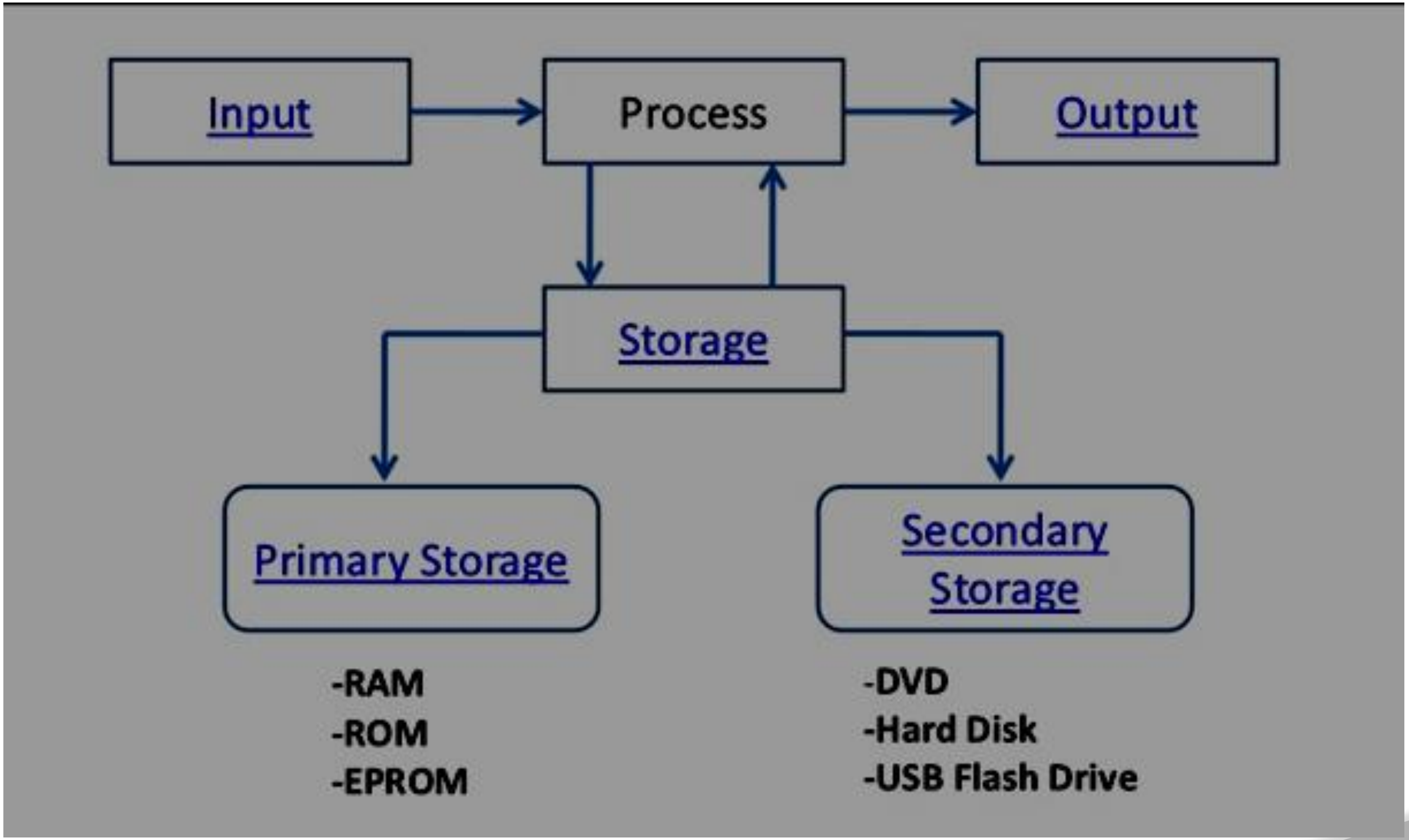
Types of Computer Systems

- Personal computers (PCs)
  - Small, inexpensive, often called microcomputers
- Network computers
  - Used for accessing networks, especially the Internet
- Workstations
  - Fit between high-end microcomputers and low-end midrange.

Types of Computer Systems con't…..

- Midrange (or 'mini') computers
  - Size of a three drawer file cabinet and accommodates several users at one time.
- Mainframe computers
  - Large and powerful, shared by hundreds concurrently.
- Supercomputers
  - Most powerful with fastest processing speeds.

Input/ Output devices of computer



Input Devices: Giving Commands

- Input
- Data or instructions entered into a computer
- Input device
- Hardware that gives users the ability to enter data and instructions into the computer’s random access memory (RAM)

Input devices

Keyboard

Most common input device—enables data and instruction entry through the use of a variety of keys

Enhanced keyboards

additional keys, such as media control buttons to adjust speaker volume, or Internet control buttons that open e-mail, a browser, or a search window with a single keystroke

Key matrix Grid of circuits located under the keys

Character map

Chart that tells the processor what key has been pressed

Wireless keyboards

Connect to the computer through infrared (IR), radio frequency (RF), or Bluetooth connections

Pointing device

Controls an on-screen pointer's movements

Pointer

On-screen symbol that signifies the command, input, or possible response

Alternative input devices include:

Microphones for speech or voice recognition

Scanner for optical character recognition (OCR)

Bar code reader

Optical mark reader (OMR)

Radio frequency identification (RFID reader)

Magnetic-ink character recognition (MICR reader)

Magnetic stripe care reader

Biometric input device

Digital cameras and digital video cameras

Webcams

Course Outcomes

Biometric input device

Digital cameras and digital video cameras

Webcams

Output devices

Enable users to see, hear, or feel the end result of processing operations

The two most popular output devices

1. **Monitors (also called displays)**
2. **Printers**

Monitors

Display a temporary copy (soft copy) of processed data

Types of monitors include:

Cathode-ray tube (CRT)

Liquid crystal display (LCD)

Monitors continued

LCD (flat-panel) displays: Have a thin profile

Are used with newer desktops and notebooks

Have largely replaced CRT monitors

May accommodate high-definition video

Monitors continued…

Resolution

Refers to the sharpness of an image

Number of pixels (picture elements) controls the resolution

Video Graphics Array (VGA)—lowest resolution standard (640 × 480)

Extended Graphics Array (XGA)—most used by computers today (1024 × 768)

Out put devices continued…

Printers

Supply a hard copy of output displayed on a computer’s monitor

Types include:

Inkjet

Laser

Dot-matrix

Photo

Plotters

Printers

Inkjet (nonimpact)—**popular with home users**

Provide excellent images—made up of small dots

Advantages:

Inexpensive

Generate professional color output

Disadvantages:

Relatively slow

Printers

Laser (nonimpact)

Use electrostatic reproductive technology to produce high-quality output

Advantages:

High-resolution

Print faster than inkjet printers

Black-and-white printing costs less per page than inkjet printing

Disadvantages:

Color laser printers more expensive

Printers

Dot-matrix (impact)

Older, less popular

Used mostly for printing multipart forms and backup copies

Advantages:

Able to print 3,000 lines per minute

Disadvantages:

Poor print quality

Noisy

Printers

Photo

Uses special ink and paper

Often are inkjet printers

Prints directly from a digital camera or memory card

Plotters

Produce images through moving ink pens

Used for making oversized prints (i.e., maps, charts, blueprints)

Printers

Other output devices include:

Speakers

LCD projectors

DLP (digital light-processing) projectors

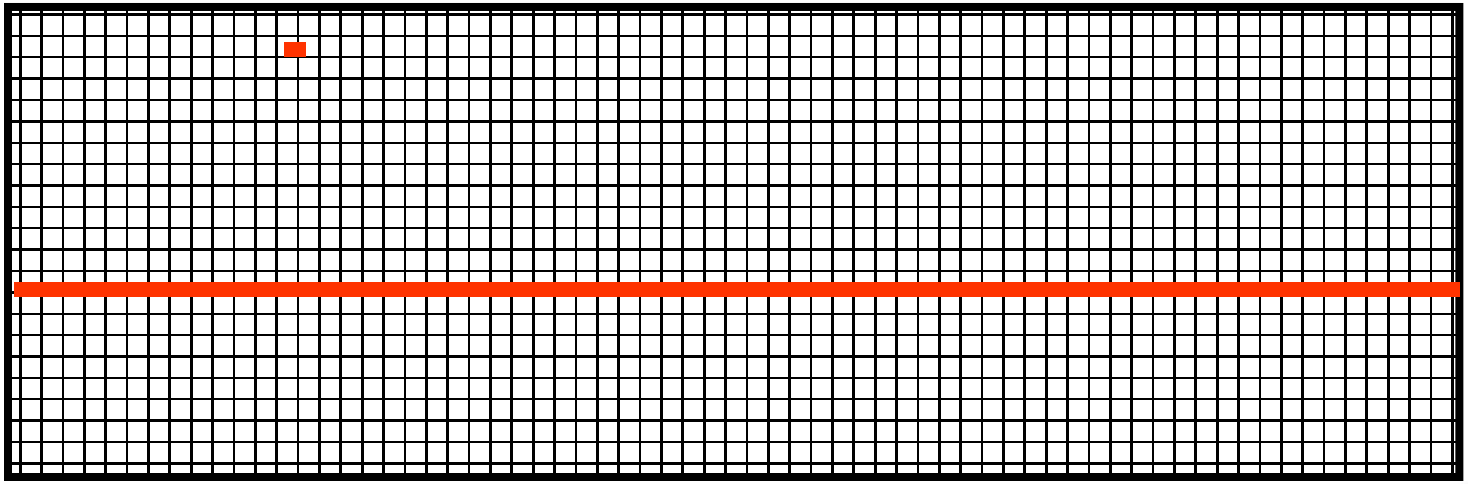
Multifunction devices

Raster Scan Displays

Raster: A rectangular array of points or dots

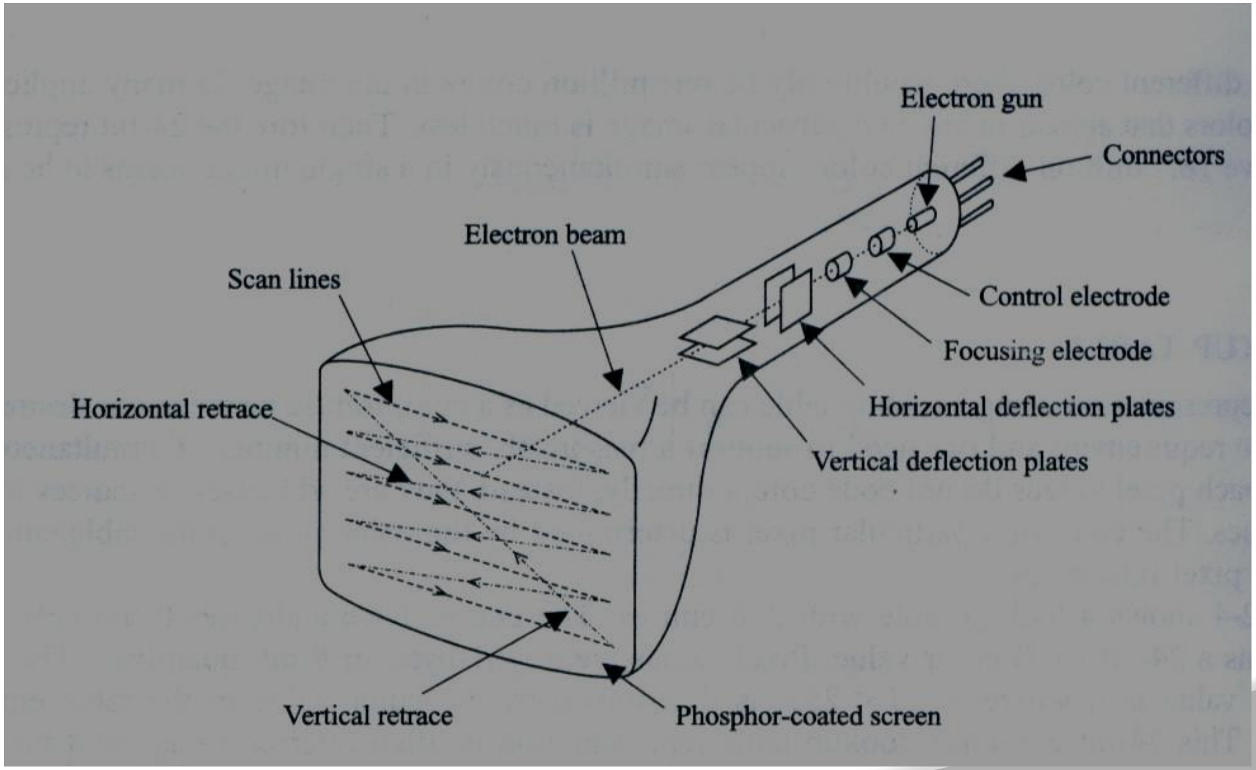
Pixel: One dot or picture element of the raster

Scan Line: A row of pixels



Raster Scan Displays

In a raster scan system, the electron beam is swept across the screen, one row at a time from top to bottom.

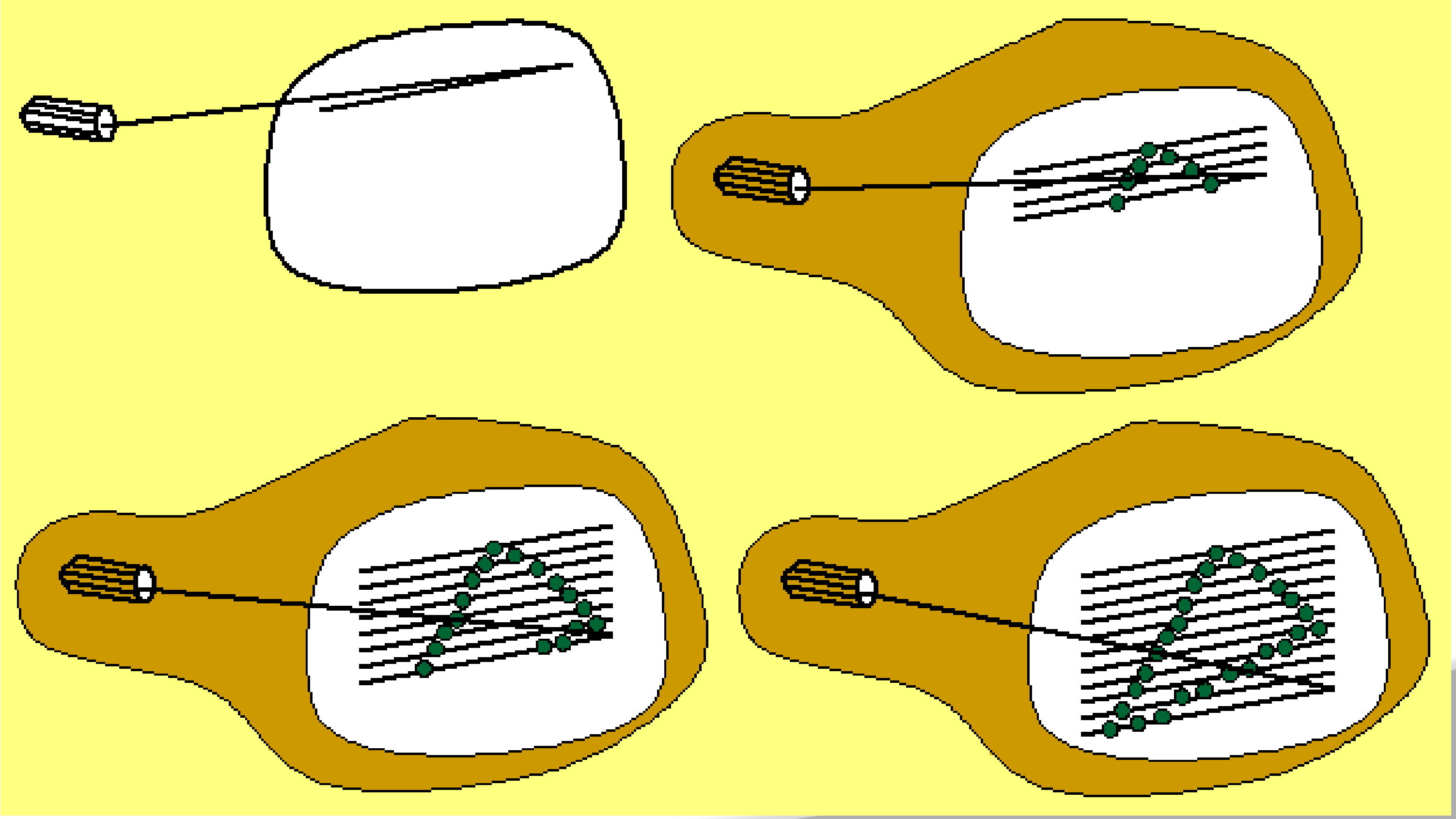


Raster Scan Displays

- As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots.
- Picture definition is stored in a memory area called the refresh buffer or frame buffer.
- Refresh buffer or frame buffer: This memory area holds the set of intensity values for all the screen points.

Raster Scan Displays

Stored intensity values then retrieved from refresh buffer and "painted" on the screen one row (scan line) at a time.



Raster Scan Displays

Refreshing on raster scan displays is carried out at the rate 60 to 80 frame per second.

Database

- Information is not useful if not organized
- In database, data are organized in a way that people find meaningful and useful.
- Database Management System (DBMS) is used to input, sort, organize and store data.

Database Model

- Database model defines the logical design of data.
- Database model describes the relation between different parts of data.
- There are three database models:
    1. Hierarchical Model
    2. Network Model
    3. Relational Model

Characteristics of Good Database

Data Integrity	**Ensuring data is valid**
Data Independence	**Data is separated from software**
Avoiding data Redundancy	**Repetition of input data is avoided**
Data Security	**Data is not accessible to unauthorized users**
Data Maintenance	**Set procedures for adding ,deleting records for the purpose of optimization**

3D TRANSFORMATIONS

Translation, Scaling , Rotation

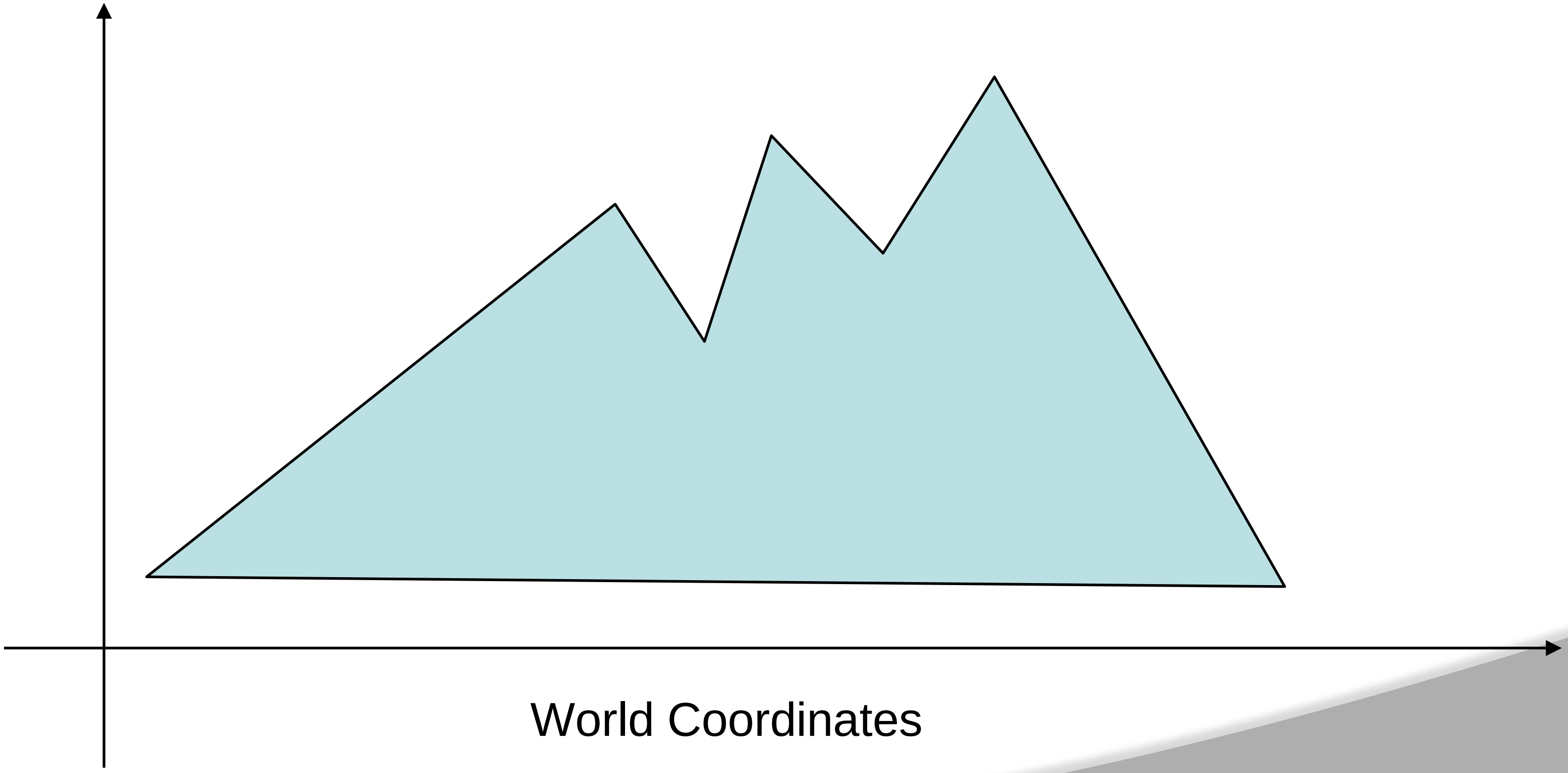
2D Clipping

1. Introduction
2. Point Clipping
3. Line Clipping
4. Polygon/Area Clipping
5. Text Clipping
6. Curve Clipping

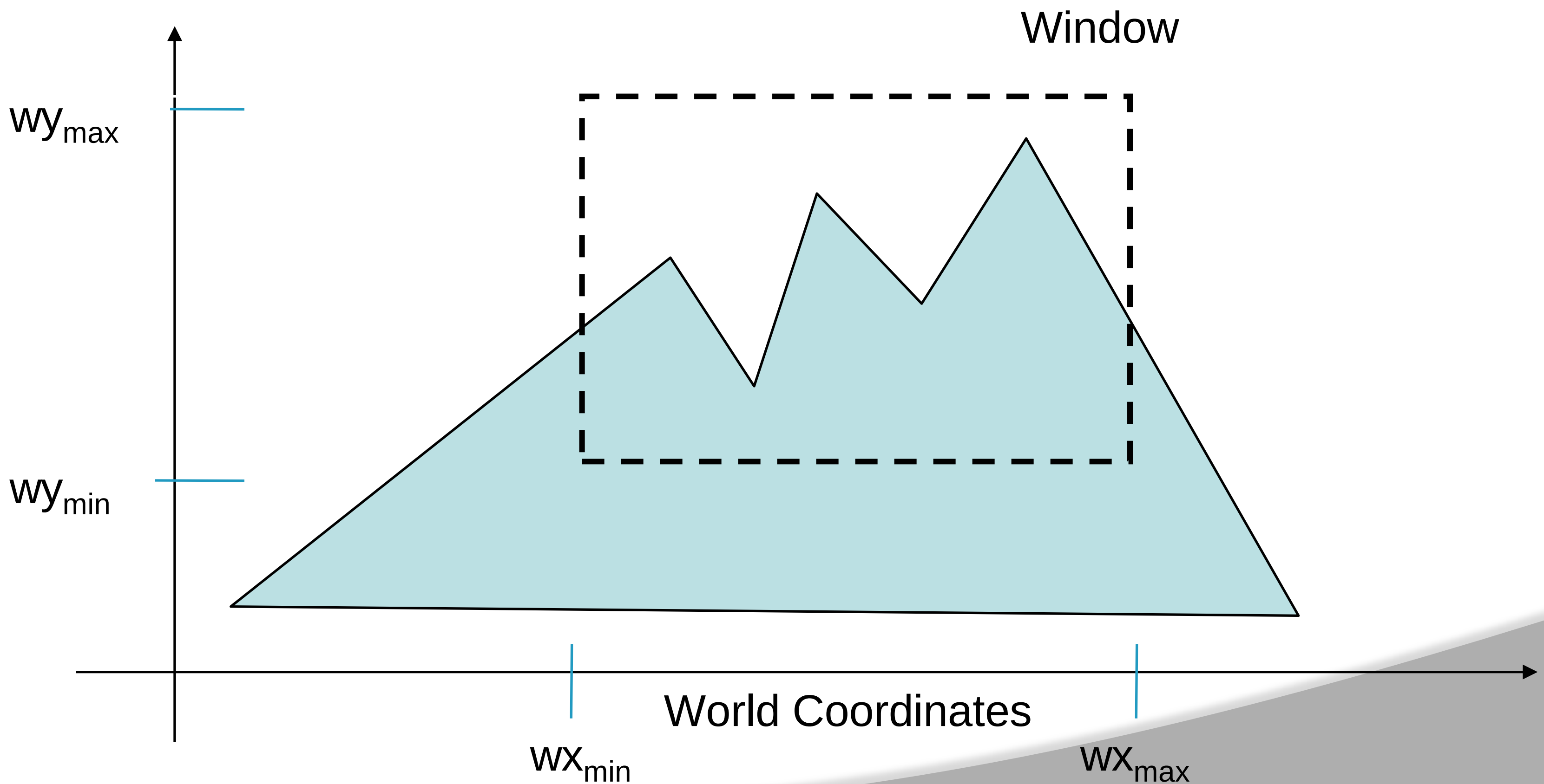
2D Clipping

1. Introduction:

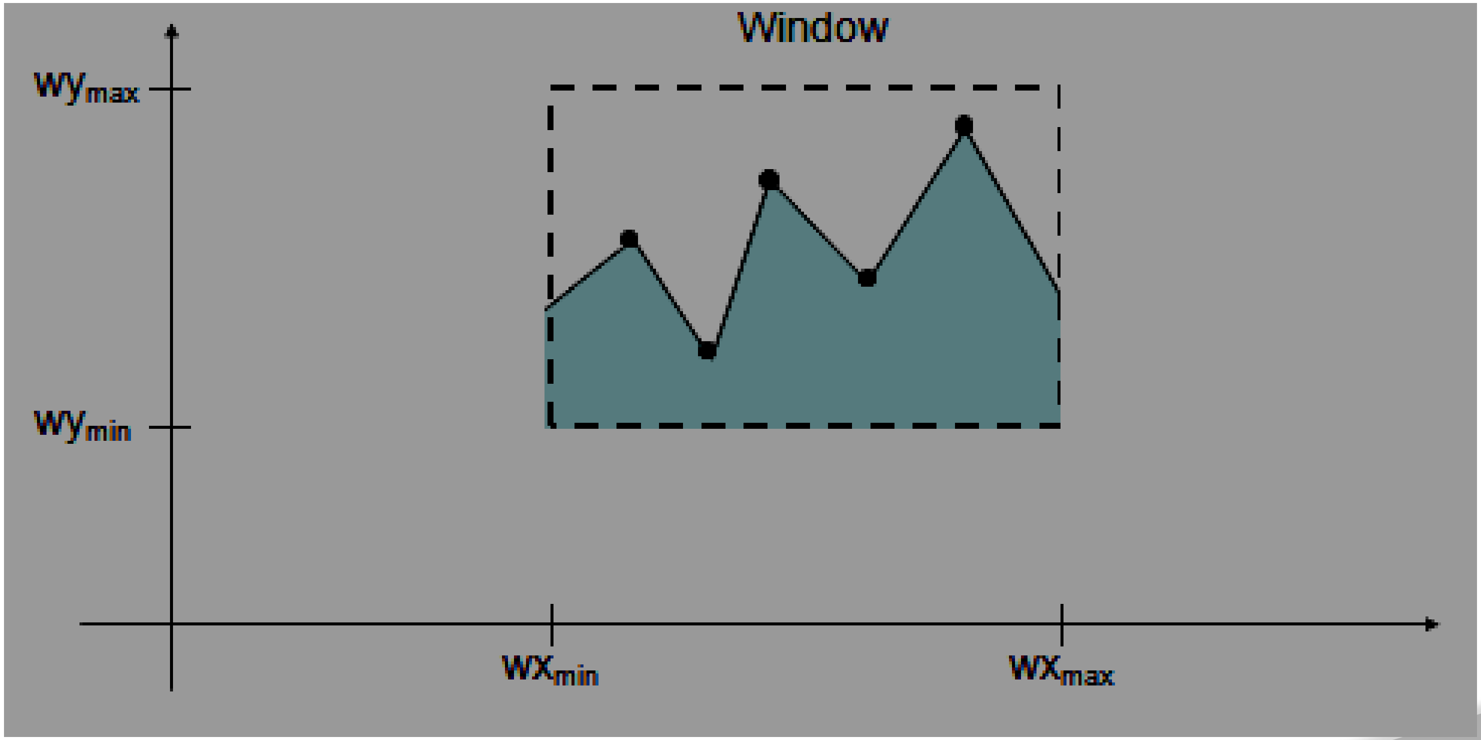
A scene is made up of a collection of objects specified in world coordinates



When we display a scene only those objects within a particular window are displayed



Because drawing things to a display takes time we clip everything outside the window



Point Clipping

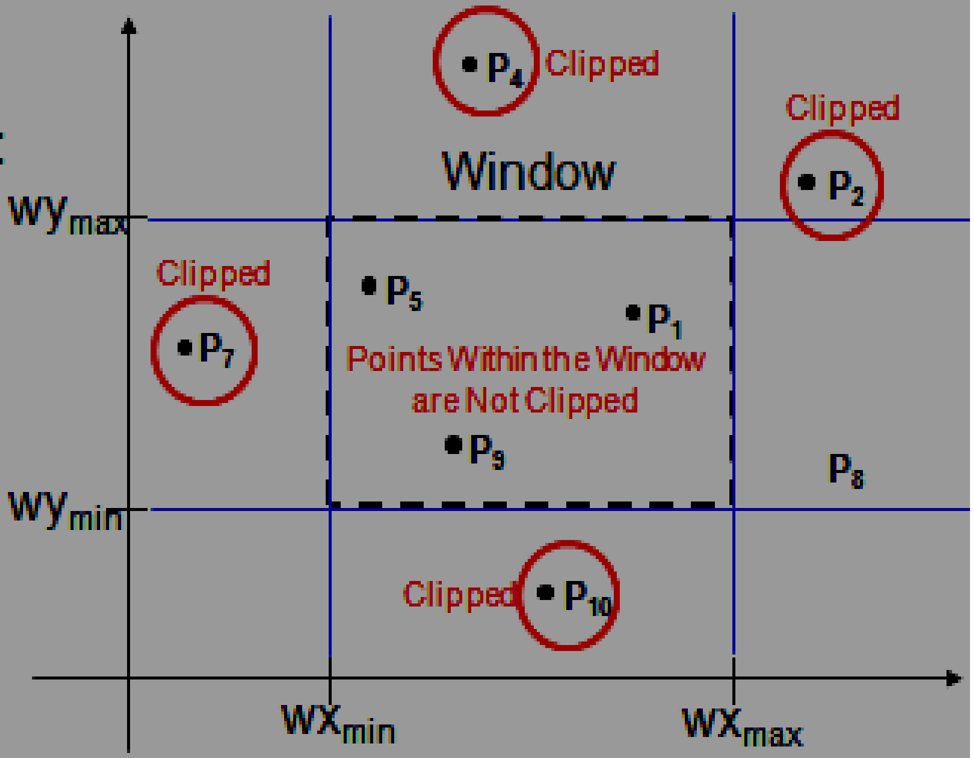
- Simple and Easy
- a point (x,y) is not clipped if:

$$wx_{min} \le x \le wx_{max}$$

&

$$wy_{min} \le y \le wy_{max}$$

- otherwise it is clipped



UNIT – II GEOMETRIC MODELING

Geometric modeling is as important to CAD as governing equilibrium equations to classical engineering fields as mechanics and thermal fluids.

