COMPUTER AIDED DESIGN & ANALYSIS

SUBJECT CODE: ME 308

S6 Mechanical Engineering, KTU

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MODULE-1

INTRODUCTION TO CAD

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CAD- SYLLABUS

MODULE-1

Introduction to CAD , Historical developments, Industrial look at CAD, Comparison of CAD with traditional designing, Application of computers in Design
Basics of geometric and solid modeling, Packages for CAD/CAM/CAE/CAPP
Hardware in CAD components, user interaction devices, design database, graphic Standards, data Exchange Formats, virtual Reality.