- **Intelligent decision on the types of entities necessary to use in a particular model to meet certain geometric requirements such as slopes and/or curvatures.**
- **Interpretation of unexpected results**
- **Evaluations of CAD/CAM systems**
- **Innovative use of the tools in particular applications.**
- **Creation of new attributes, or modify the obtained models to benefit new engineering applications.**
- **Understanding of terminology**

General Requirements

- Complete part representation including topological and geometrical data
- Geometry: shape and dimensions
- Topology: the connectivity and associativity of the object entities; it determines the relational information between object entities
- Able to transfer data directly from CAD to CAE and CAM.
- Support various engineering applications, such as mass properties, mechanism analysis, FEA/FEM and tool path creation for CNC, and so on.

Basic Geometric Modeling Techniques

- Wireframe Modeling
- Surface Modeling

  Analytical Surface

  Free-form, Curved, & Sculptured Surface
- Solid Modeling

  Constructive Solid Geometry (CSG)

  Boundary Representation (B-Rep)

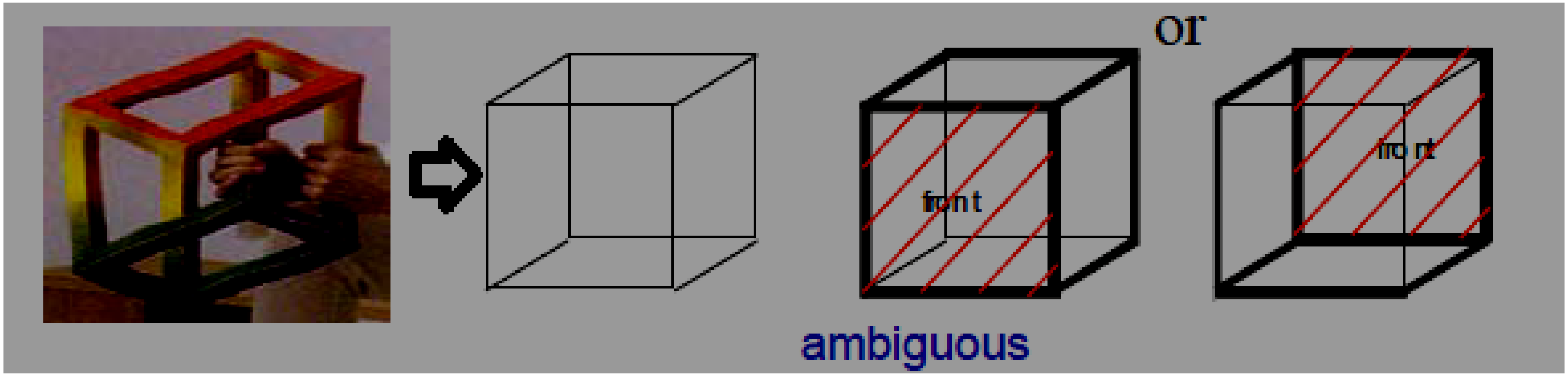
  Feature Based Modeling

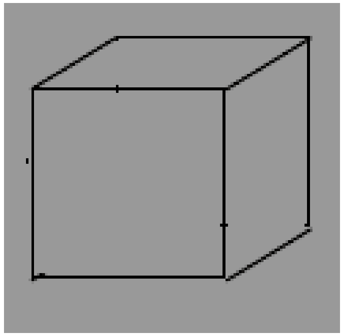
  Parametric Modeling

Wireframe Modeling

- Developed in 1960s and referred as “a stick figure” or “an edge representation”
- The word “wireframe” is related to the fact that one may imagine a wire that is bent to follow the object edges to generate a model.
- Model consists entirely of points, lines, arcs and circles, conics, and curves.
- In 3D wireframe model, an object is not recorded as a solid. Instead the vertices that define the boundary of the object, or the intersections of the edges of the object boundary are recorded as a collection of points and their connectivity.

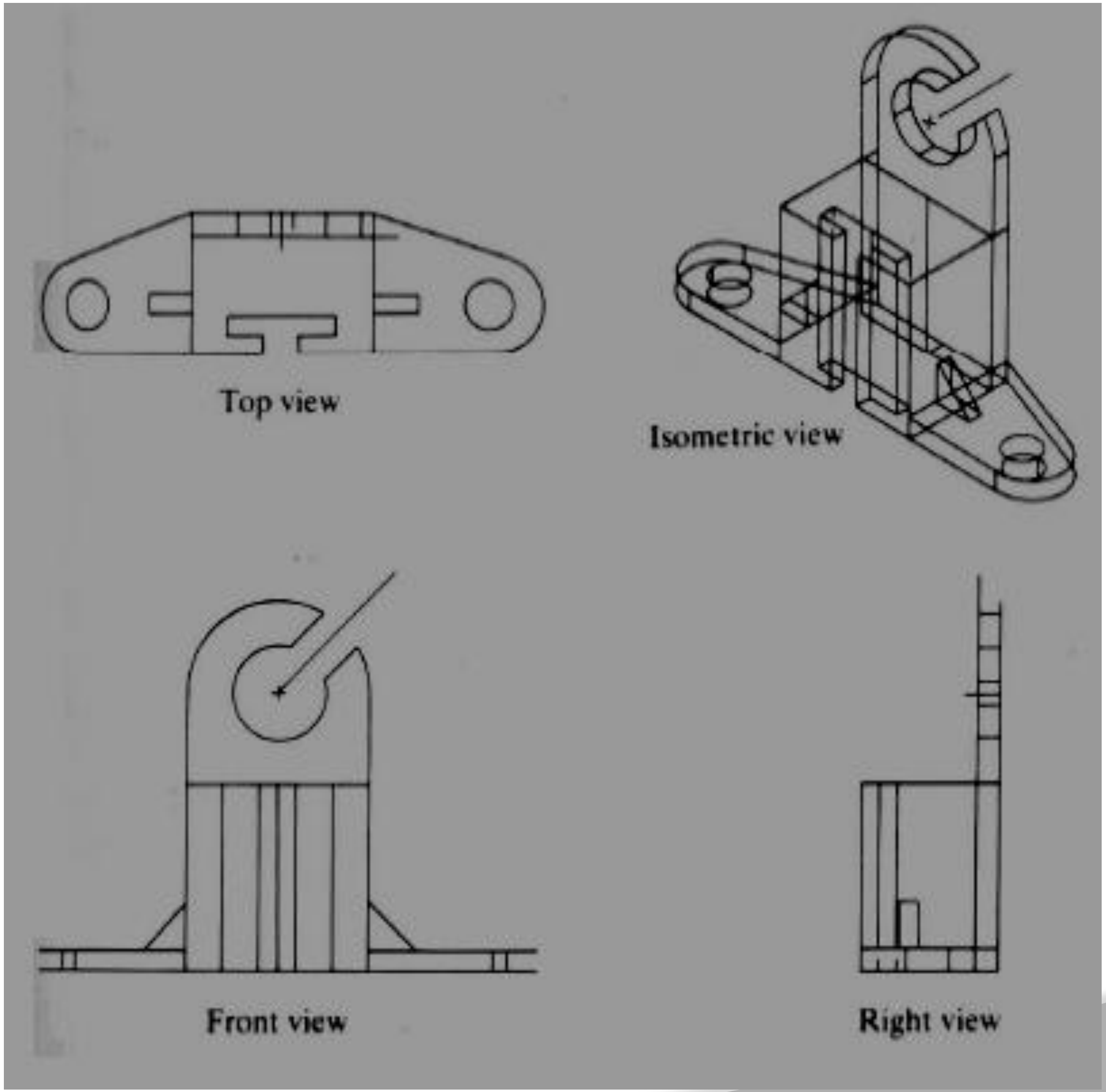
Wire frame model





Hidden line removal

Example of wire frame model

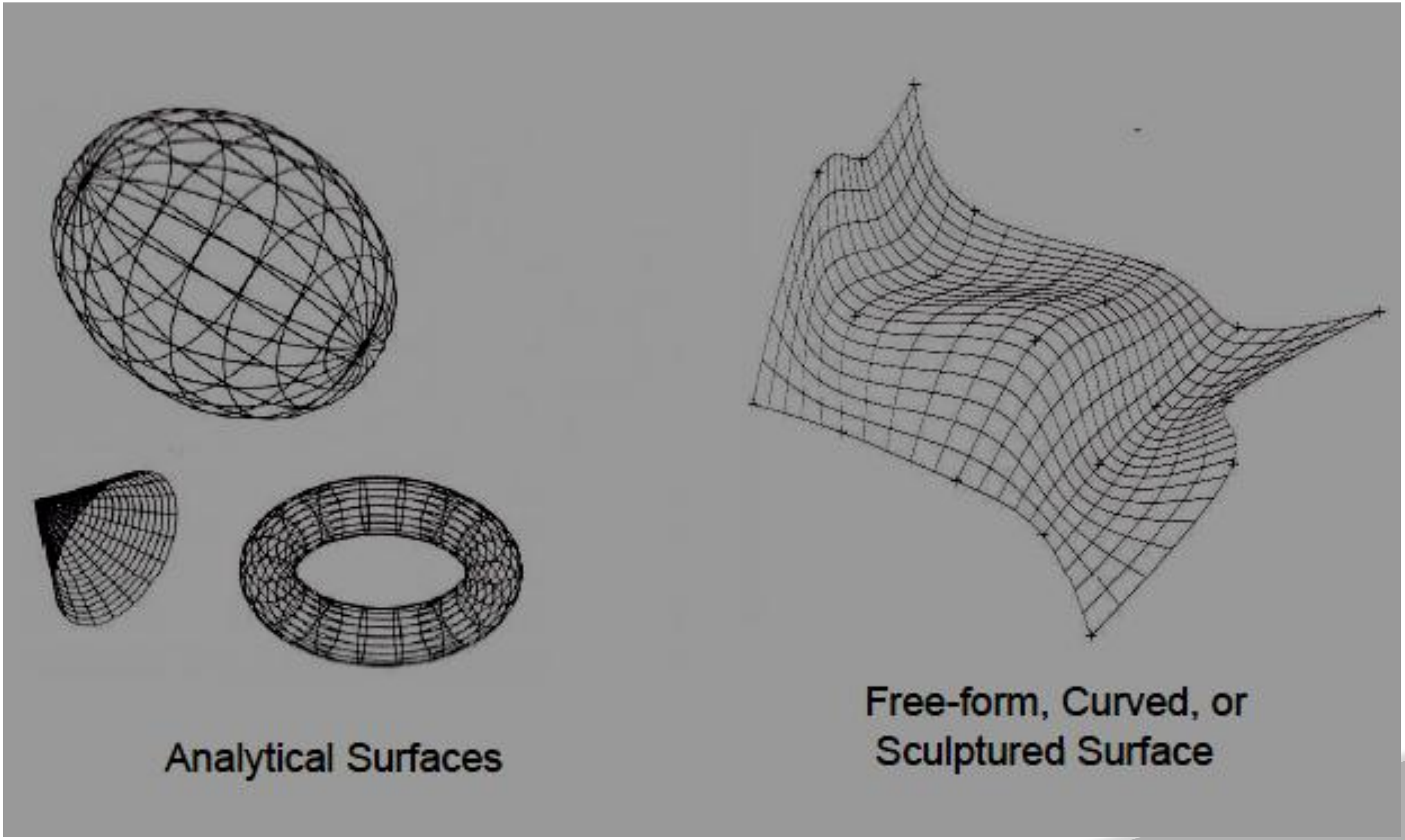


Surface Modeling

A surface model is a set of faces.

- A surface model consists of wireframe entities that form the basis to create surface entities.
- In general, a wireframe model can be extracted from a surface model by deleting or blanking all surface entities
- Shape design and representation of complex objects such as car, ship, and airplane bodies as well as castings
- Used to be separated, shape model are now incorporated into solid models (e.g. creo)

Examples of Surface Models



Solid Modeling

- **The boundary of the model separates the interior and exterior of the modeled object.**
- **The object is defined by the volume space contained within the defined boundary of the object.**
- **In general speaking, a closed boundary is needed to define a solid object.**

- It is complete, valid, and unambiguous representation

– points in space to be classified relative to the object, if it is inside, outside, or on the object

- store both geometric and topological information; can verify whether two objects occupy the same space.
- improves the quality of design, improves visualization, and has potential for functional automation and integration.

Why Solid Modeling

Solid Modeling Support

- **Using volume information**

– weight or volume calculation, centroids, moments of inertia calculation,

– stress analysis (finite elements analysis), heat conduction calculations, dynamic analysis,

– system dynamics analysis

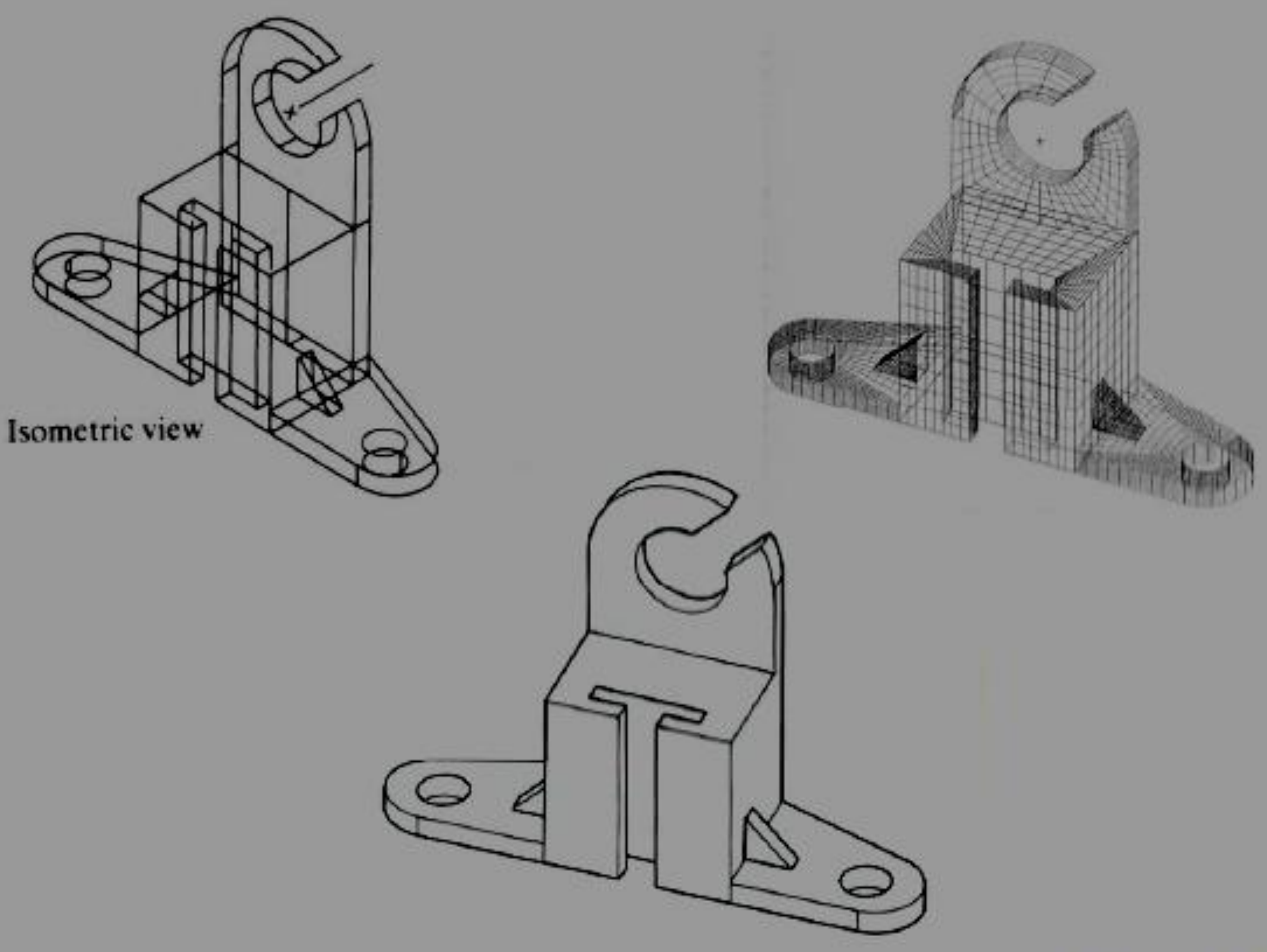
- **Using volume and boundary information**

– generation of CNC codes, and robotic and assembly simulation

Different Solid Modeling Techniques

- Constructive Solid Geometry (CSG)
- Sweeping
- Boundary Representation (B-Rep)
- Feature-Based Modeling - uses feature-based primitives to conduct a design
- Primitive Instancing - uses large numbers (200 - 300) of "primitives" to build object - used for programming NC machine tools (past)
- Cell Decomposition, Spatial Enumeration, Octree (connected cubes of varying size) – used for irregular objects, image processing, medical applications (CT)

Solid model

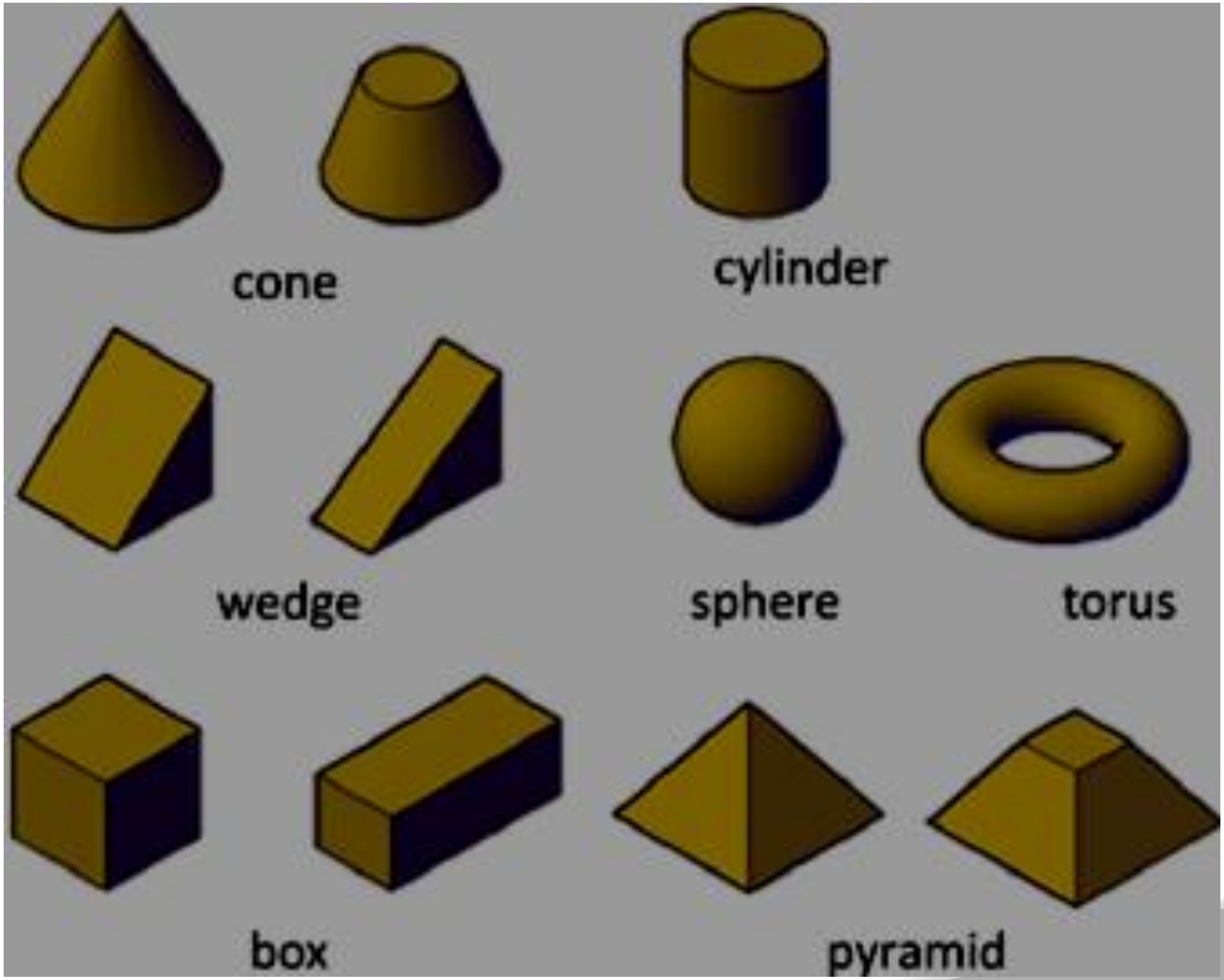


Information complete, unambiguous, accurate **solid model**

Constructive Solid Geometry (CSG)

- Pre-defined geometric primitives
- Boolean operations
- CSG tree structure (building process/approach)

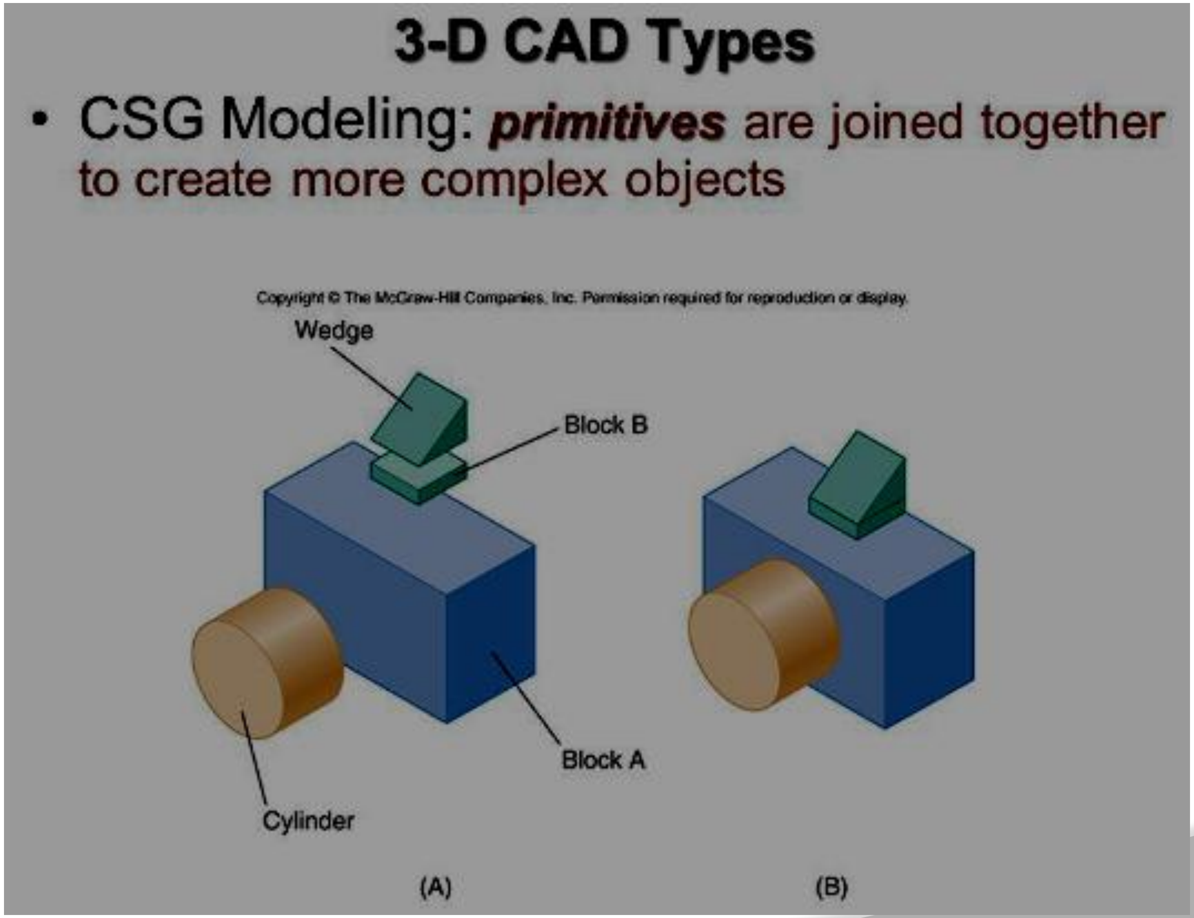
Solid primitives



Solid model development

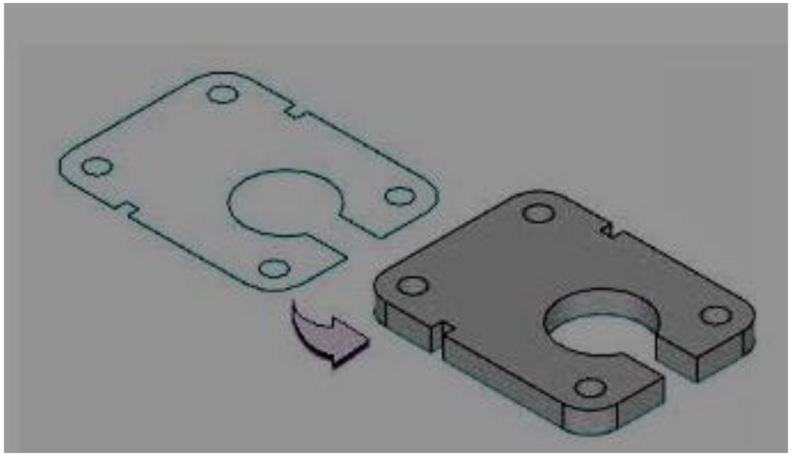
Geometric Primitives - CSG

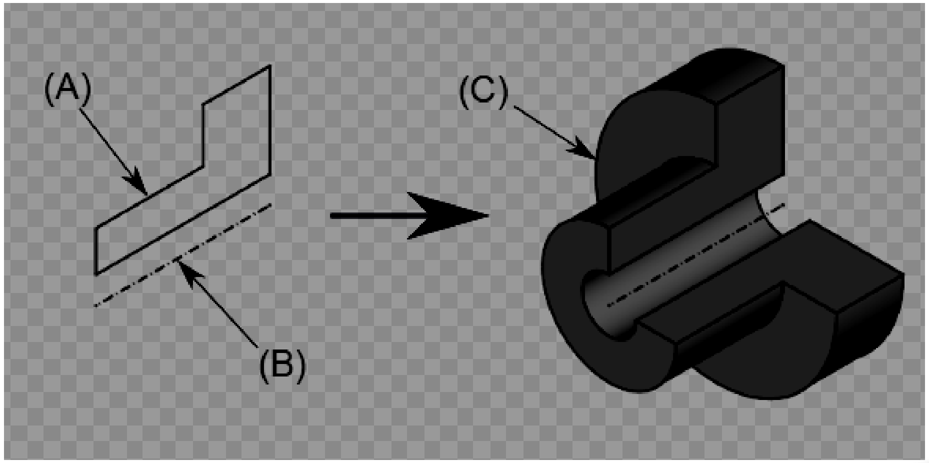
- A collection of pre-defined (low level) geometric primitives



Sweeping

- **Sweeping of a 2D cross-section in the form of extrusion and revolving are used to define the 3D shape (for uncommon shapes).**

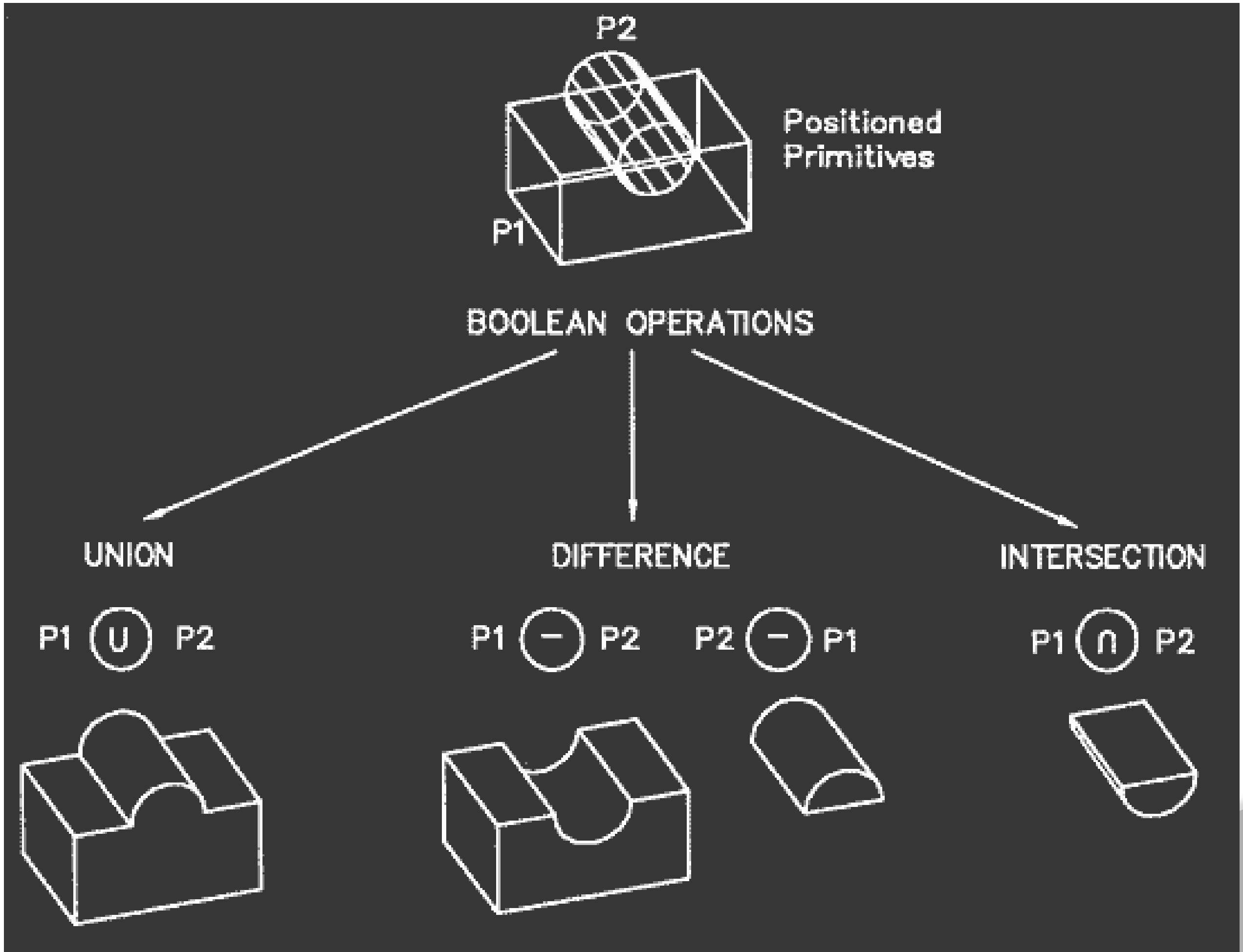




Boolean Operations ex1

BOOLEAN OPERATIONS:

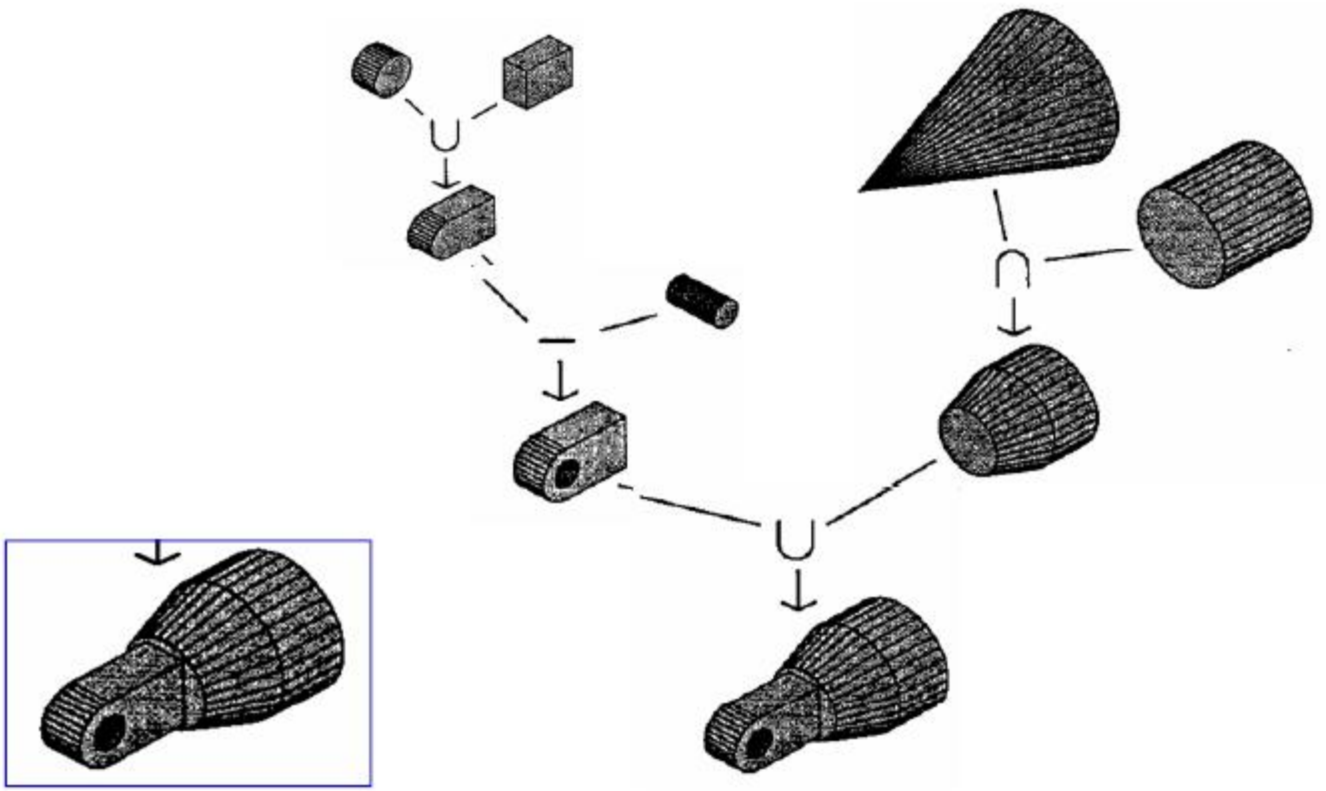
1. UNION
2. DIFFERENCE
3. INTERSECTION



Boolean Operations Used in Constructive Solid Geometry Modeling.

Boolean Operations ex2

CSG Tree



Sweeping

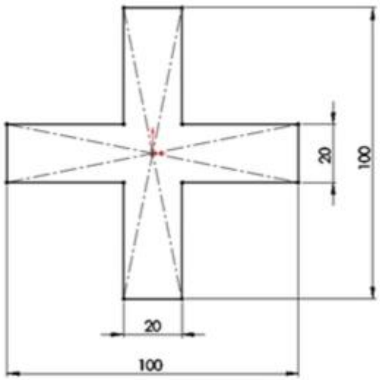
Sweeping can be carried out in two different forms:

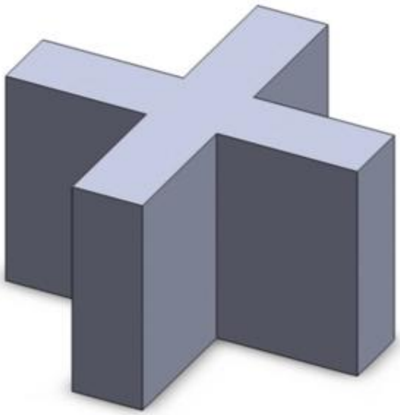
- **Extrusion - to produce an object model from a 2D cross-section shape, the direction of extrusion, and a given depth. Advanced applications include curved extrusion guideline and varying cross-sections.**

- **Revolving - to produce a rotation part, either in solid or in shell shape. Revolving a 2D cross-section that is specified by a closed curve around the axis of symmetry forms the model of an axially symmetric object.**

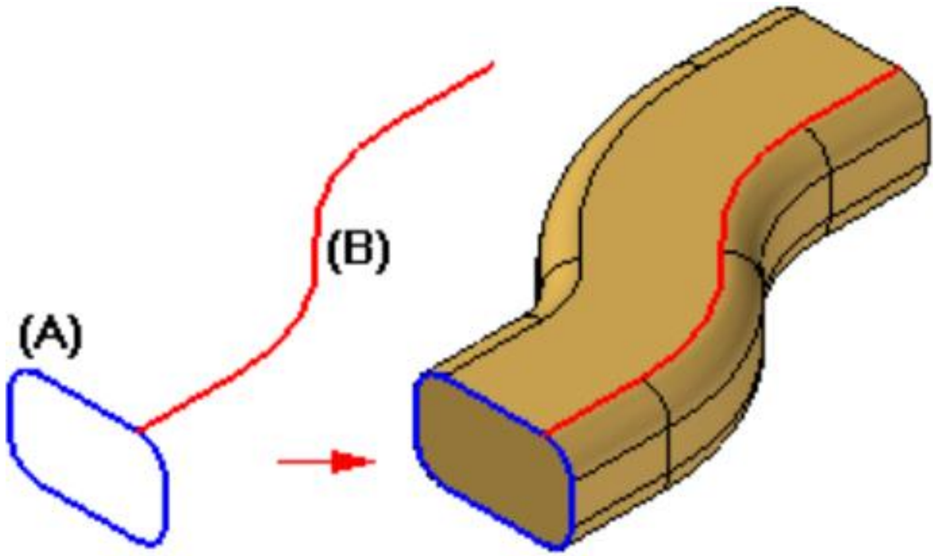
Sweeping – Extrusion , revolve

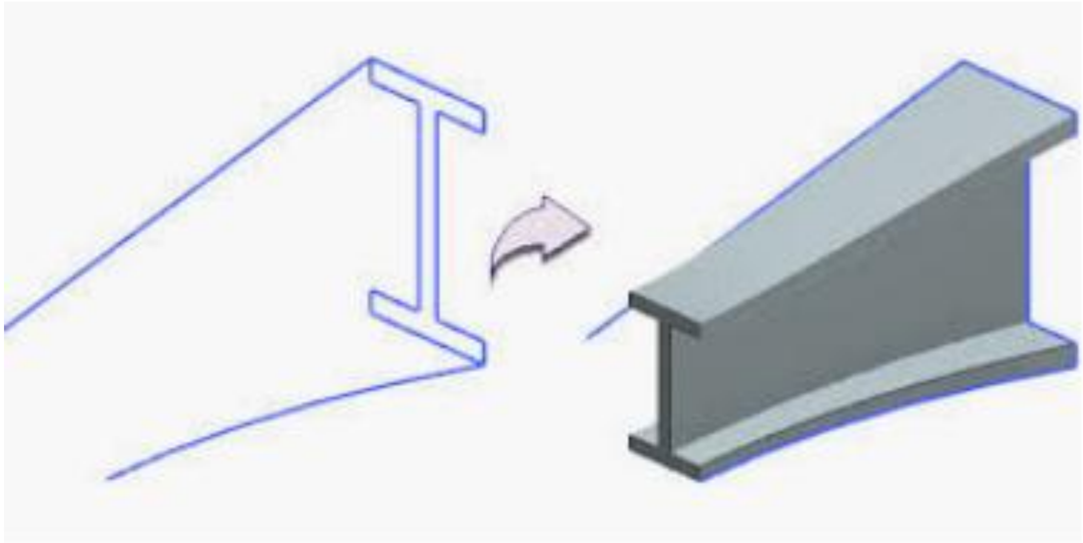
Sweeping is most convenient for solids with translational or rotational symmetry. Sweeping also has the capability to guarantee a closed object. Advanced: spatial sweeping; & varying cross-section





Sweeping – along guide curve





Boundary Representation (B-rep)

Boundary representation—often abbreviated as B-rep or BREP—is a method for representing shapes using the limits. A solid is represented as a collection of connected surface elements, the boundary between solid and non-solid.

Boundary Representation (B-rep)

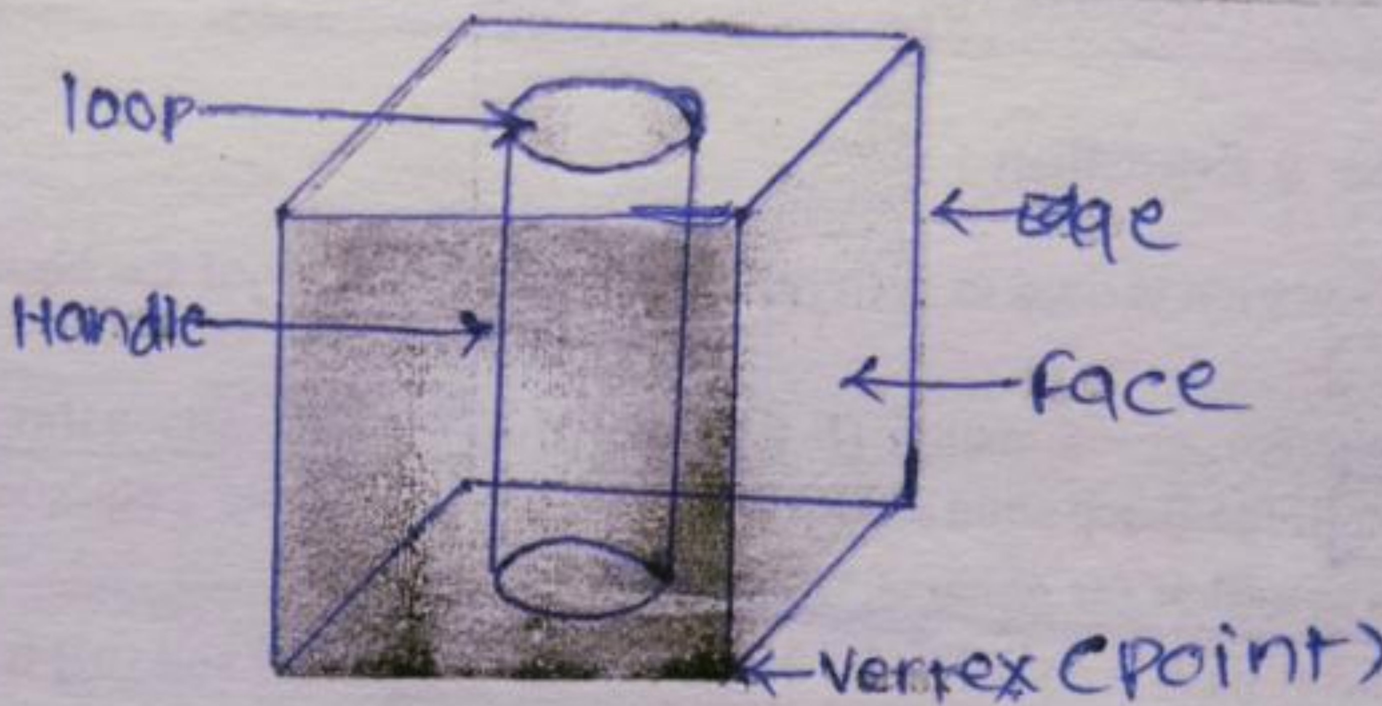


Fig. 5.4.1 : B-Rep Model of Object

A loop is a hole in a face. It is a two dimensional entity.

Boundary Representation (B-rep)

The boundary representation method represents a solid as a collection of boundary surfaces.

The database records both of the surface geometry and the topological relations among these surfaces.

Boundary representation does not guarantee that a group of boundary surfaces (often polygons) form a closed solid. The data are also not in the ideal form for model calculations.

Summary - Geometric Modeling

Geometric Modeling is a fundamental CAD technique.

The capability of various CAD tools in geometric modeling is usually used as a crucial factor in tool selection.

- **Wireframe models consist entirely of points, lines, and curves.**

Since wireframe models do not have “body knowledge”, topological data are not needed in construction.

Surface models store topological information of their corresponding objects.

Both surface models and solid models support shading.

Surface models is still ambiguous and thus cannot support a full range of engineering activities such as stress analysis.

Solid models have complete, valid and unambiguous spatial addressability.

In general, a wireframe model can be extracted from a surface or a solid model.

Wireframe Modeling - advantages

Advantages

1. Simple to construct
2. Does not require as much as computer time and memory as does surface or solid modeling (manufacturing display)
3. As a natural extension of drafting, it does not require extensive training of users.
4. Form the basis for surface modeling as most surface
5. algorithms require wireframe entities (such as points, lines and curves)

Wireframe Modeling - disadvantages

Disadvantages

1. The input time is substantial and increases rapidly with the complexity of the object
2. Both topological and geometric data need to be user-input; while solid modeling requires only the input of geometric data.
3. Unless the object is two-and-a-half dimensional, volume and mass properties, NC tool path generation, cross-sectioning, and interference cannot be calculated.

Surface Modeling - advantages

Advantages:

1. Less ambiguous
2. Provide hidden line and surface algorithms to add realism to the displayed geometry
3. Support shading
4. Support volume and mass calculation, finite element modeling, NC path generation, cross sectioning, and interference detection. (when complete)

Surface Modeling - disadvantages

- **Disadvantages**

1. **Require more training and mathematical background of the users.**
2. **Require more CPU time and memory.**
3. **Still ambiguous; no topological information.**
4. **Awkward to construct.**

CSG and Brep-comparison

1. CSG uses Euler operators in modeling.

2. CSG needs low storage due to the simple tree structure and primitives.

3. CSG primitives are constructed from the half-space concept.

4. Directed surfaces, Euler operations and Euler's law fundamentally distinguish the B-rep from wireframe modeling.

5. Traditionally, CSG cannot model sculptured objects and thus is limited in modeling capability.

(This is no longer true for Advanced CAD systems, such as creo)

6. It is easier to convert a CSG model to a wireframe model than to convert a B-rep model to a wireframe model.

7. Because both CSG and B-rep use face direction (half-space or surface normal), they can have a full “body knowledge.”

8. Generally speaking, most high-end CAD tools have the B-rep (or hybrid) method while most low-end tools rely heavily on the CSG method.

Curve Representation

Two types of representation are parametric and non-parametric representation.

In parametric representation all variables (i.e., coordinates) are expressed in terms of common parameters. For example, a point can be expressed with respect to a parameter as

$$P(u) = [x(u), y(u), z(u)], \quad u_{\mathrm{min}} \leq u \leq u_{\mathrm{max}}$$

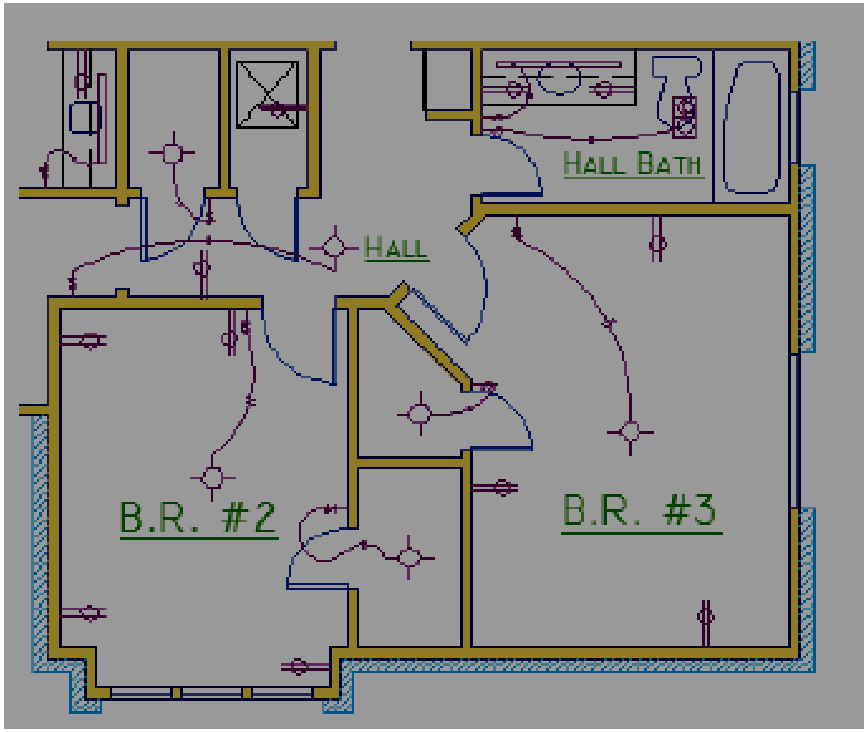
Non-parametric representation is the conventional representation as

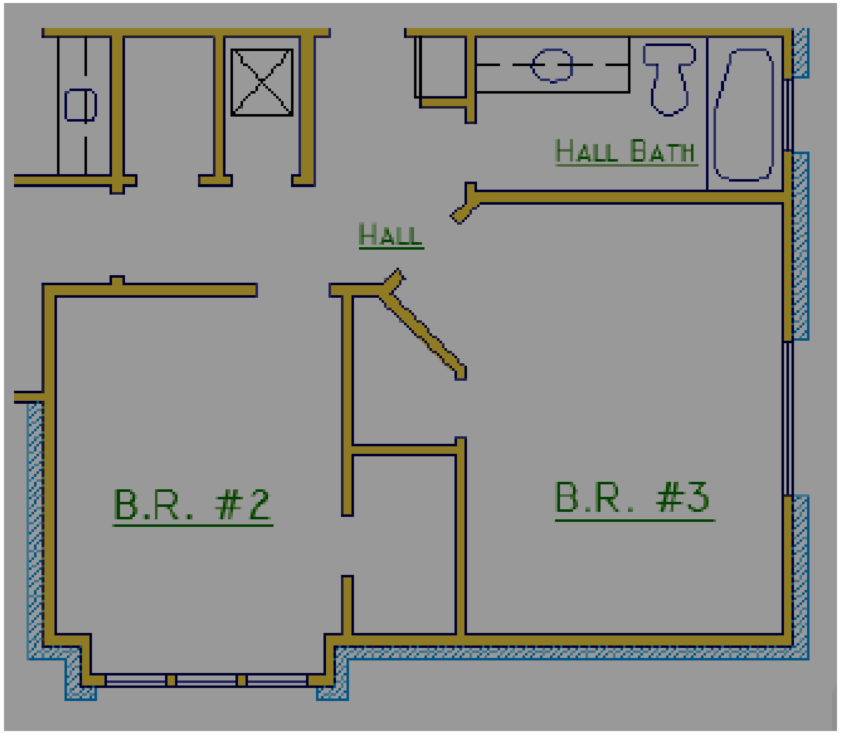
$$P = [x, y(x), z(x)]$$

Layers

1. Organize your drawing by assigning objects to layers.
2. When a drawing becomes visually complex, you can hide objects that you currently do not need to see.
3. You can assign properties such as color and line type to individual objects, or as default properties assigned to layers.

In the drawing below, the doors and electrical wiring were temporarily hidden by hiding their layers.





Maintain Your Standards

It's important to either establish or conform to a company-wide layer standard. With a layer standard, drawing organization will be more logical, consistent, compatible, and maintainable over time and across departments. Layer standards are essential for team projects.

If you create a standard set of layers and save them in a drawing template file, those layers will be available when you start a new drawing, and you can start working immediately. Additional information about drawing template files is presented in the Basics topic.

Display control commands

1. ZOOM

Increases or decreases the apparent size of objects in the current viewport

2. PAN

Shifts the location of a view

3. Redraw and Regen

Redraw refreshes the current view.

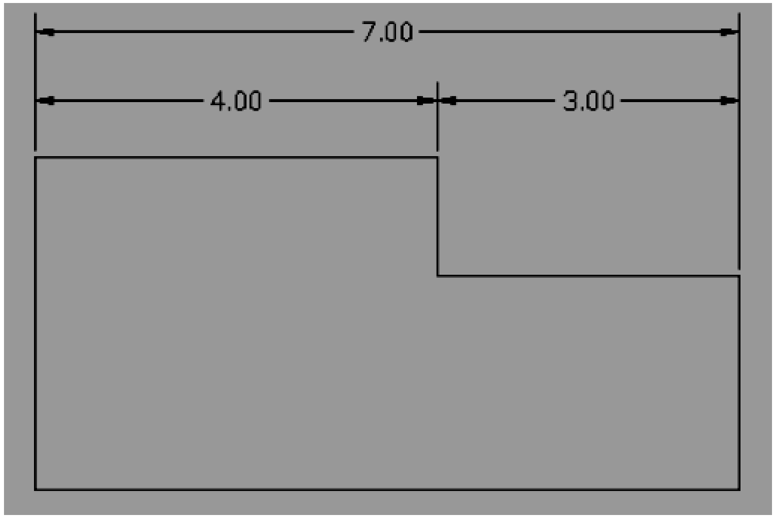
EDIT commands

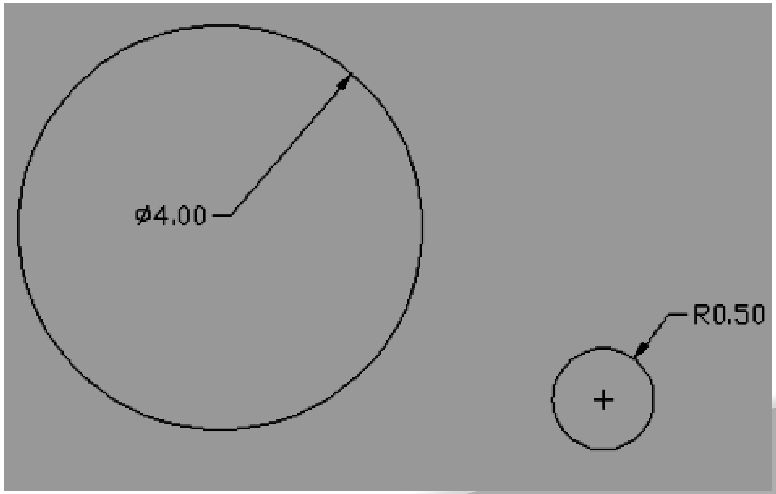
- Move (M+Enter)
- Rotate (RO+Enter)
- Copy (CO+Enter)
- Mirror (M+Enter)
- Stretch
- Scale (SC+Enter)
- Trim (TR+Enter)
- Extend (EX+Enter)
- Fillet (F+Enter)
- Chamfer (CHA+Enter)
- Blend Curves
- Offset (O+Enter)

- Array (AR+Enter)
- Explode
- Lengthen
- Break (BR+Enter)
- Break at point
- Join (J+Enter)
- Edit Hatch
- Edit Array
- Edit Polyline (PEdit+Enter)
- Edit Spline
- Erase (E+Enter)

Dimensioning command (DIM)

Creates multiple types
of dimensions within a single
command session. When you
hover over an object for
dimensioning, the
DIM command automatically
previews a
suitable dimension type to use.
Select objects, lines, or points
to dimension and click
anywhere in the drawing area
to draw the dimension.






LMX VII
TANAKA
CNC Laser Cutting Machine, Capacity upto 28 mm Thickness.

Numerical Control (NC) Defined

NC (numerical control) machine tools are the machine tool, of which the various functions are controlled by : letters , numbers and symbols.

The NC machine tool runs on a program fed to it; without human operator. The NC program consist of a set of instruction or statement for controlling the motion of the drives of the machine tools as well as the motion of the cutting tool.

NC machine tools, one or more of the following function may be automatic :

- Starting and stopping of the machine tool spindle;
- Controlling the spindle speed;
- Positioning the tool at the desired location and guiding it along the desired path by automatic control of the motion of slides;
- Controlling the feed rate; and
- Changing the tools.

Components of NC machine tool system

NC machine tools, one or more of the following function may be automatic :

Part program:-

- Using the part drawing and the cutting parameters, the part program is written.
- The part program is a set of step by instruction to the machine tool for carrying out the operation.

Method use for part programming

1. Manual part programming

2. Computer-aided part programming

2. Program Tape:-

- The part program is entered on the program tape.
- The program is entered on the tape in the form of punched holes. The holes are punched with the help of punching machine.

3. Machine Control Unit(MCU):-

- The program tape is read by the tape reader.
- The controller takes input from the tape reader.

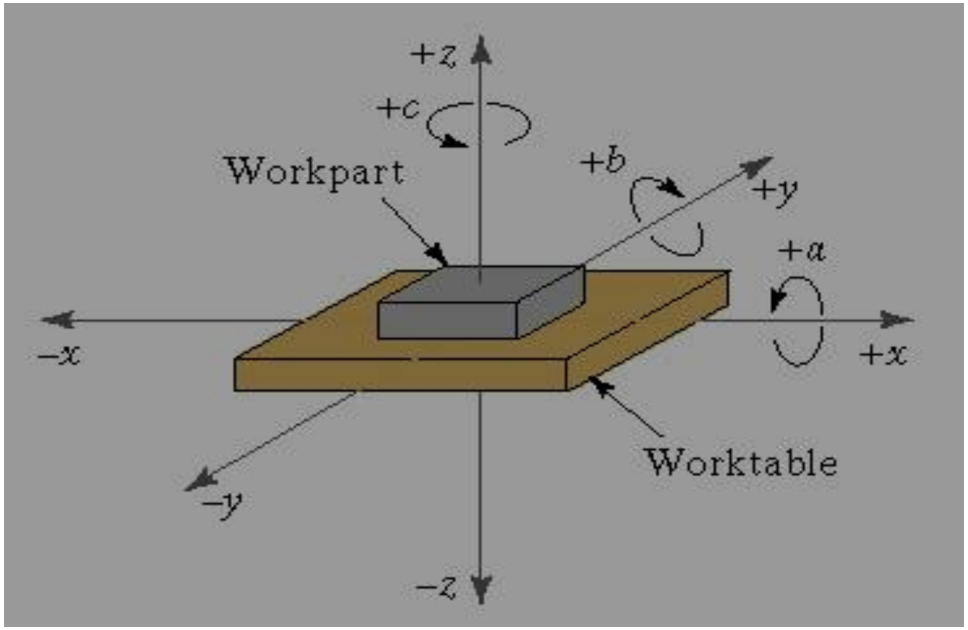
4. Machine Tool:-

- The machine tool is operated by the controller of the machine control unit.

NC Coordinate Systems

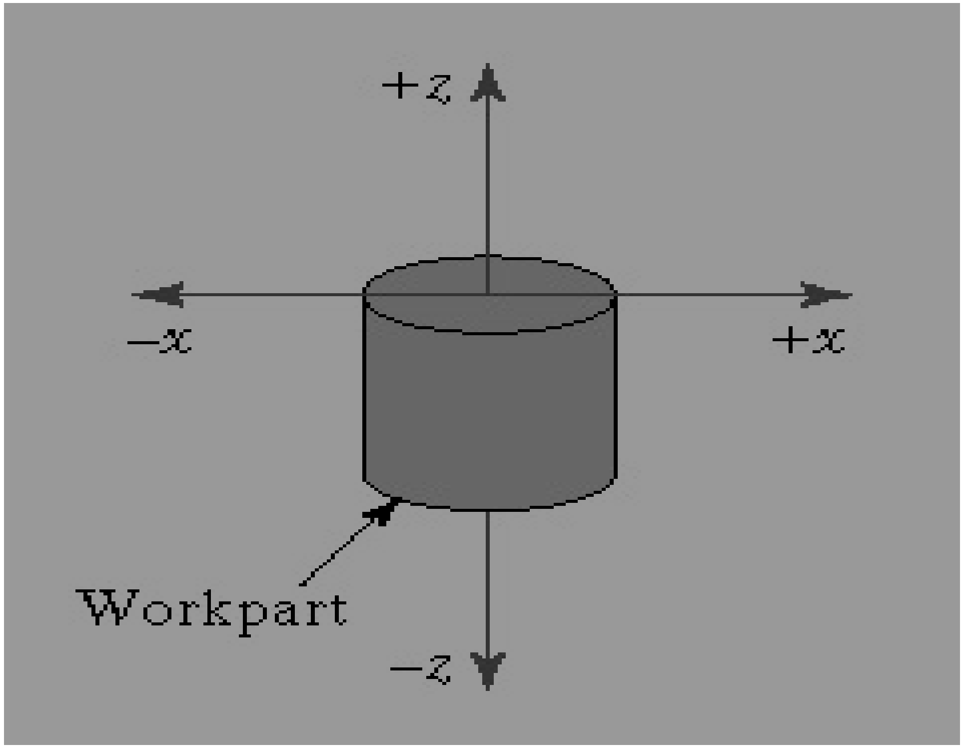
For flat and prismatic (block-like) parts:

- Milling and drilling operations
- Conventional Cartesian coordinate system
- Rotational axes about each linear axis



For rotational parts:

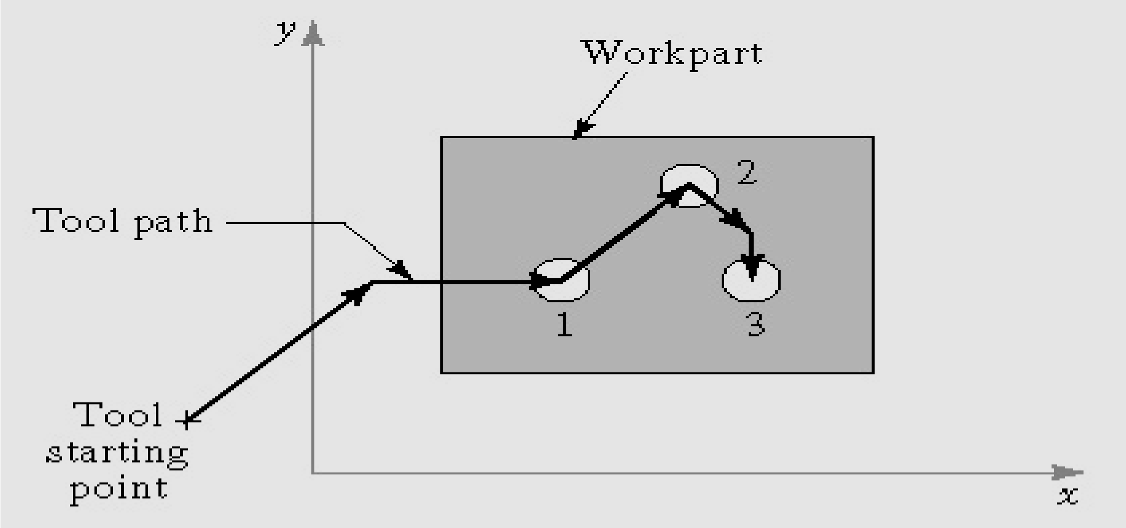
- Turning operations
- Only *x*- and *z*-axes



Motion Control Systems

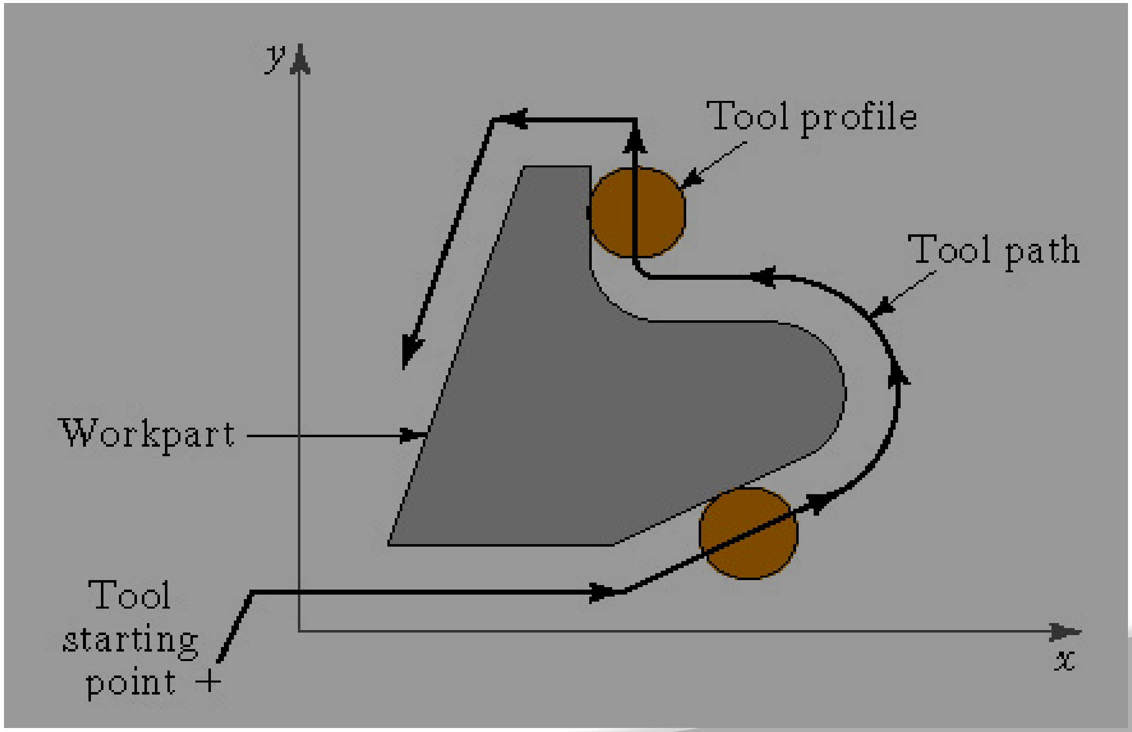
1. **Point-to-Point systems**

- **Also called position systems**
- **System moves to a location and performs an operation at that location (e.g., drilling)**
- **Also applicable in robotics**



2. Continuous path systems

- Also called contouring systems in machining
- System performs an operation during movement (e.g., milling and turning)



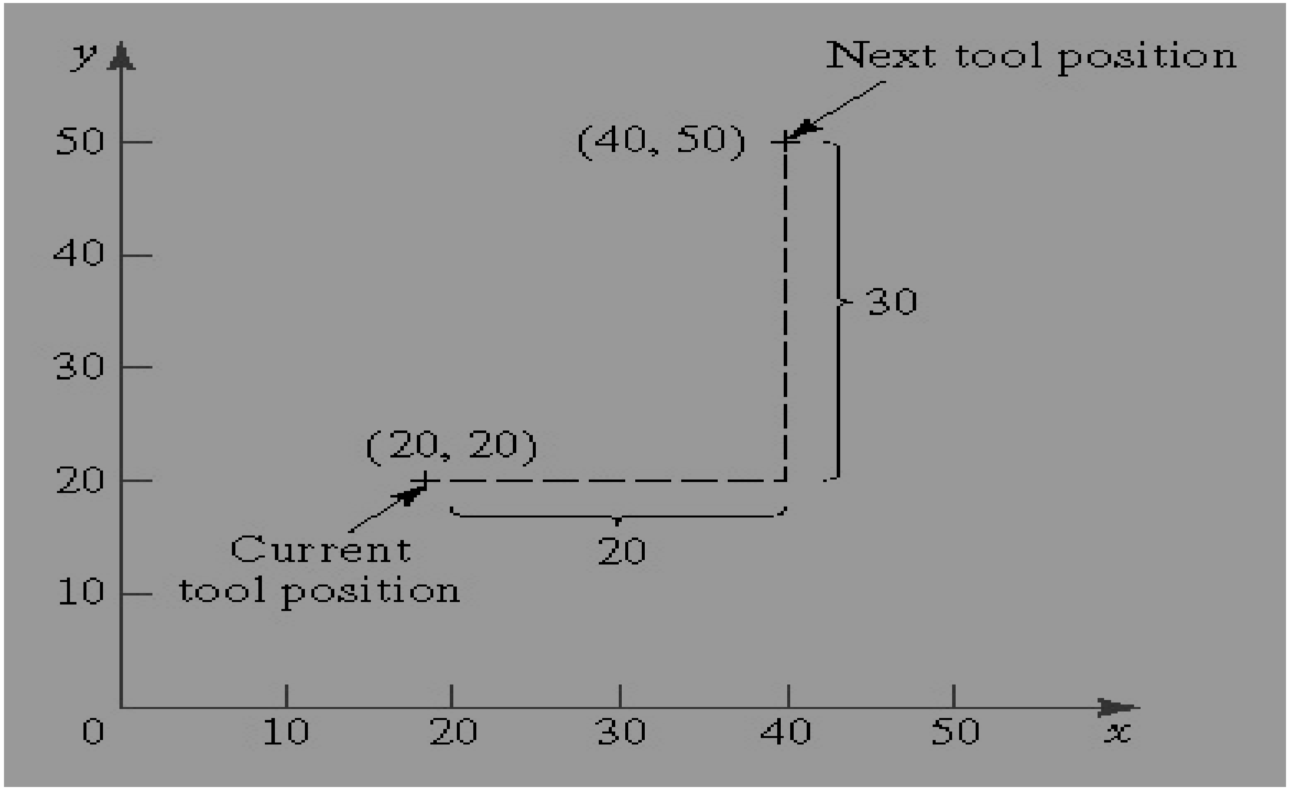
Absolute vs. Incremental Positioning

Absolute positioning

***Move is: x* = 40, *y* = 50**

Incremental positioning

***Move is: x* = 20, *y* = 30.**



Advantages of NC machine tool

- Cycle time reduction
- Complex machining operation
- High degree of accuracy
- Less inspection required
- Reduction of scrap and wastage
- Increasing productivity
- Lower tooling cost
- Reduction of human error
- Greater operation safety
- Greater operation efficiency
- Reduction space required
- Operator skill-level reduced

Limitation of NC machine tool

- High investment cost
- High maintenance effort
- Need for skilled programmers
- High utilization required

Introduction to CNC Machine Tools

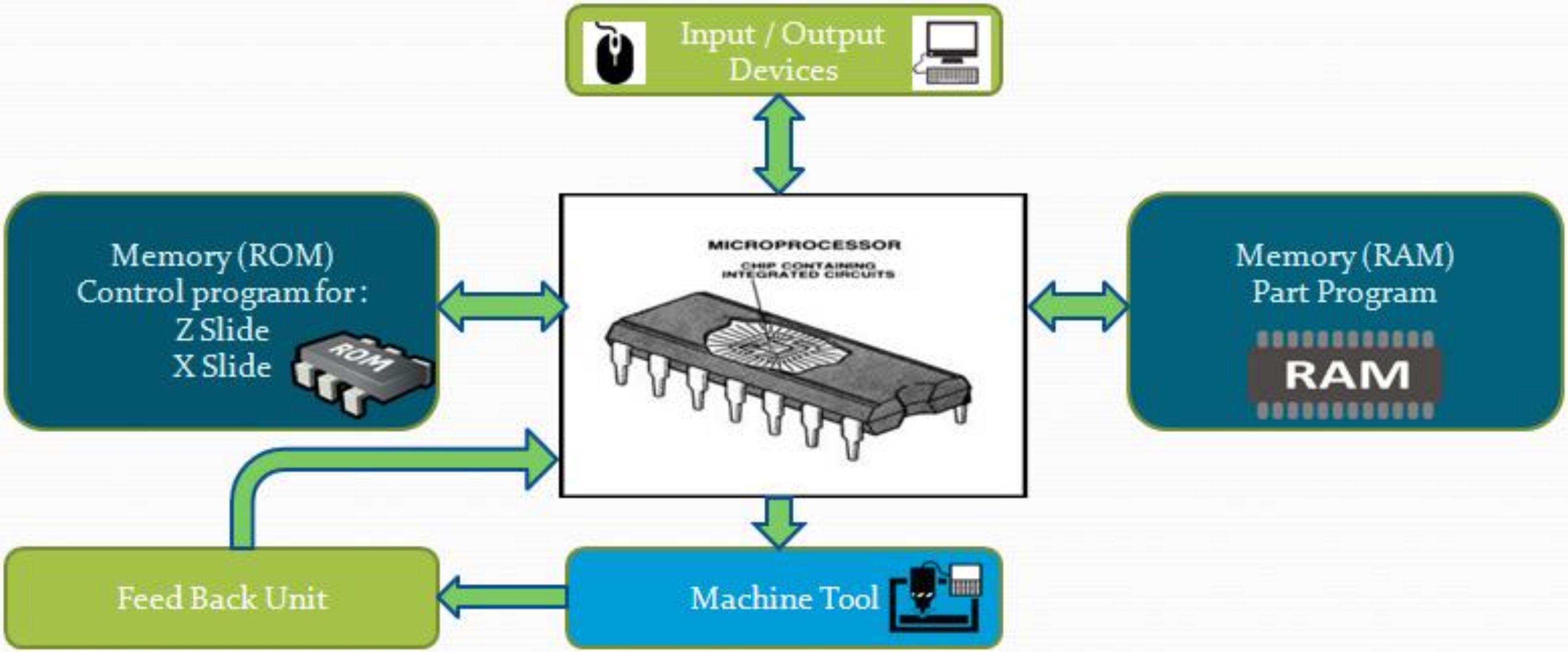
- CNC (Computer Numerical Control) machine is a NC machine which uses a dedicated computer as the machine control unit.
- The entire program is entered and stored in computer memory. The machining cycle for each component is controlled by the program contained in the computer memory.
- The stored part program listing can be used for future production also.

Components of CNC machine tool system

The main components of CNC machine tools are as follows :

1. **Input / Output Console.**
2. **Microprocessor Based control unit.**
3. **Memory.**
4. **Feedback unit.**
5. **Machine Tool.**
6. **Interfaces.**

CNC machine



CNC Machine - units

- **Input / Output Console : It is the unit through which part program is fed to the CNC machine tool system and required output is taken out. It basically consists of monitor and Keyboard.**

- **Microprocessor : This controller takes input from Input / Output device, Feedback from feedback unit and actuates the drives as well as the tool of the machine tool.**

Memory : It consists of RAM & ROM. The RAM stores part program, while ROM stores the programs for machine control.

Feedback unit : The feedback unit takes input from machine tool and transfers it to control unit for necessary corrections.

Machine tool : Machine tool is operated by the control unit.

Interfaces : They are the connections between the different components of the CNC machine tool system.

Classification of CNC Machine tool systems

(a) According to type of Feedback systems

1. Open loop type CNC machine.
2. Closed loop type CNC machine.

(b) According to type of tool motion control

1. Finite positioning control CNC machines.
2. Continuous path control CNC machines.

(c) According to program methods

1. Absolute Programming CNC machine systems.
2. Incremental Programming CNC machine systems.

(d) According to type of controller

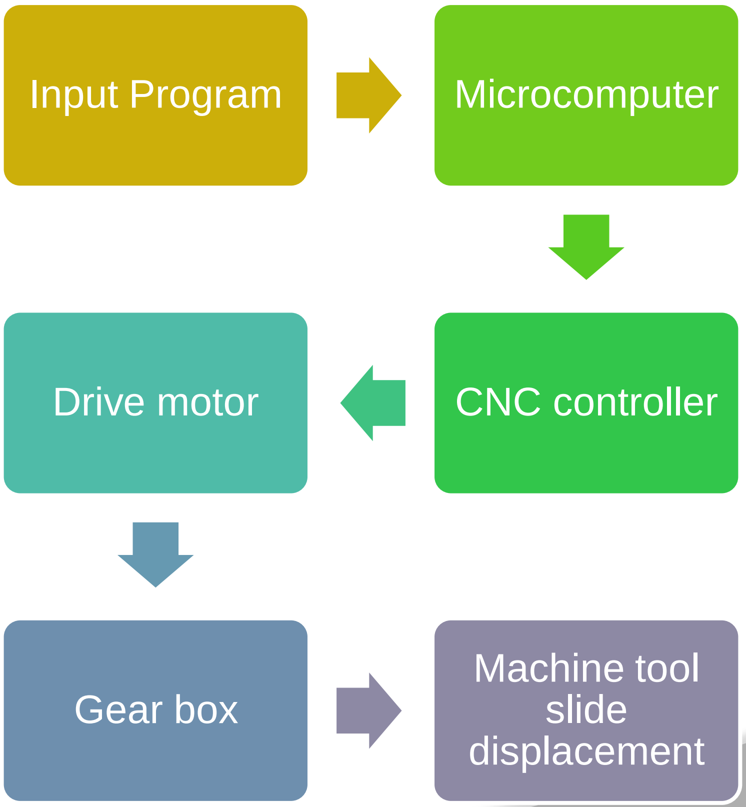
1. Hybrid controller CNC systems.
2. Straight controller CNC systems.

(e) According to axis & type of operations

1. CNC horizontal machining centre.
2. CNC vertical machining centre.
3. CNC turning centre.
4. CNC milling centre.

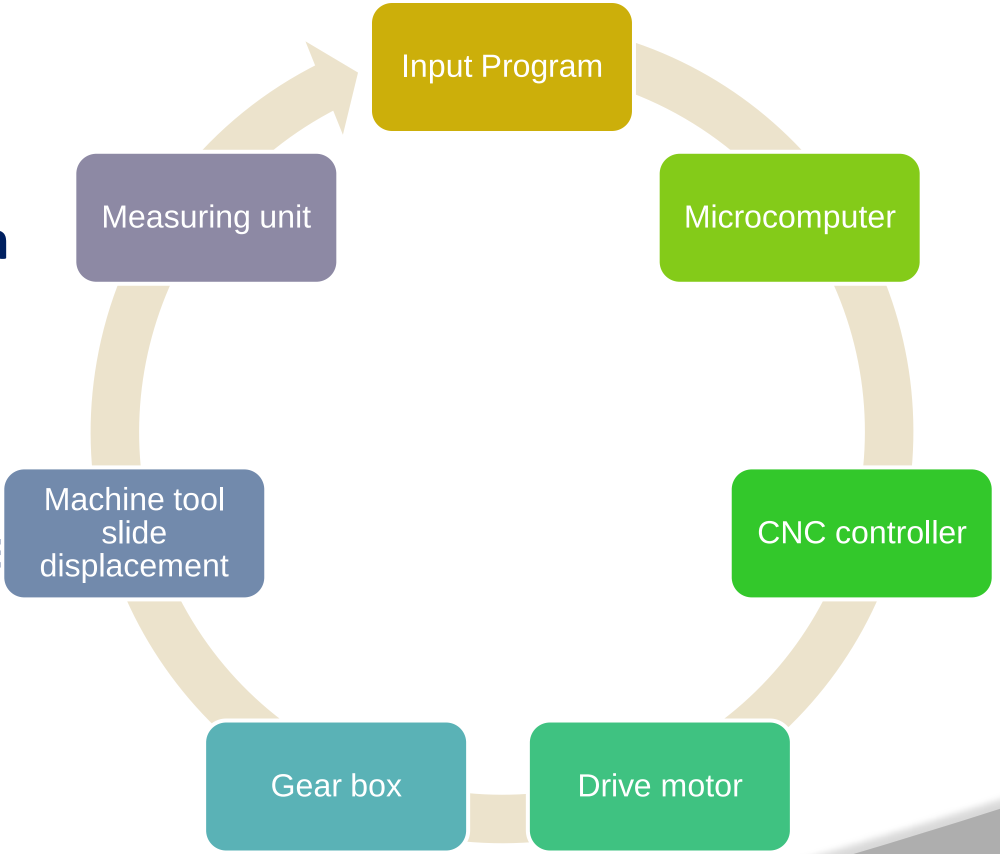
1. Open-Loop type CNC Machine

- **It does not have any feedback mechanism.**
- **It only has motion control but do not have any provision for feedback, which is needed to be compared with input for better control & correction of drive system.**



2. Closed-Loop type CNC Machine

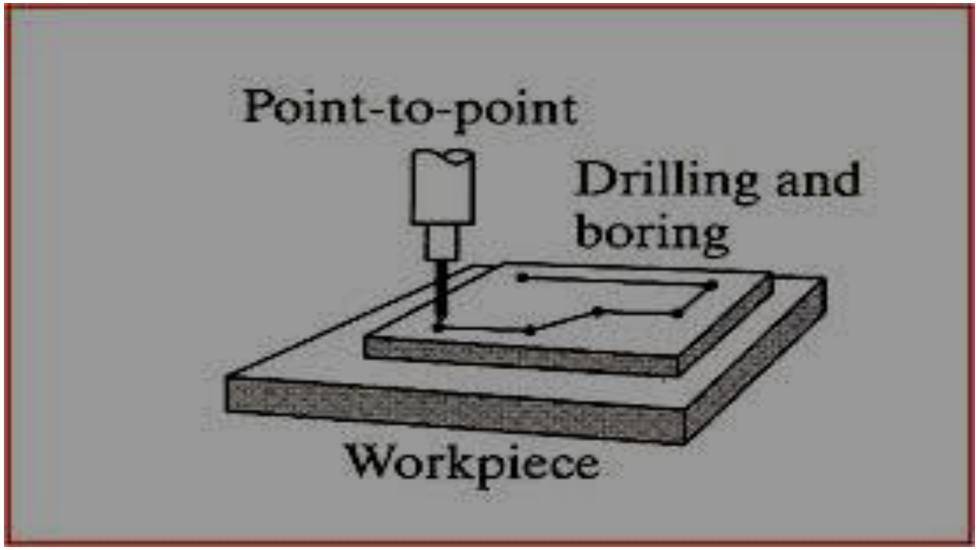
- It has a feedback mechanism.
- It has the motion control with a provision of feedback of motion control.
- Which can be used for accurately controlling the drive system by comparing it with the input information until the required or desired position is achieved.



According to type of tool motion control:

1. Finite positioning control CNC machines-point to point

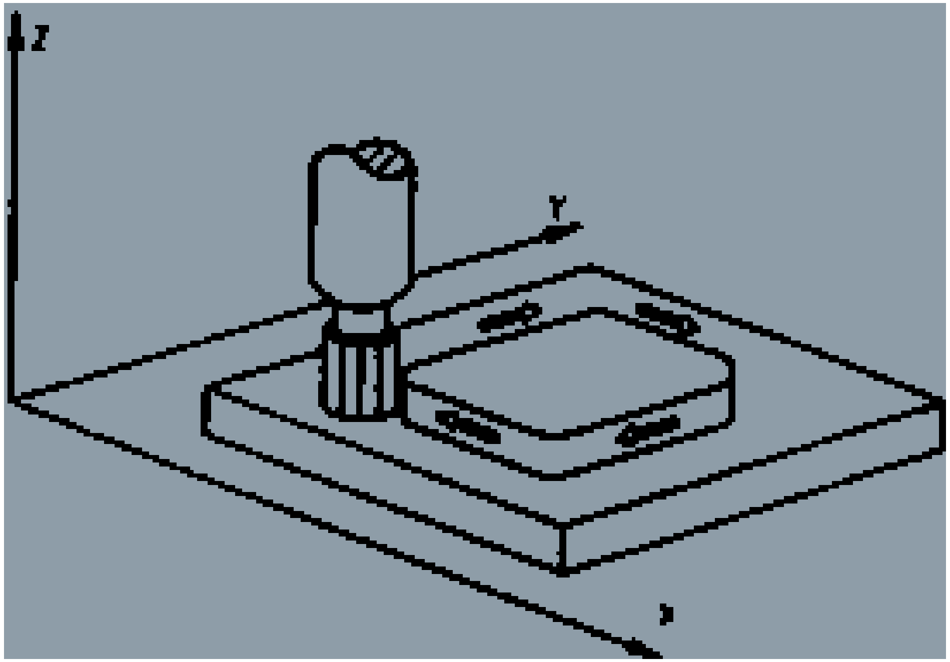
- In point to point CNC machines, the movement of cutting tool from one predefined position to another predefined position is important, while the path along which this tool moves is irrelevant. Commonly used in drilling & punching operations.



According to type of tool motion control

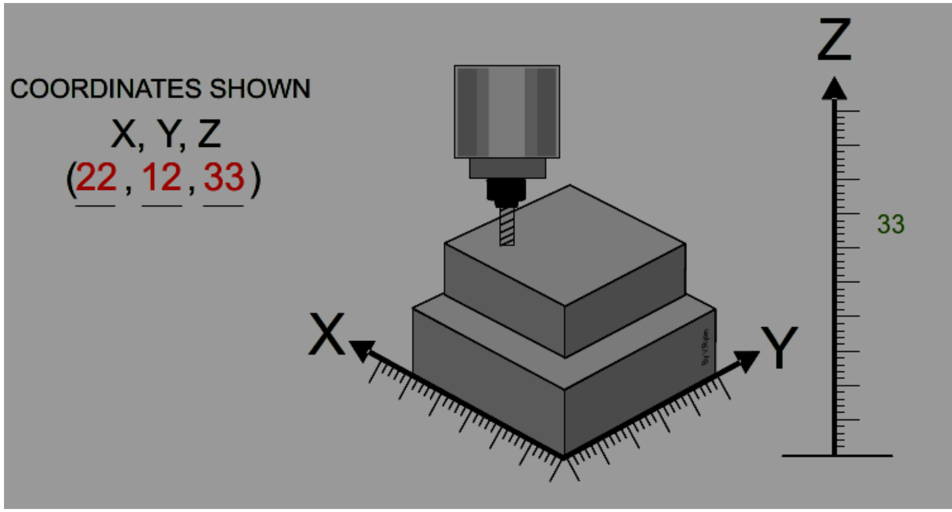
1. Finite positioning control CNC machines-straight cut

- **Straight cut line control mode is the extension version of point to point method, straight cut is obtained controlling the movement of tool with controlled feed rate in one of the axis direction at a time. Commonly used in Face milling, pocket milling and step turning operations.**



2. Continuous path control CNC machine

The continuous path control system is used for continuous, simultaneous & coordinated motions of cutting tool & work piece along different axes.



Such motion enables machining of different contoured profiles & curved surfaces.

Types : 2 axis, 2 ½ axis, 3 axis, Multi axis countering.

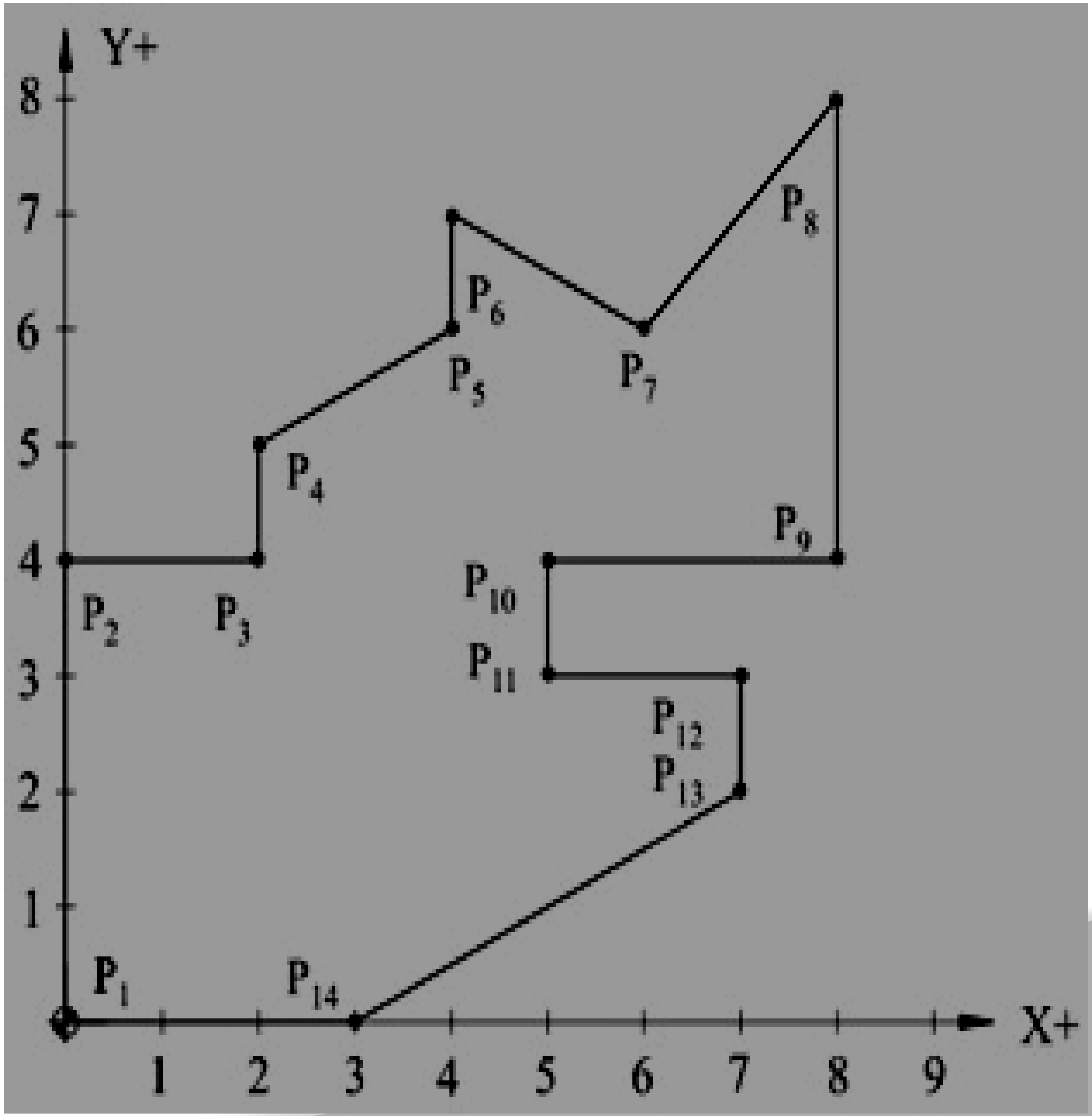
According to programming Methods

1. Absolute programming CNC machine systems

- In Cartesian coordinate geometry system using absolute measurement, each point is always specified using same zero established for a given coordinate system.

Example-Absolute

X	Y
0	0
0	4
2	4
2	5
4	6
4	7
6	6
8	8
8	4
5	4



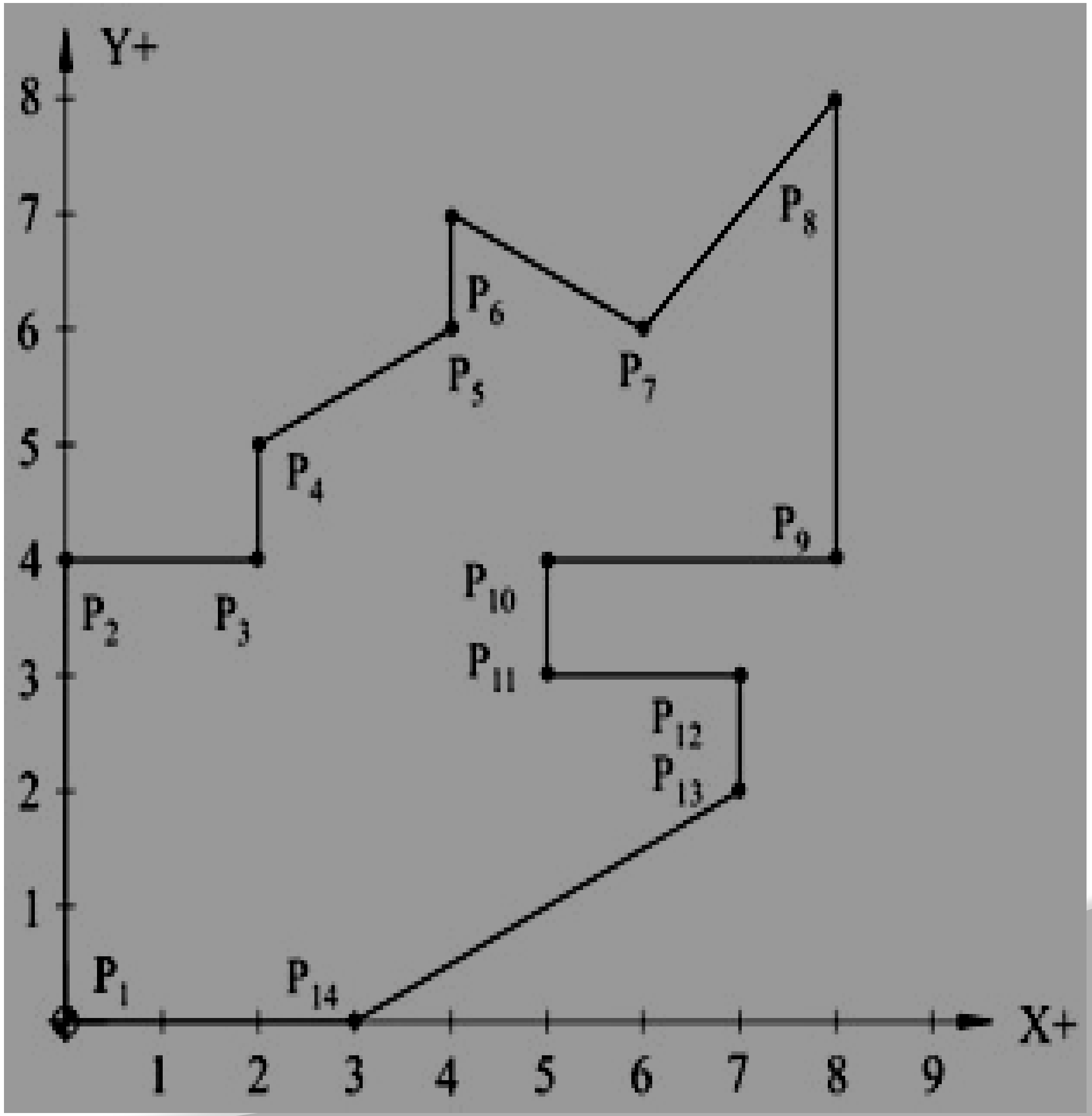
According to programming Methods

2. Incremental programming CNC machine systems

- In Cartesian coordinate geometry system using incremental measurement, each point is specified using the path differential from the preceding point position. So in such programming, controller must store and process additional path measurement.

Example-Incremental

X	Y
0	0
0	4
2	0
0	1
2	1
0	1
2	-1
2	2
0	-4
-	-

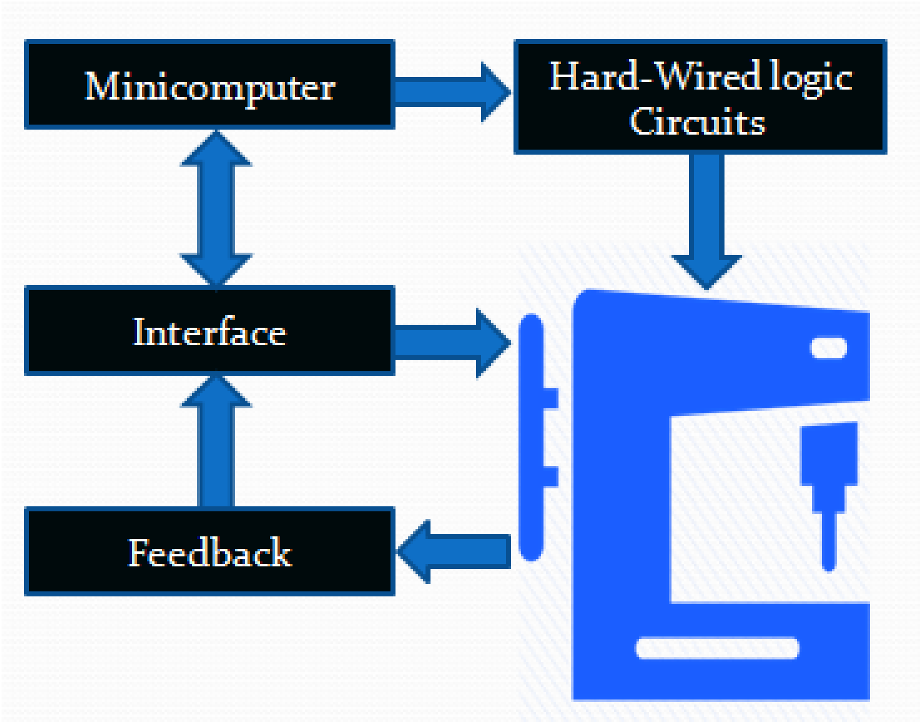


According to type of controllers

1. Hybrid controller CNC systems

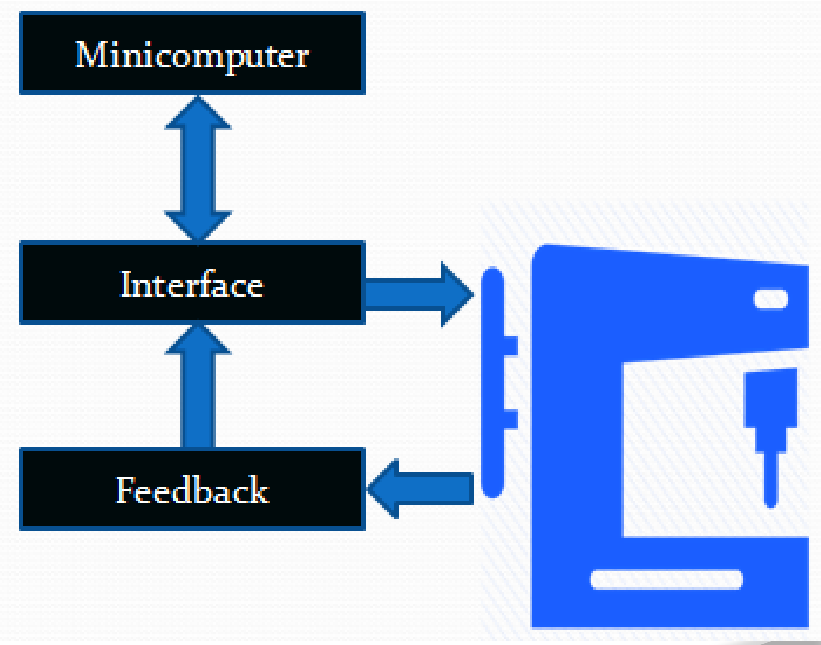
Hard wired logic circuits : It performs those functions for which they are best suited, such as feed rate generation and interpolation.

Soft wired computer : The computer performs the remaining control functions plus other duties not normally associated with a conventional hard-wired controller.



2. Stage controller CNC systems

- It uses a computer to perform all the functions.
- The interpolation, feed rate generation and all other functions are performed by the computer with the help of software.
- The only hard-wired elements are those required to interface the computer with machine tool and operator's console.



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.

Programming Types:

1. **Manual part programming**
2. **Computer-assisted part programming**

1. Manual part programming

In manual part 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.

2. Computer-assisted part programming

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

Standard G and M Codes

The most common codes used when programming NC machines tools are G-codes (preparatory functions), and M codes (miscellaneous functions).

Other codes such as F, S, D, and T are used for machine functions such as feed, speed, cutter diameter offset, tool number,

some of important codes with their functions

G-Codes (Preparatory Functions)

G00	Rapid positioning
G01	Linear interpolation
G02	Circular interpolation clockwise (CW)
G03	Circular interpolation counterclockwise (CCW)
G20	Inch input (in.)
G21	Metric input (mm)
G90	Absolute programming
G91	Incremental programming

M codes (miscellaneous functions)

M00	Program stop
M02	End of program
M03	Spindle start (forward CW)
M04	Spindle start (reverse CCW)
M05	Spindle stop
M06	Tool change
M08	Coolant on
M09	Coolant off
M99	End of subprogram

GT is a manufacturing philosophy in which similar parts are identified and grouped together to take advantage of their similarities in design and production

Where to implement GT?

- **Plants using traditional batch production and process type layout**
- **If the parts can be grouped into part families**

How to implement GT?

- **Identify part families**
- **Rearrange production machines into machine cells**

- An approach to manufacturing in which similar parts are identified and grouped together in order to take advantage of their similarities in design and production
- Similarities among parts permit them to be classified into part families
- In each part family, processing steps are similar
- The improvement is typically achieved by organizing the production facilities into manufacturing cells that specialize in production of certain part families

Part Family

- A group of parts that possess similarities in geometric shape and size, or in the processing steps used in their manufacture
- Part families are a central feature of group technology
- There are always differences among parts in a family
- But the similarities are close enough that the parts can be grouped into the same family

Introduction to Group Technology (GT)

- Group Technology (GT) is a manufacturing philosophy in which similar parts are identified and grouped together to make advantage of their similarities in design and production.

- Similar parts bare arranged into part families, where each part family possesses similar design and/or manufacturing characteristics.

- Grouping the production equipment into machine cells, where each cell specializes in the production of a part family is called cellular manufacturing.

Implementing Group Technology (GT)

- **There are two major tasks that a company must undertake when it implements Group Technology.**

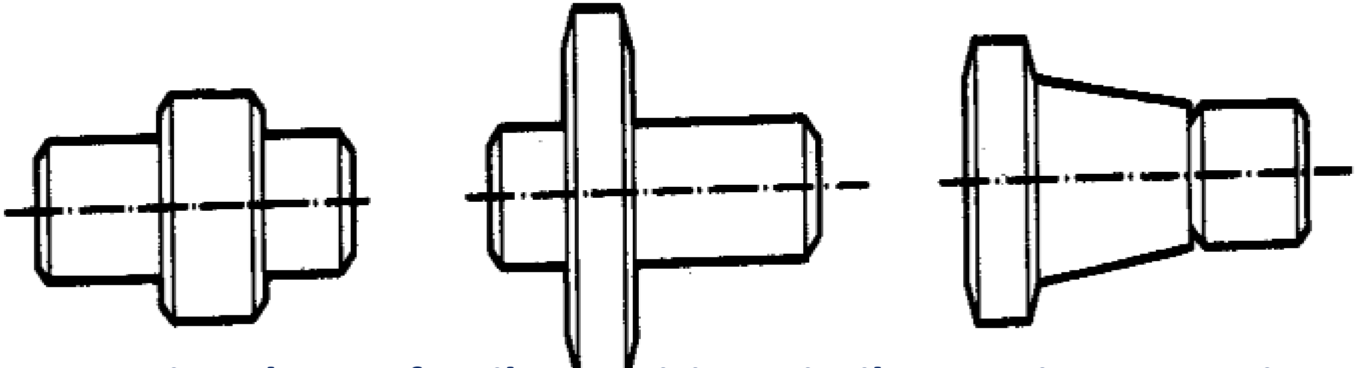
1. **Identifying the part families. If the plant makes 10,000 different parts, reviewing all of the part drawings and grouping the parts into families is a substantial task that consumes a significant amount of time.**
2. **Rearranging production machines into cells. It is time consuming and costly to plan and accomplish this rearrangement, and the machines are not producing during the changeover.**

Benefits of Group Technology (GT)

- GT promotes standardization of tooling, fixturing and setups.
- Material handling is reduced because parts are moved within a machine cell rather than within the entire factory.
- Process planning and production scheduling are simplified.
- Setup times are reduced, resulting in lower manufacturing lead times

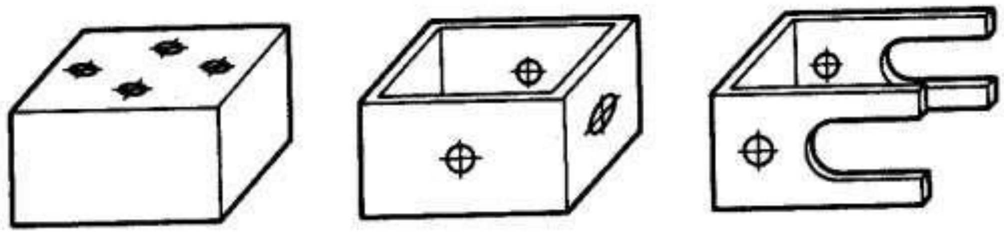
Part Families

- A part family is a collection of parts that 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 inclusion as members of the part family.

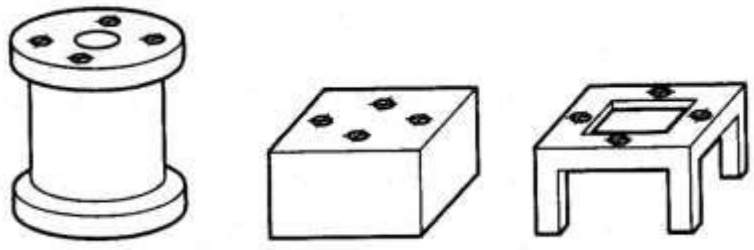


Rotational part family requiring similar turning operations

Part Families



Similar prismatic parts requiring similar milling operations



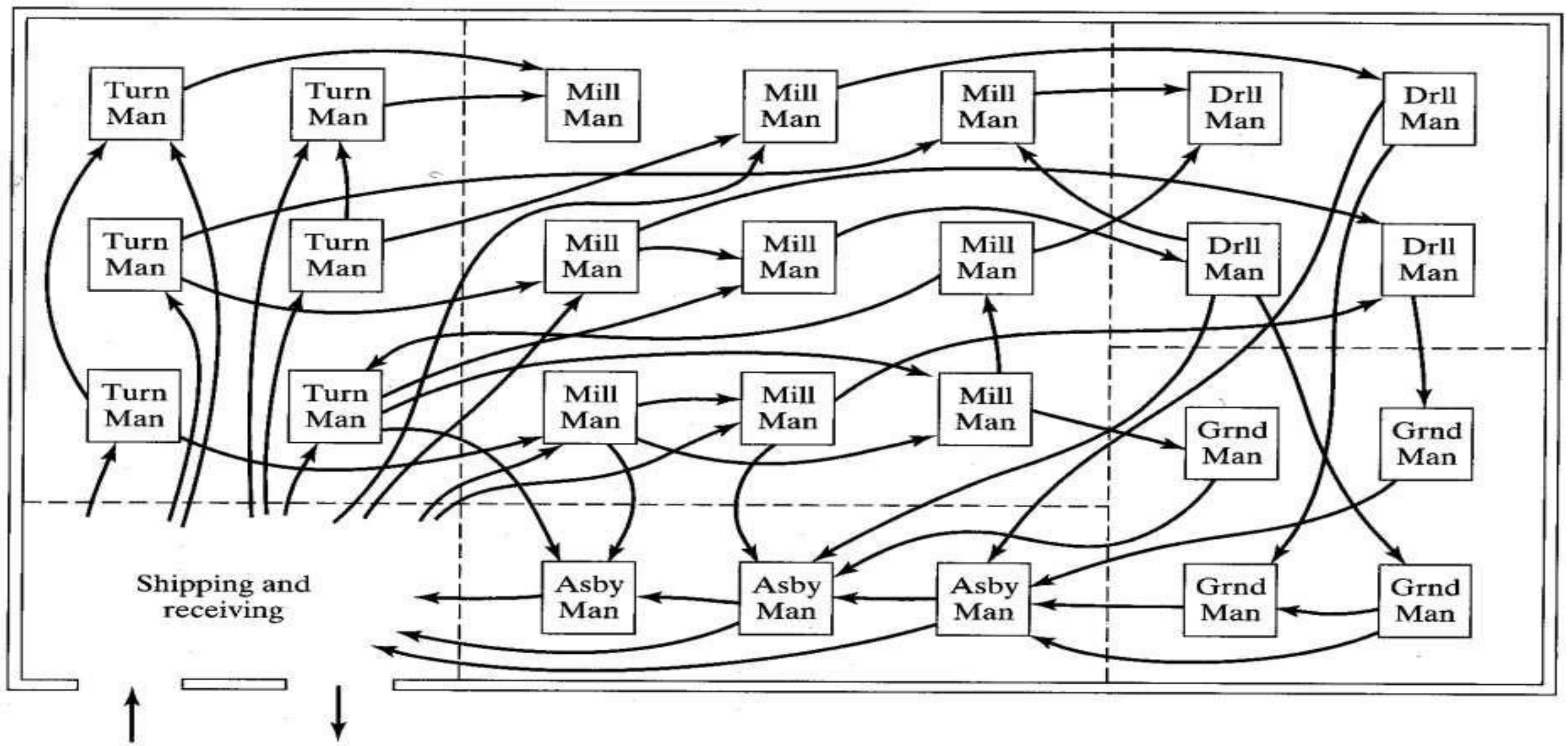
Dissimilar parts requiring similar machining operations (hole drilling, surface milling

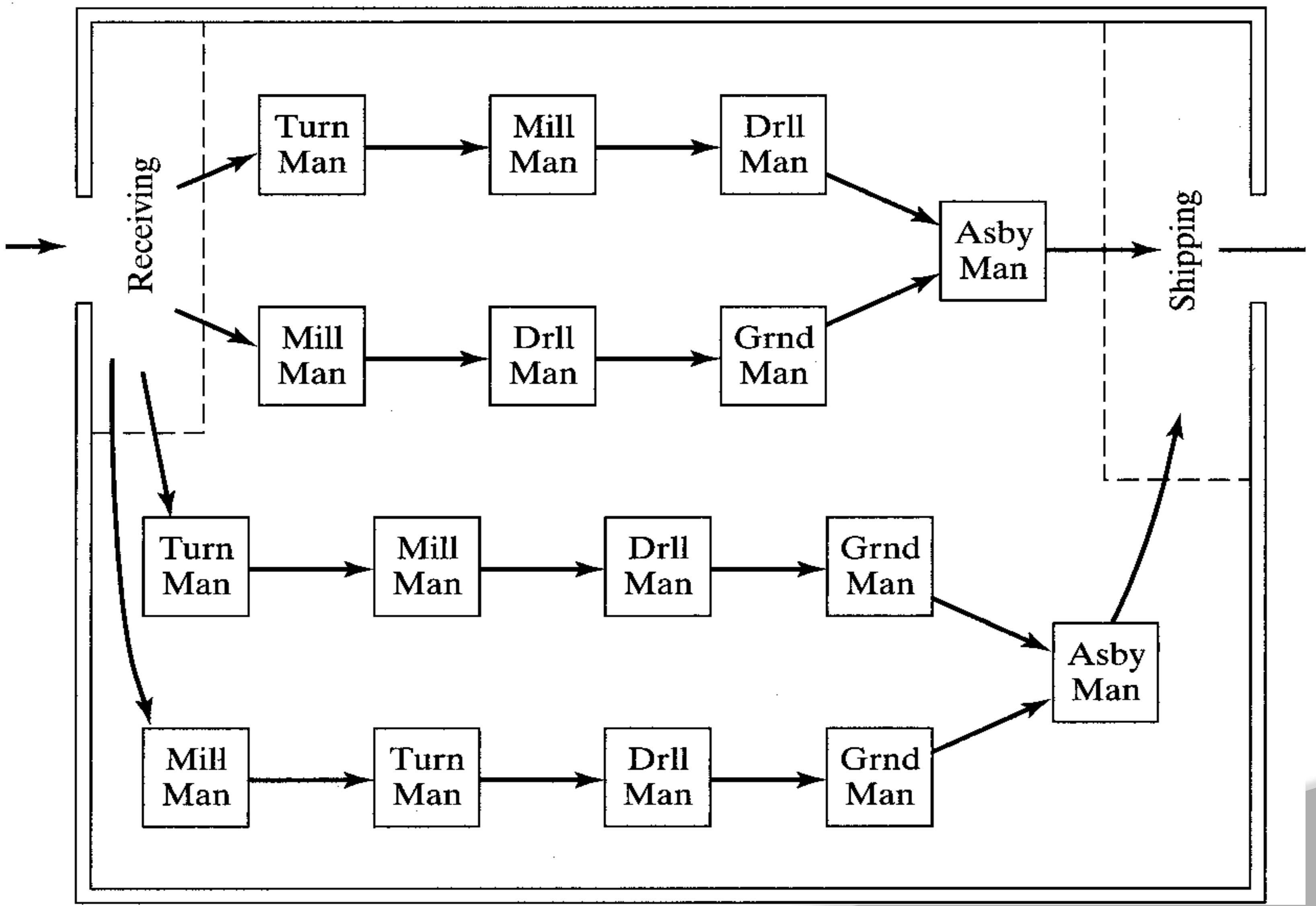
Material: Plastic

Material: Steel

Identical designed parts requiring completely different manufacturing processes

One of the important manufacturing advantages of grouping can be explained with reference to figures below



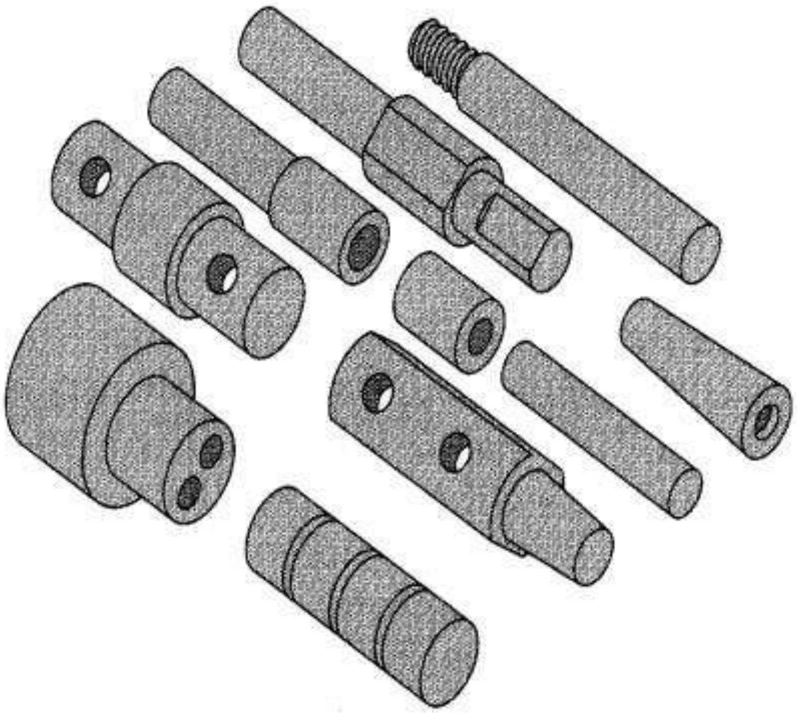

Receiving
Turn Man
Mill Man
Drll Man
Mill Man
Drll Man
Grnd Man
Asby Man
Shipping
Turn Man
Mill Man
Drll Man
Grnd Man
Mill Man
Turn Man
Drll Man
Grnd Man
Asby Man

Grouping Part Families

There are three general methods for solving part families grouping. All the three are time consuming and involve the analysis of much of data by properly trained personnel

- **The three methods are:**
  1. **Visual inspection.**
  2. **Parts classification and coding.**
  3. **Production flow analysis.**

- **The visual inspection method is the least sophisticated and least expensive method.**
- **It involves the classification of parts into families by looking at either the physical parts or their photographs and arranging them into groups having similar features.**



2-2- Parts classification and Coding

- **In parts classification and coding, similarities among parts are identified, and**

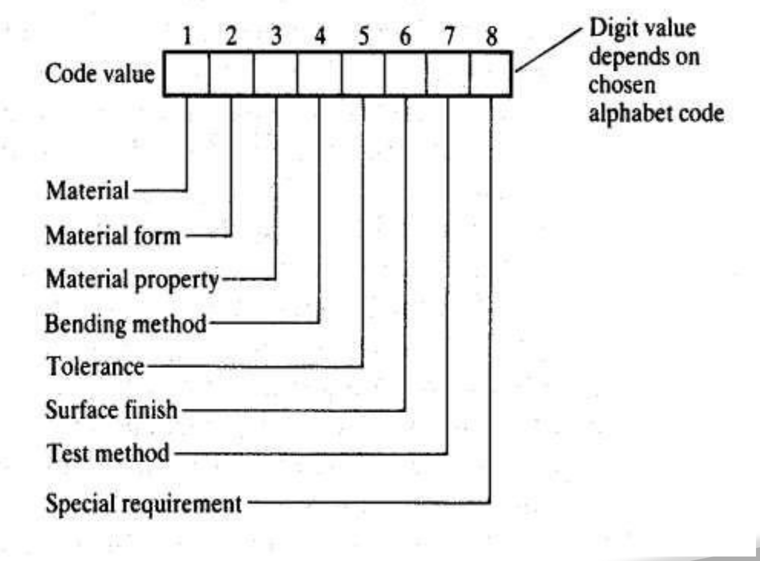
these similarities are related in a coding system.

- **Two categories of part similarities can be distinguished:**

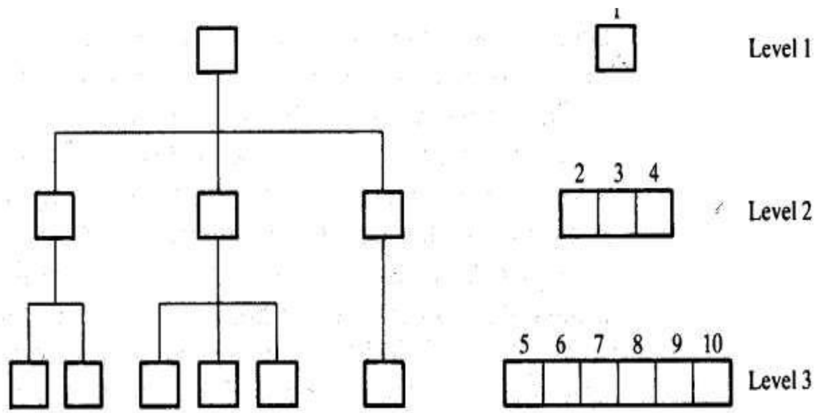
1.Design attributes, which concerned with part characteristics such as geometry, size and material.

2.Manufacturing attributes, which consider the sequence of processing steps required to make a part.

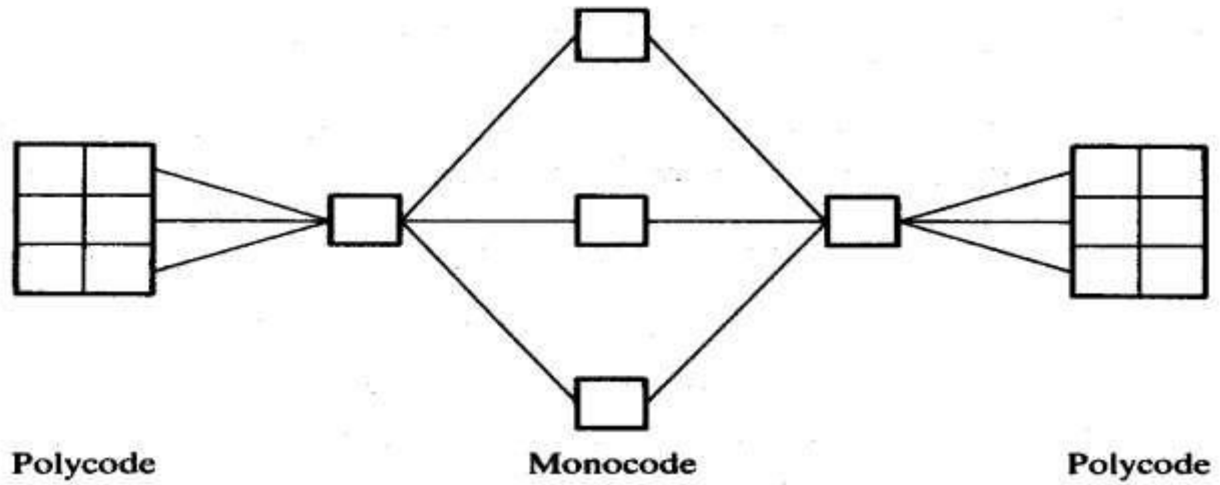
- coding system consists of a sequence of symbols that identify the part's design and/or manufacturing attributes.
- The symbols are usually alphanumeric, although most systems use only numbers.
- The three basic coding structures are:
  1. Chain-type structure, also known as a polycode, in which the interpretation of each symbol in the sequence is always the same, it does not depend on the value of the preceding symbols.



2.Hierarchical structure, also known as a monocode, in which the interpretation of each successive symbol depends on the value of the preceding symbols.

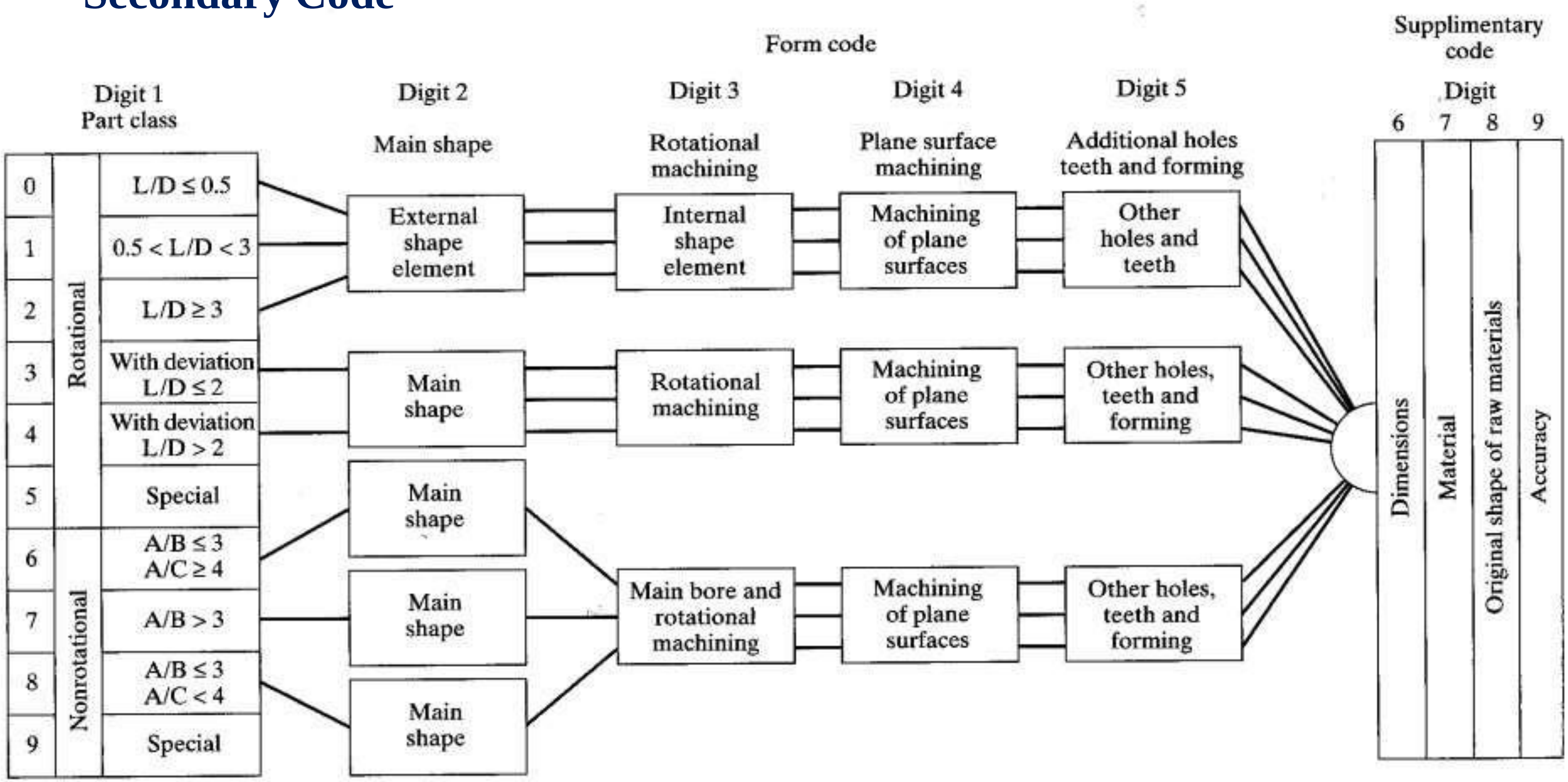


3 *Hybrid structure*, a combination of hierarchical and chain-type structures



Opitz Classification and Coding System

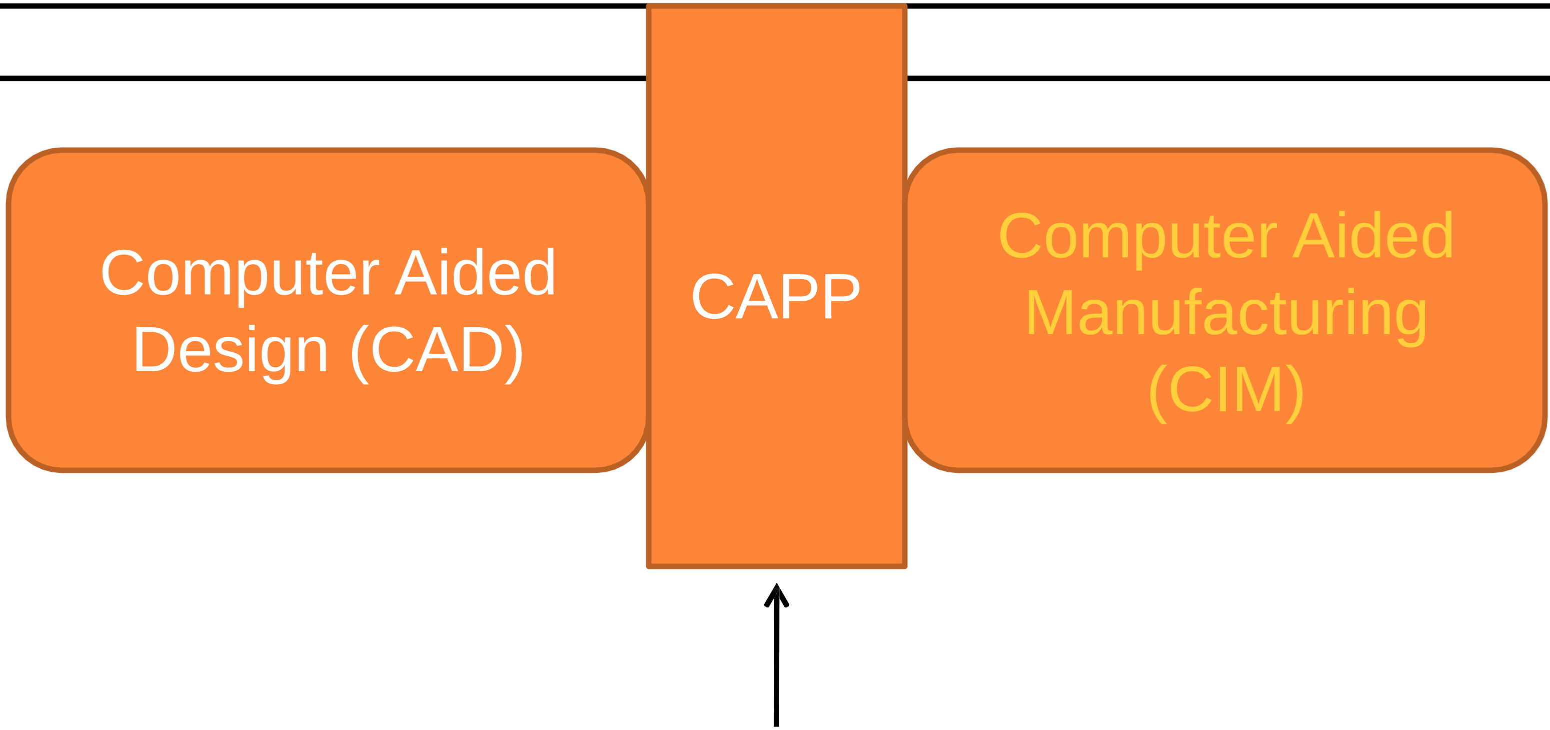
- **Form Code**
- **Supplementary Code**
- **Secondary Code**



COMPUTER AIDED PROCESS PLANNING (CAPP)

- **CAPP is the use of computer technology to aid in the process planning of a part or product in manufacturing.**
- **CAPP is the link between CAD and CAM in that it provides for the planning of the process to be used in producing a designed part.**
- **Process planning is a production organization activity that transforms a product design into a set of instruction (sequence, machine tool setup etc.) to manufacture machined part economically and competitively**

FLOW CHART OF CAPP

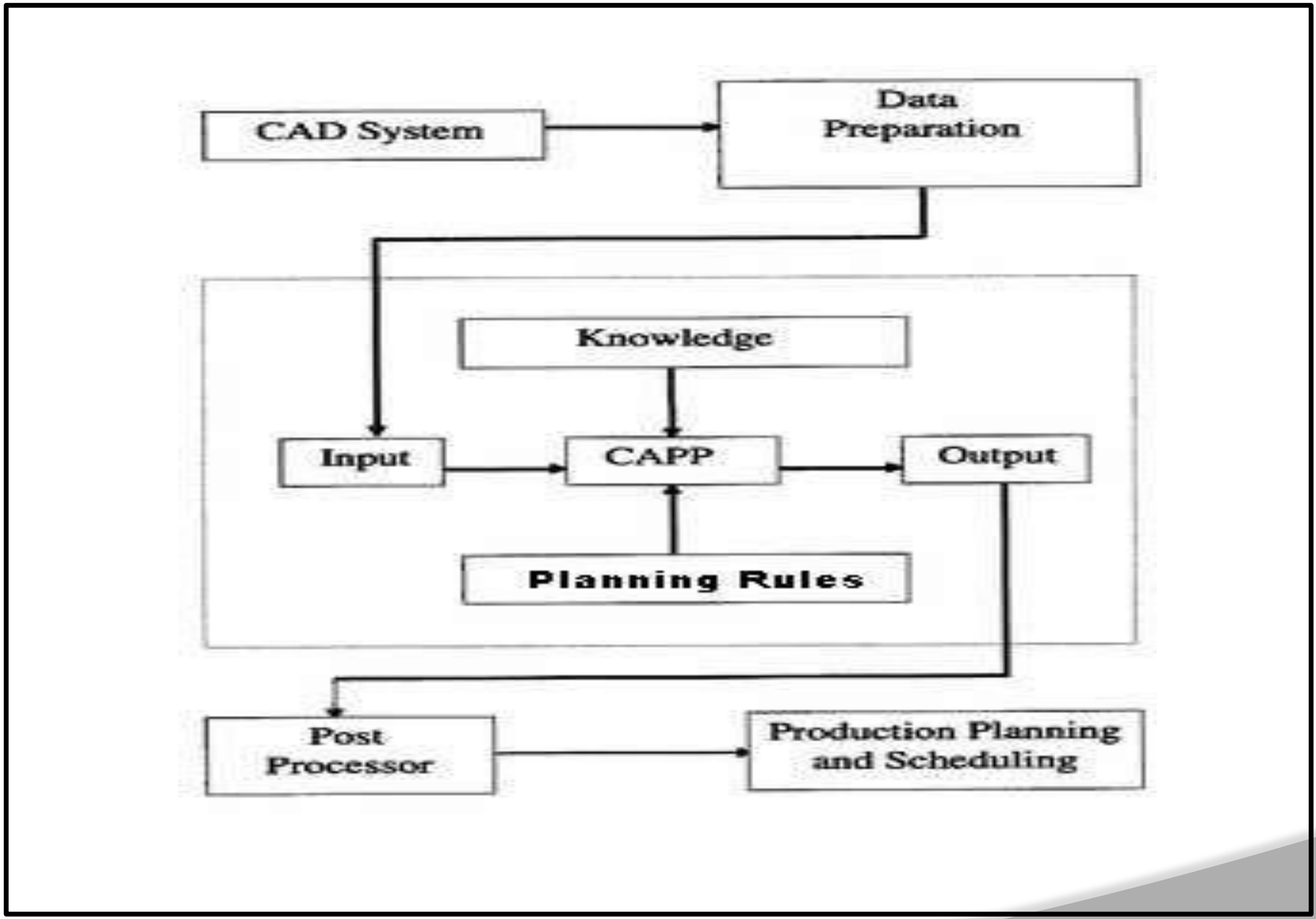


Synergy results in when CAM is integrated with CAD to form CAM/CAD system than stand alone CAD or CAM system. In such a system CAPP becomes a direct connection between design and manufacturing

COMPUTER AIDED PROCESS PLANNING (CAPP) ROLES IN MANUFACTURING

- **Used to develop a product manufacturing plan based on projected variables such as cost, lead times, equipment availability, production volumes, potential material substitution routings and testing requirements.**
- **CAPP is a decision-making process, it determines a set of instruction and machining parameters required to manufacture a part.**
- **Integrates and optimizes system performance for every product/component to ensure functionality aspect and design specifications meet requirements.**

CAPP Model



CAD System
Data Preparation
Knowledge
Input
CAPP
Output
Planning Rules
Post Processor
Production Planning and Scheduling

Two method in Process Planning:-

The manual experience based planning method

- **The manual experience based process planning is most widely used**
- **It is mainly based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes and tooling.**

Two method in Process Planning:-

b) Computer Aided Process Planning

- **Purpose of process planning is to translate the design requirements into manufacturing process details**
- **A system was developed in which design information is processed by the process planning system to generate manufacturing process details.**

CAPP PROGRAMMING SOFTWARE

LISP

➢ **Is a functional programming language and offer flexibility in writing rules so that can use logical programming language .**

PROLOG

➢ **Programming in PROLOG involves writing logical formula which indicate logic relation in problem.**

Contribution CAPP in implementation of CIM

- **The improved quality can be achieved through better design and better quality control in the manufacturing control.**
- **Improved production scheduling, improved cost estimating procedures and fewer calculation errors.**
- **The system will be more efficient and organized in engineering, production, marketing, and support functions of a manufacturing.**

Block Diagram for Variant CAPP

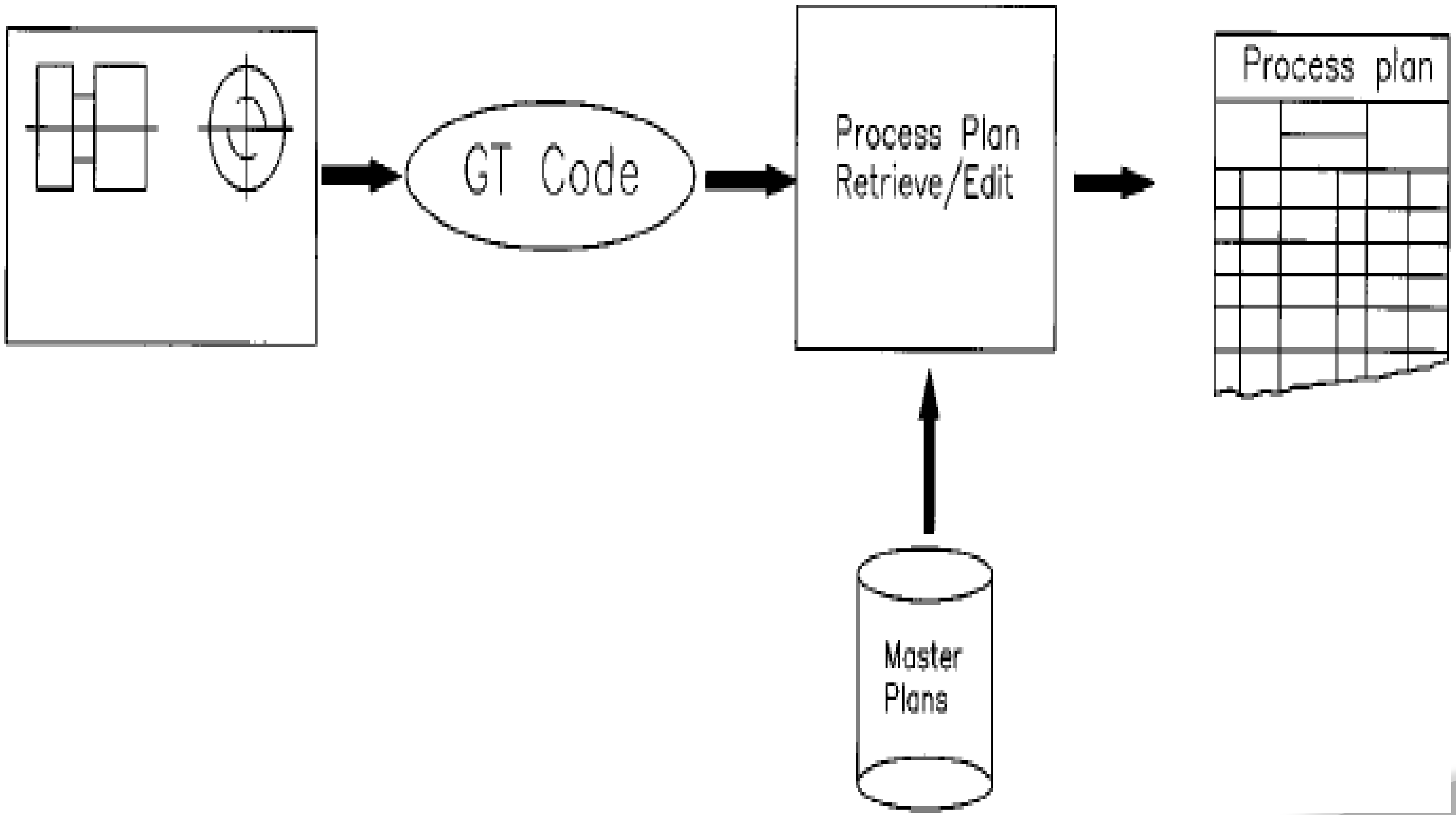
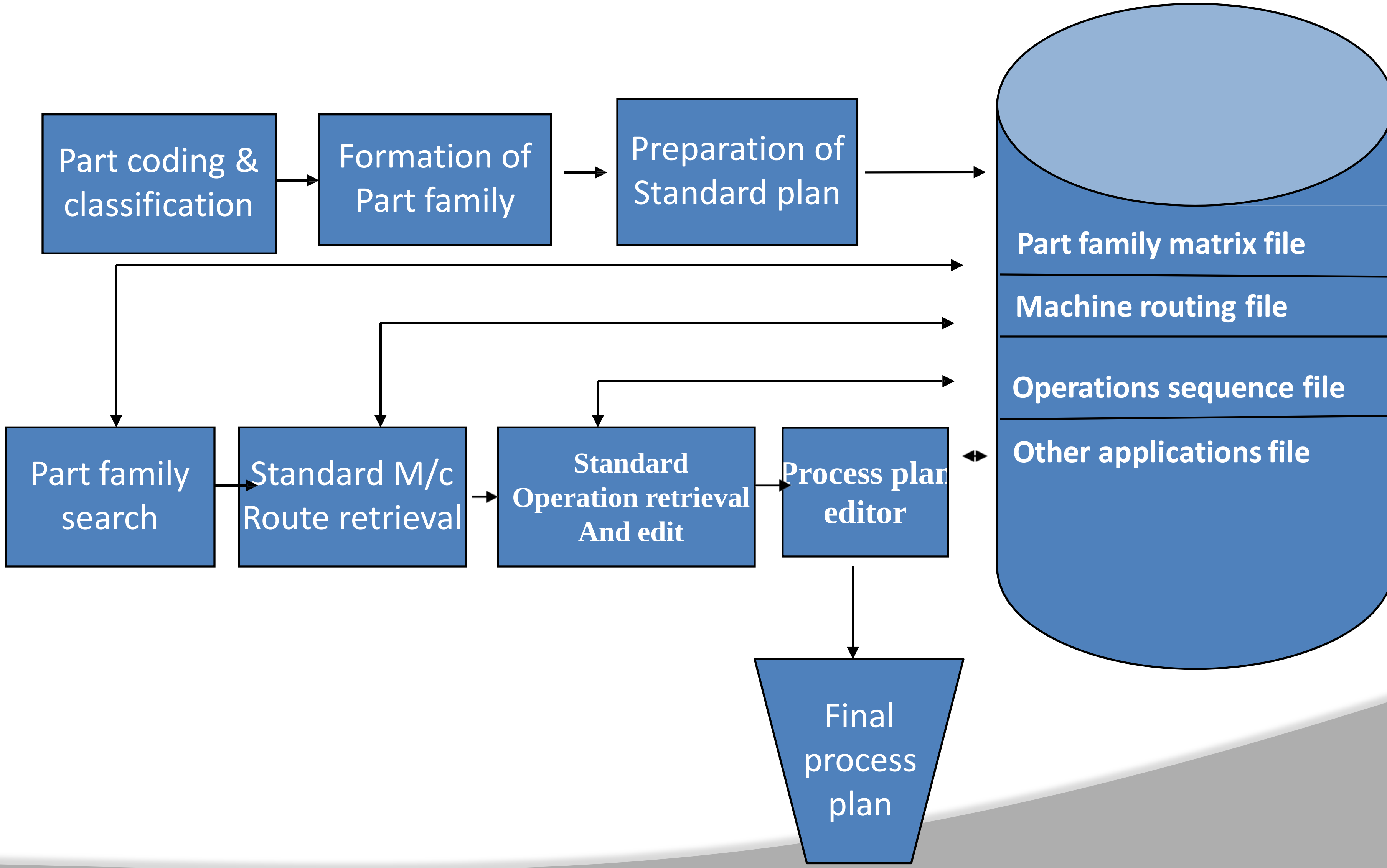


Diagram of Variant process plan



Generative process planning

- **It is the system which creates plan by means of decision logic, formulas, geometry based data and other logical procedures.**
- **In this method process plans are prepared without the assistance of human and predefined plans**
- **After retrieving this information, the system can generate the required processes and process sequences for the work part.**

Two major components of generative

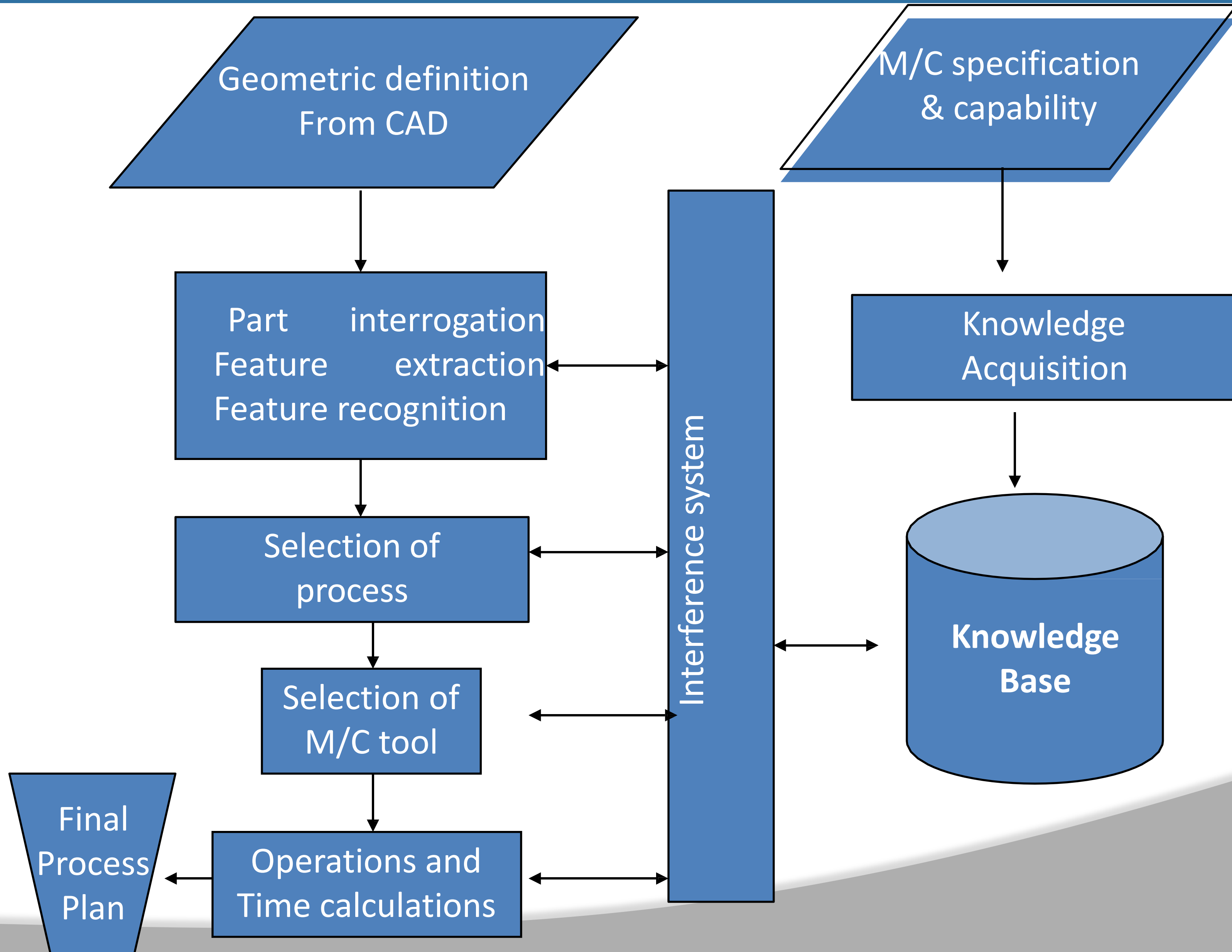
Geometry description and coding component:

- **This defines all geometric features for process related surfaces together with feature dimensions, locations, tolerances and the surface finish desired on the features.**
- **The level of detail is much greater in a generative system than a variant system.**

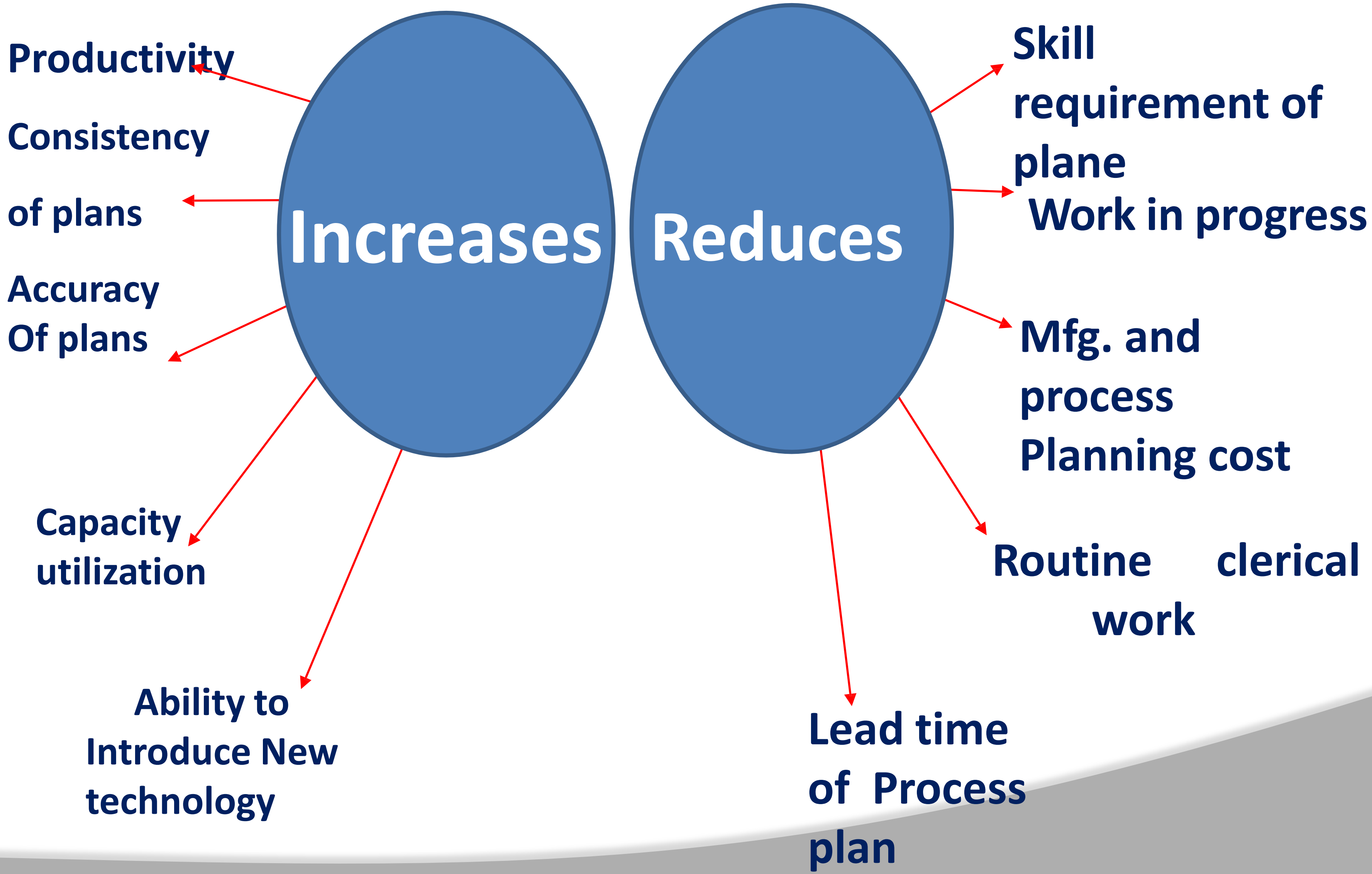
Process knowledge database & decision making logic:

- **The knowledge will be in the form of decision logic.**
- **It is required to match the part geometry requirement with manufacturing capability using decision logic and data.**
- **It includes selection of processes, mfg. equipment's, work holding devices, jigs & fixtures, inspection instruments, etc.**

Diagram of Generative process Plan



Benefits of CAPP



Inspection Methods

Contact vs. Non-contact Inspection Techniques

- **Inspection techniques can be divided into two broad categories:**
  1. **Contact Inspection.**
  2. **Non-contact Inspection.**

- **In contact inspection, physical contact is made between the object and the measuring or gaging instrument.**
- **In non-contact inspection no physical contact is made.**

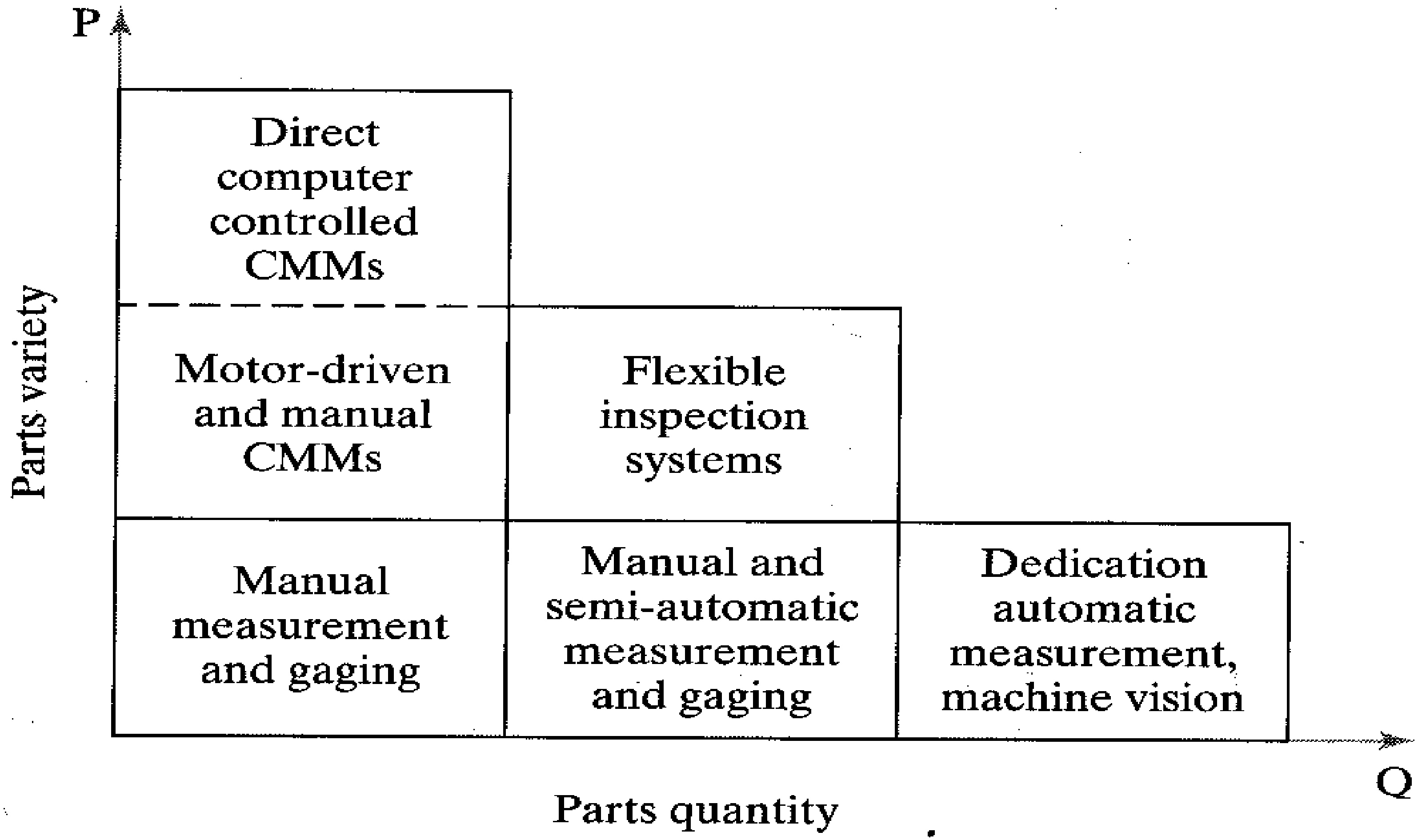
Contact Inspection Techniques

- **Contact inspection involves the use of a mechanical probe or other device that makes contact with the object being inspected.**
- **The purpose of the probe is to measure or gage the object in some way.**
- **Contact inspection is usually concerned with some physical dimension of the part.**
- **These techniques are widely used in the manufacturing industries, in particular the production of metal parts (metal working processes)**
- **The principal contact technologies are:**

  - **Conventional measuring and gaging instruments, manual and automated.**
  - **Coordinate Measuring Machines (CMMs)**
  - **Stylus type surface texture measuring machines.**

Contact Inspection Techniques

- **Conventional measuring and gaging techniques and coordinate measuring machines measure dimensions and related specifications.**
- **Conventional techniques and CMMs compete with each other in the measurement and inspection of part dimensions. The general application ranges for the different types are presented in the PQ chart below**



Contact Inspection Techniques

commercially important include the following:

1. **They are the most widely used inspection technologies today.**
2. **They are accurate and reliable.**
3. **In many cases, they represent the only methods available to accomplish the inspection.**

Non-Contact Inspection Techniques

- **Non-contact inspection methods utilize a sensor located at a certain distance from the object to measure or gage the desired features.**
- **The non-contact inspection technologies can be classified into two categories:**
    1. **Optical inspection**
    2. **Non-optical inspection**

- **<u>Optical inspection technologies</u> make use of light to accomplish the measurement or gaging cycle. The most important optical technology is machine vision.**

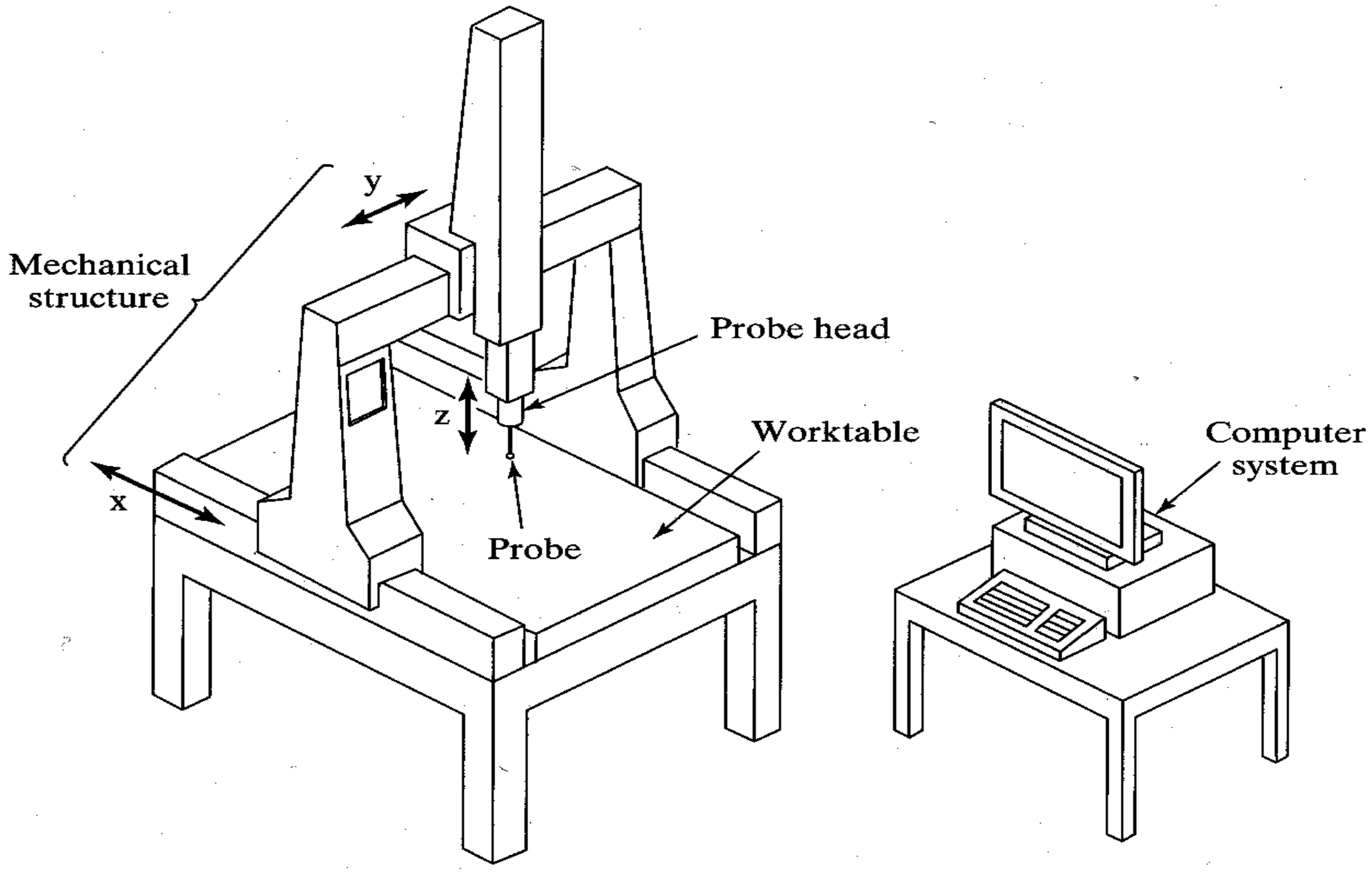
- **<u>Non-optical inspection technologies</u> utilize energy forms other than light to perform the inspection: these other energies include various electrical fields, radiation, and ultrasonics.**

Coordinate Measuring Machines

- **Coordinate metrology is concerned with the measurement of the actual shape and dimensions of an object and comparing these with the desired shape and dimensions.**

- ***A Coordinate Measuring Machine (CMM)*** **is an electromechanical system designed to perform coordinate metrology.**

Coordinate Measuring Machines



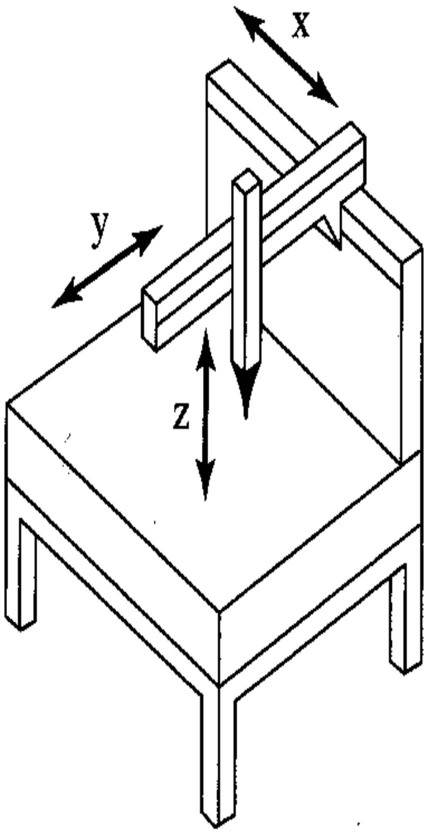
Coordinate Measuring Machines

Probe head and probe to contact the work part surface .

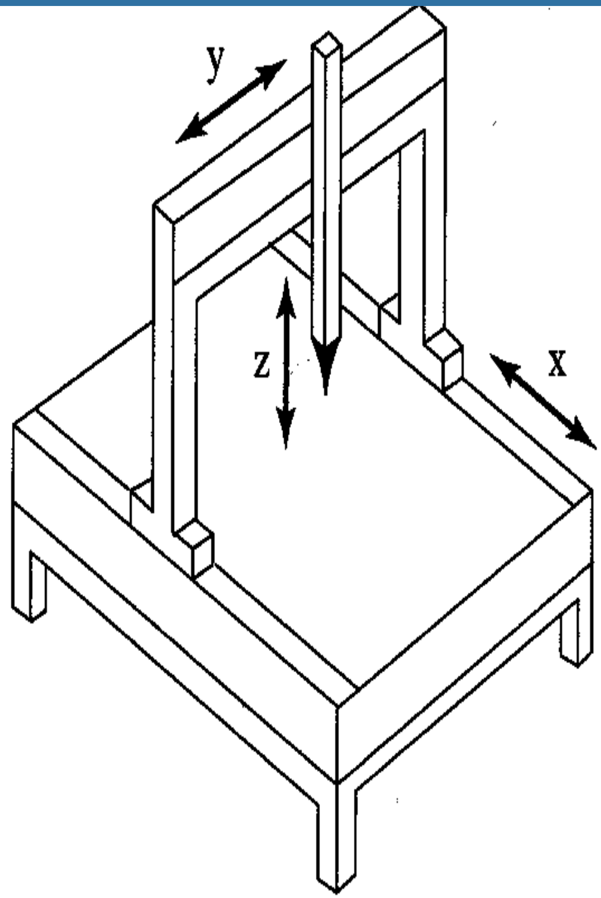
- Mechanical structure that provides motion of the probe in three Cartesian axes and displacement transducers to measure the coordinate values of each axis.

- In addition, many CMM have the following components:
  - Drive system and control unit to move each of the three axes
  - Digital computer system with application software.

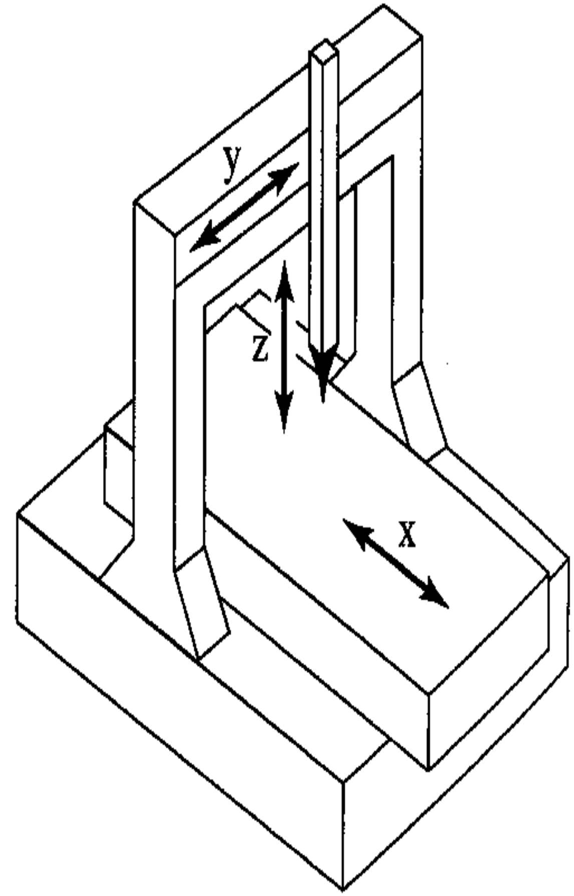
CMM Mechanical Structure



(a)



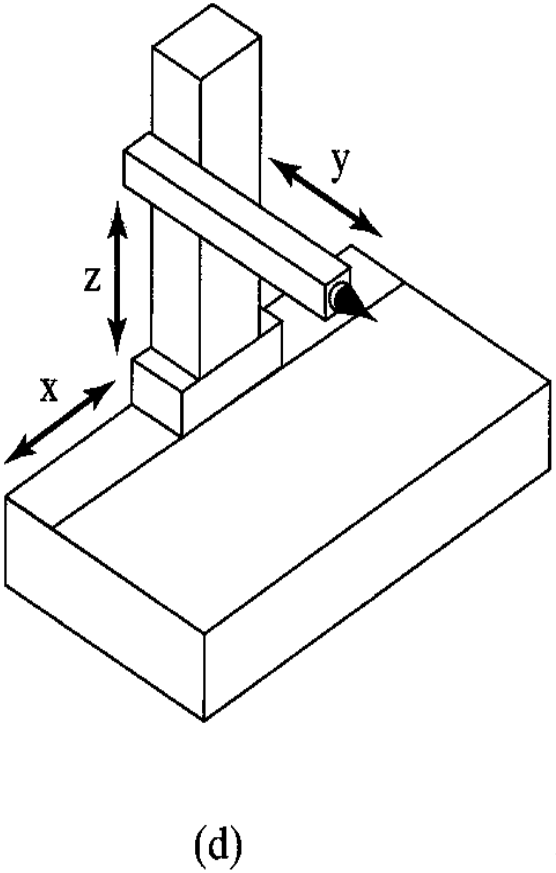
(b)

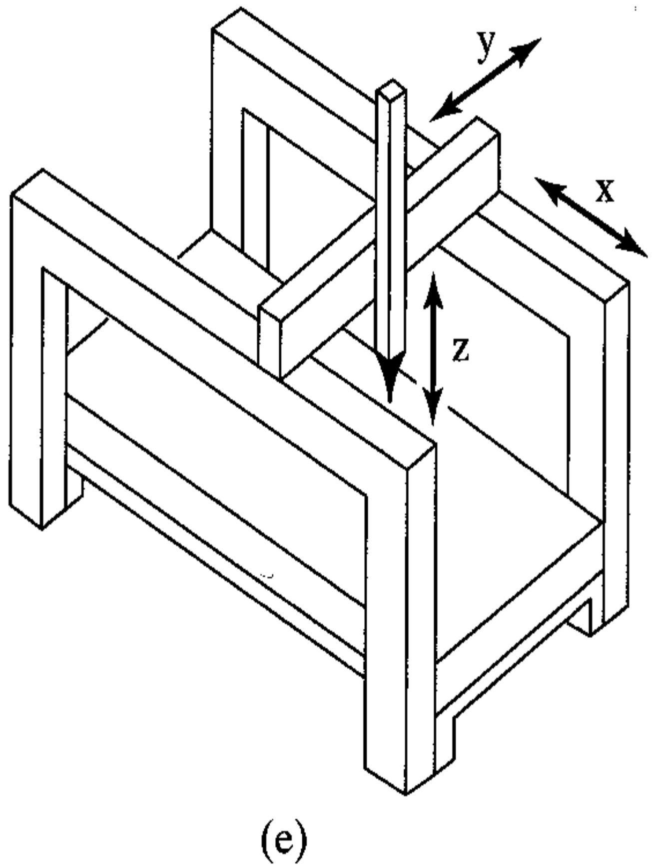


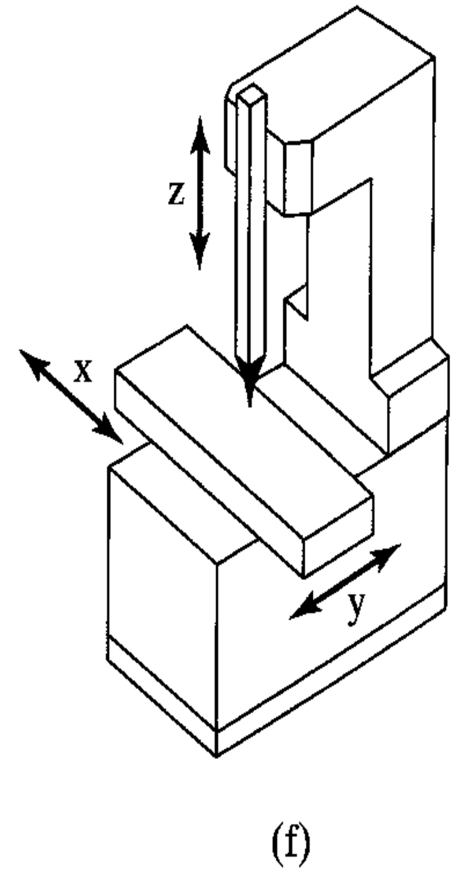
(c)

(a) Cantilever **(b) Moving bridge** **(c) Fixed bridge**

CMM Mechanical Structure







(d) Horizontal Arm **(e) Gantry** **(f) Column**

The term CIM comprises three words – computer, integrated and manufacturing. CIM is the application of computers in manufacturing in an integrated way.
CIM is an attempt to combine computer technologies in order to manage and control the entire business and manufacturing.
CIM is the computerization of design, manufacturing, distribution and financial/business function into one coherent.

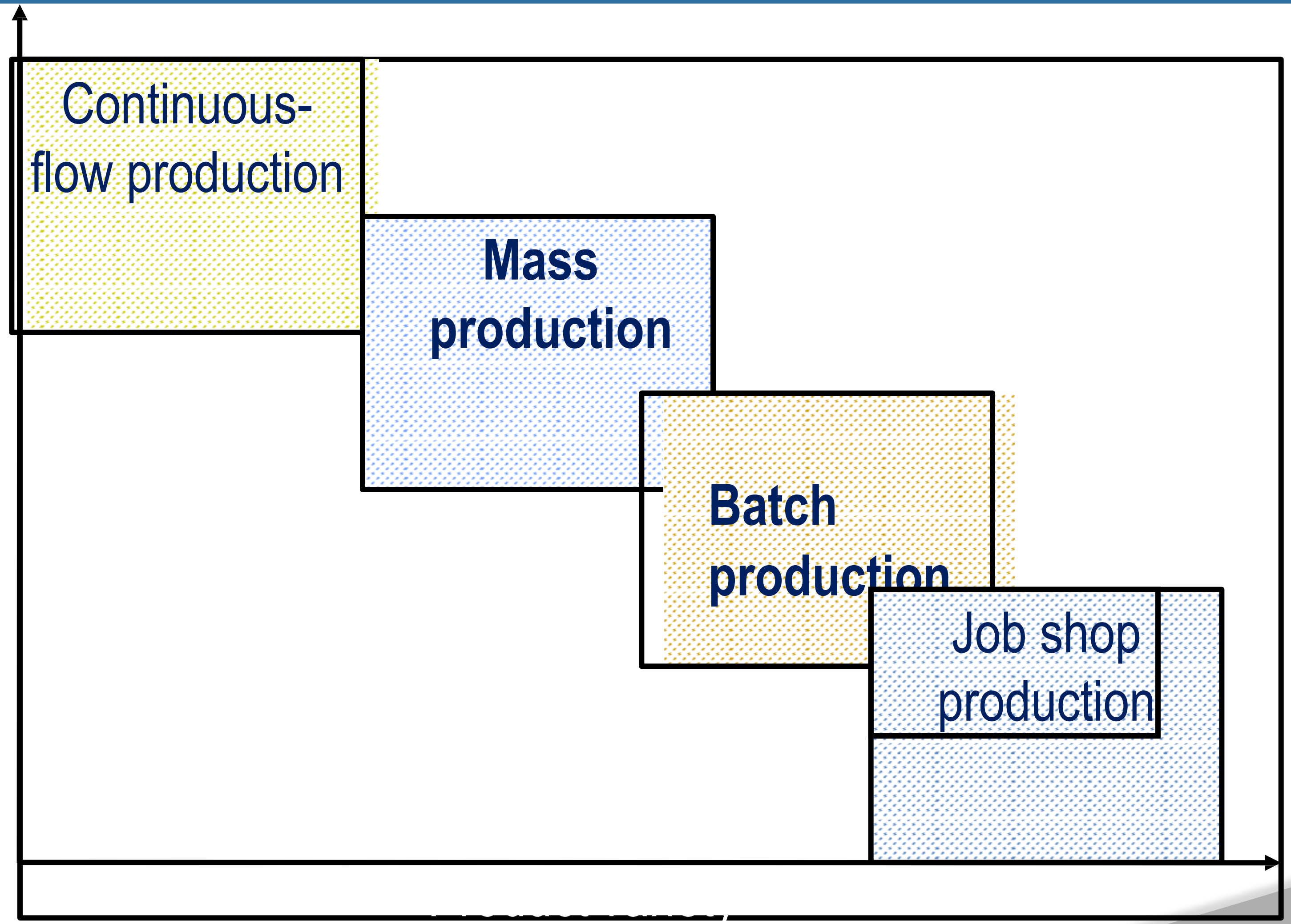
DEFINITION OF CIM:

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

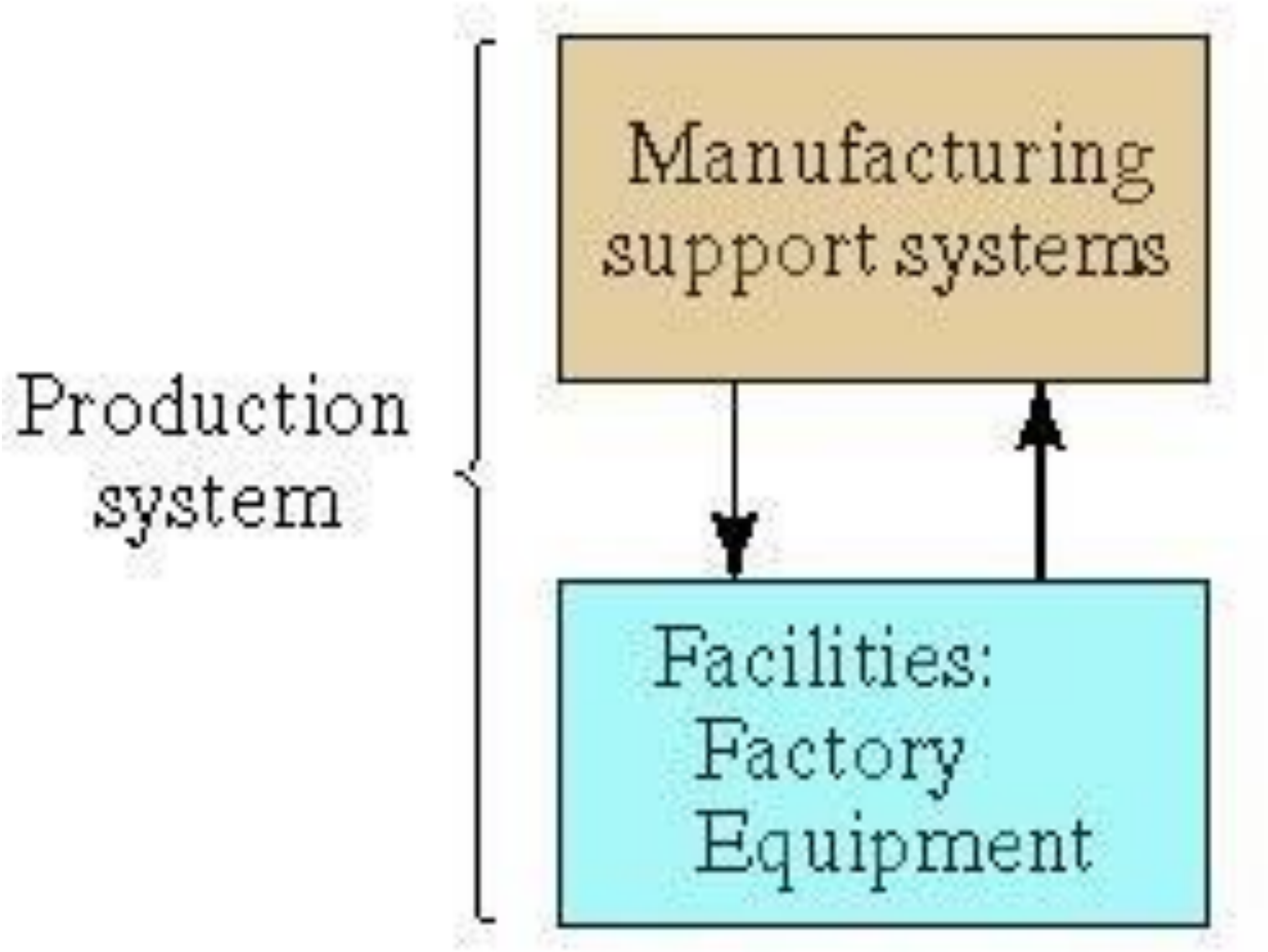
Types of Productions:

1. **Continuous-flow processes**
   amount of bulk product. Continuous manufacturing is represented by chemicals, plastics, petroleum, and food industries
2. **Mass production of discrete products**
   quantities of one product (with perhaps limited model variations). Examples include automobiles, appliances and engine blocks.
3. **Batch production. Production of medium lot sizes of the same product. The lot may be produced once or repeated periodically. Examples: books, clothing and certain industrial machinery.**
4. **Job-shop production. Production of low quantities, often one of a kind, of specialized products. The products are often customized and technologically complex. Examples: prototypes, aircraft, machine tools and other equipment.**

Types of Productions:



Flow chart:


Production system
Manufacturing support systems
Facilities:
Factory
Equipment

Production System Facilities:

Facilities include the factory, production machines and tooling, material handling equipment, inspection equipment, and computer systems that control the manufacturing operations

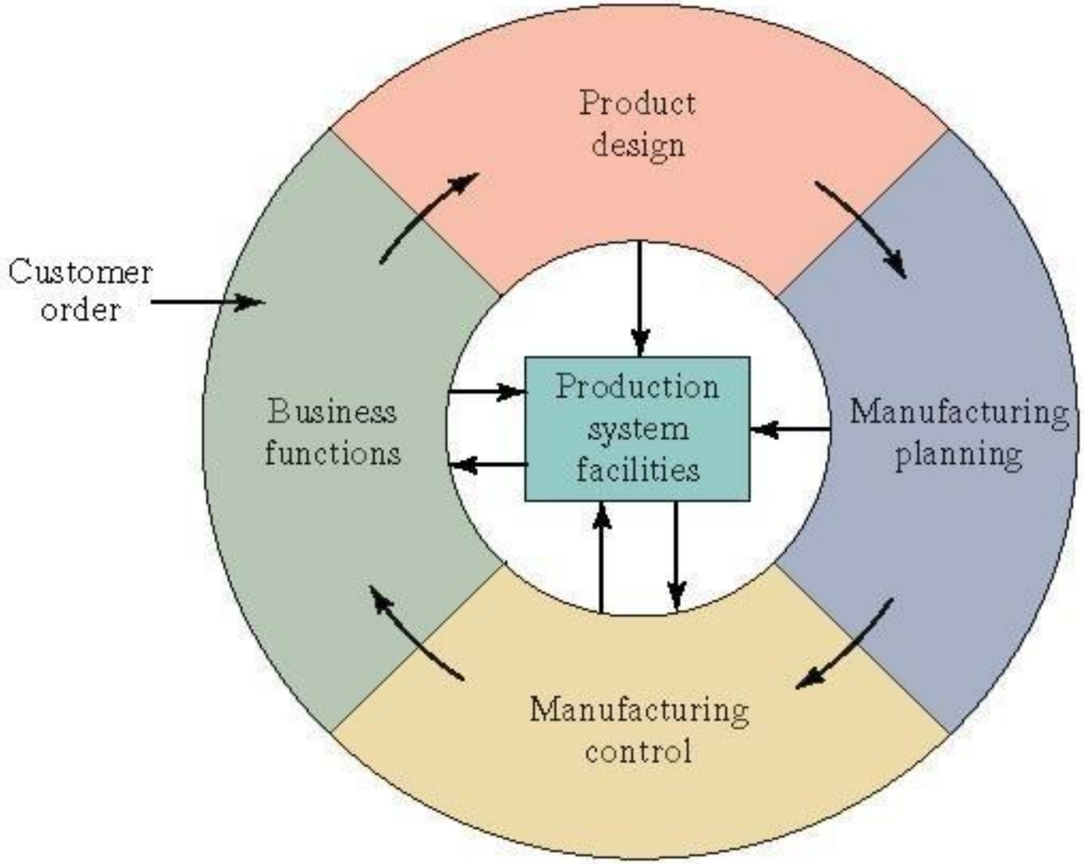
- Plant layout – the way the equipment is physically arranged in the factory
- Manufacturing systems – logical groupings of equipment and workers in the factory
  - Production line
  - Stand-alone workstation and worker

Manufacturing Support System:

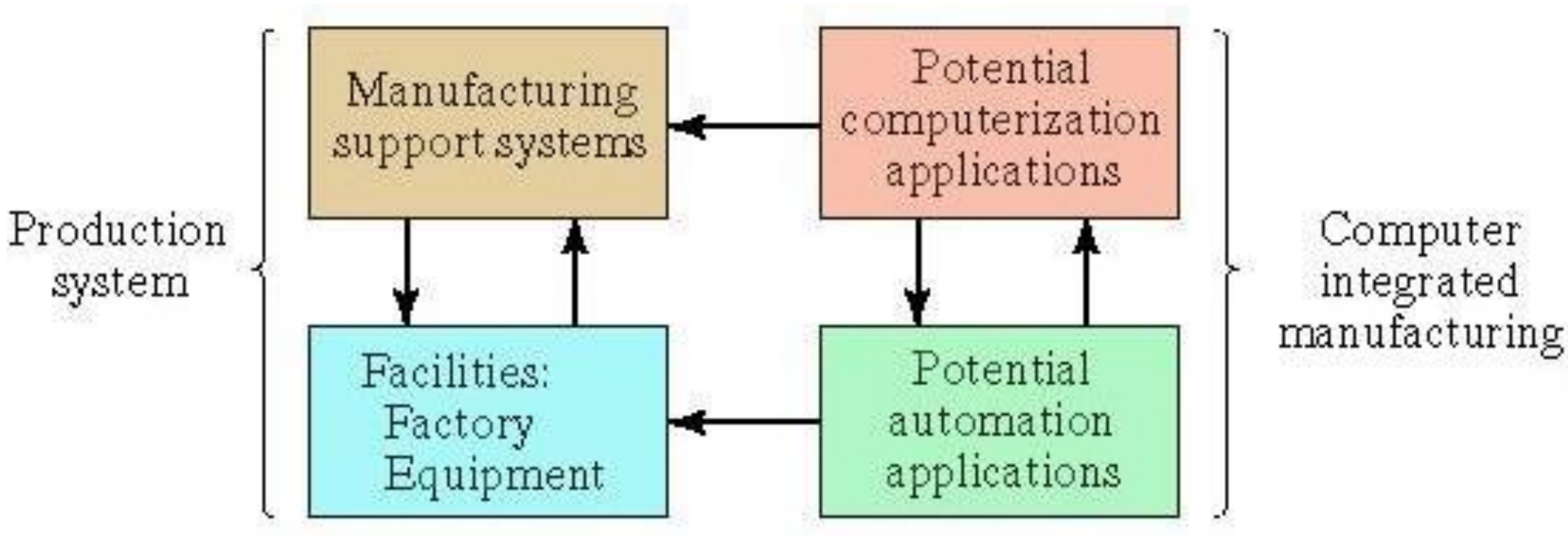
Involves a cycle of information-processing activities that consists of four functions:

1. **Business functions - sales and marketing, order entry, cost accounting, customer billing**
2. **Product design - research and development, design engineering, prototype shop**
3. **Manufacturing planning - process planning, production planning, MRP, capacity planning**
4. **Manufacturing control- shop floor control, inventory control, quality control.**

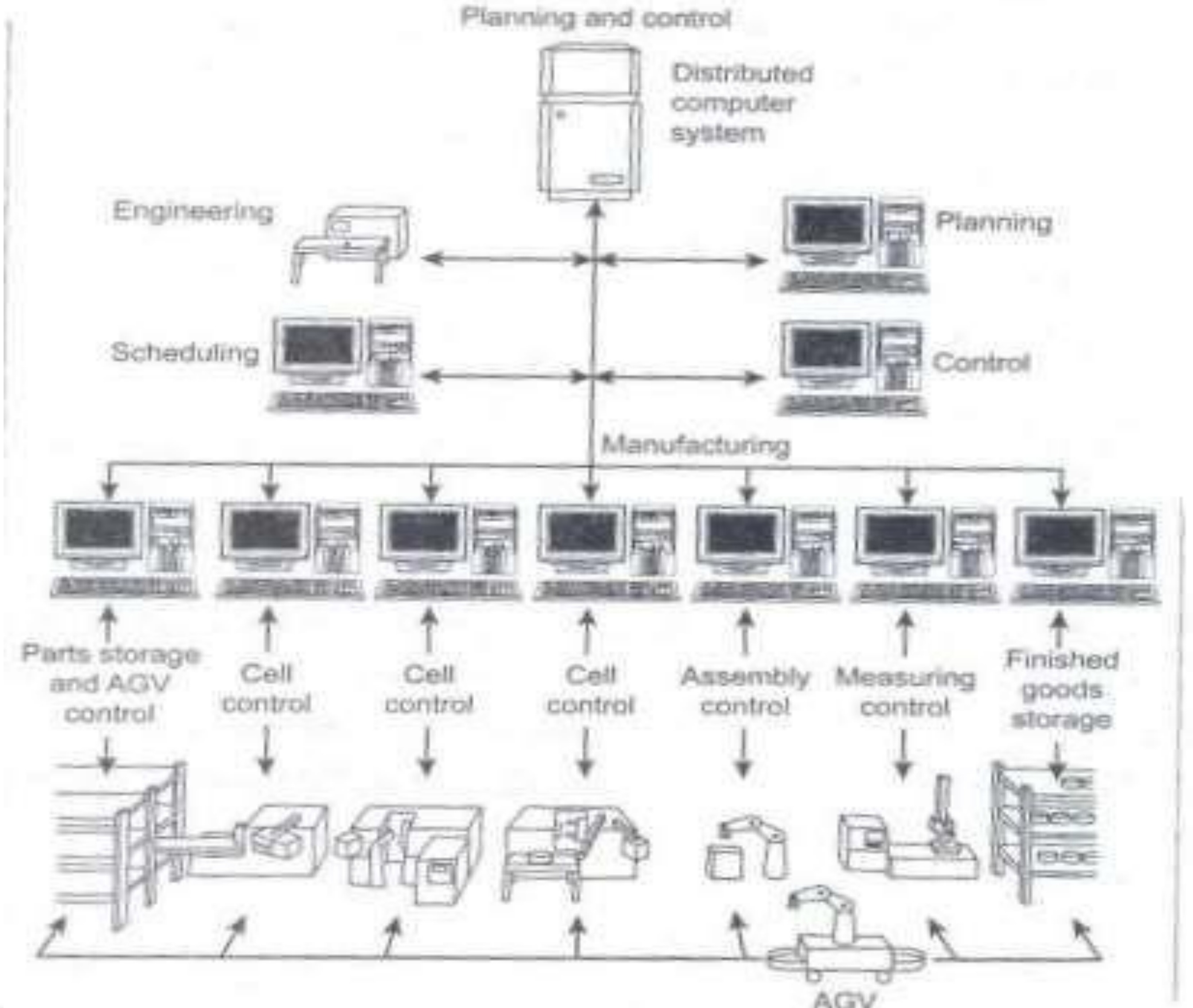
Information Processing Cycle in Manufacturing Support Systems



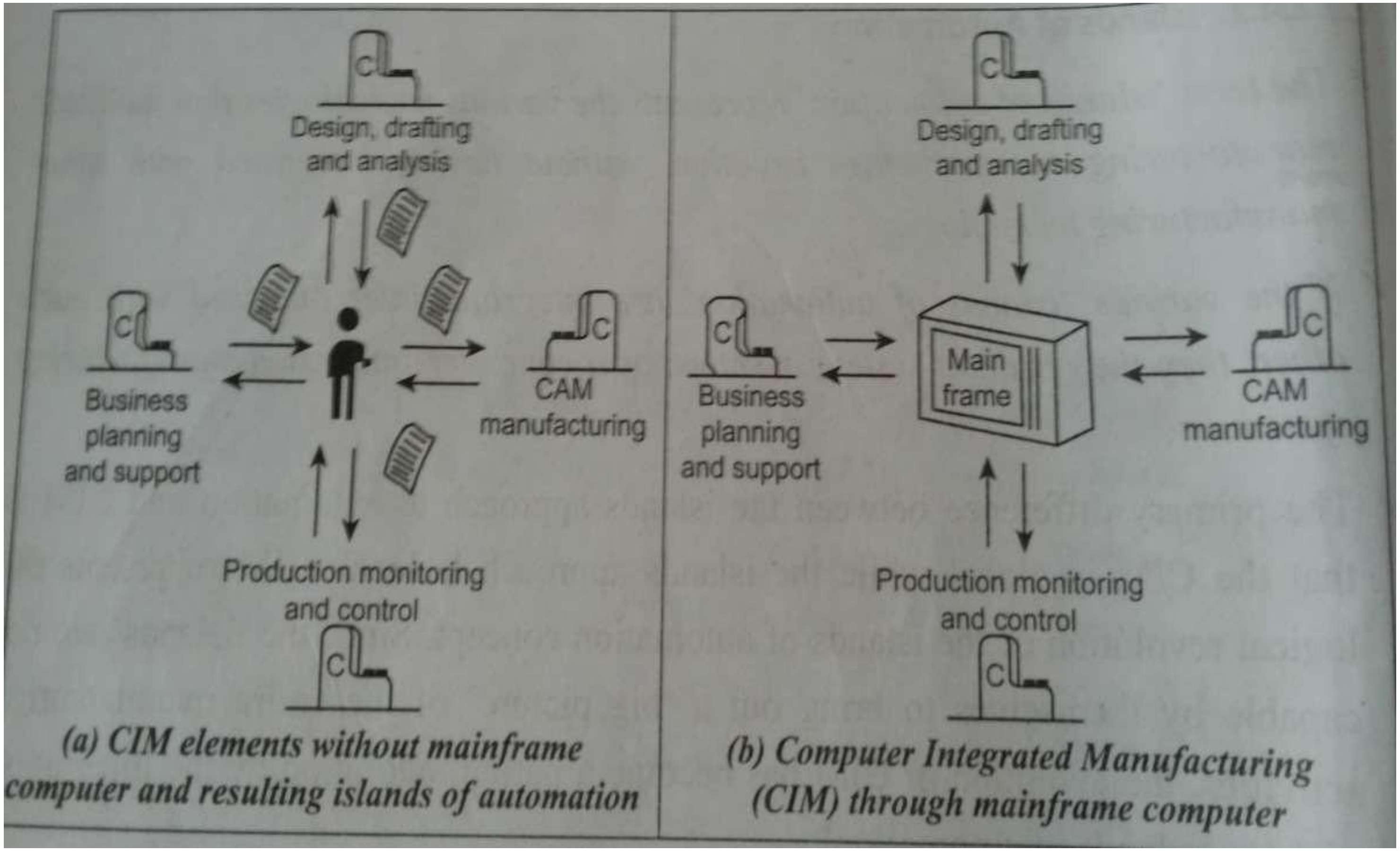
Computer Integrated Manufacturing



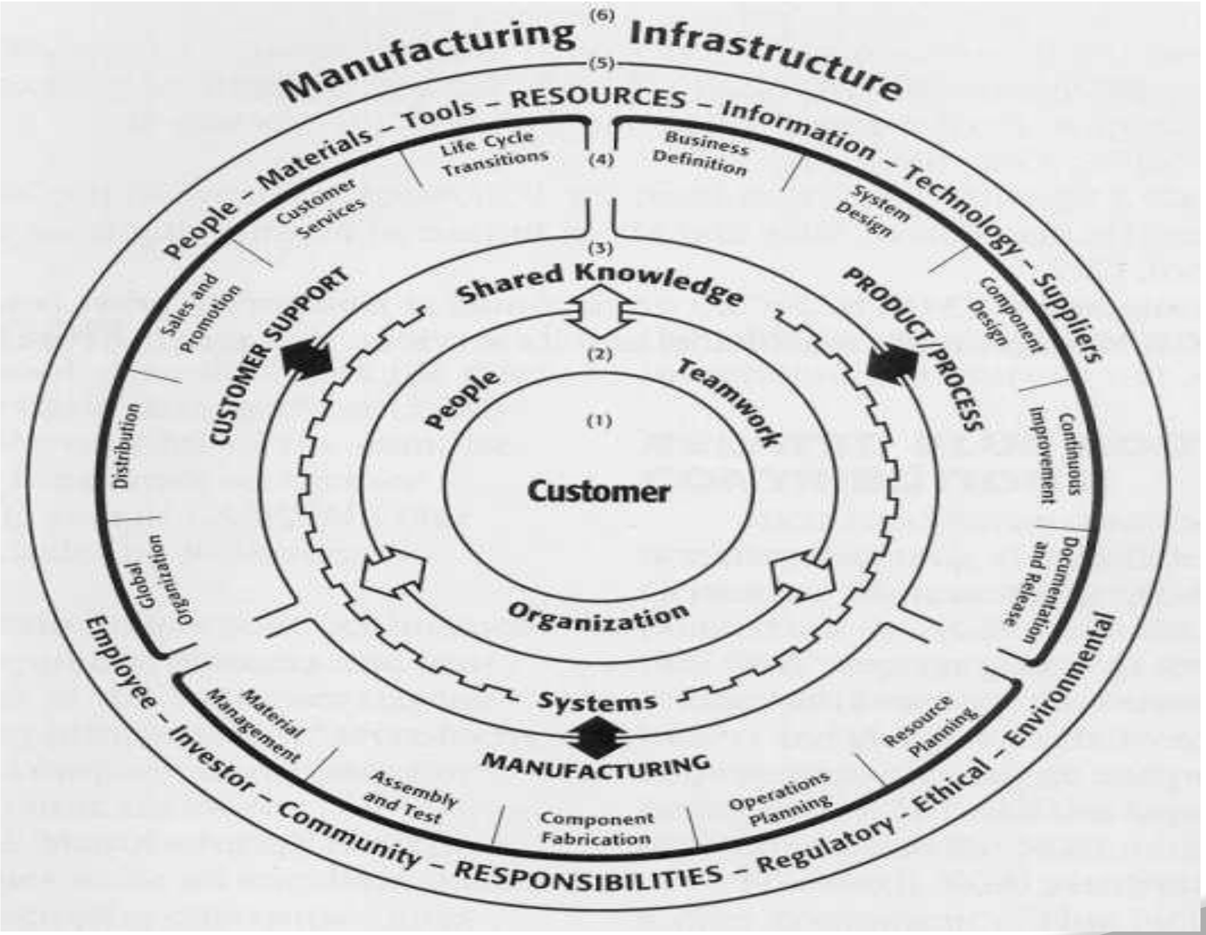
Schematic diagram of CIM



CIM ELEMENTS AUTOMATION



The new SME manufacturing enterprise wheel



BENFITS OF CIM:

- TANGIBLE BENEFITS

Higher Profits, Improved Quality, Lower Cost, Reduced Scrap and Rework, Increased Factory Capacity, Shorter Lead Time, Improved Performance, Reduced Inventory, Increased Manufacturing Productivity, Increased machine utilization, Etc.

- INTANGIBLE BENEFITS
- **Greater Flexibility, Greater Improved, Working Environment**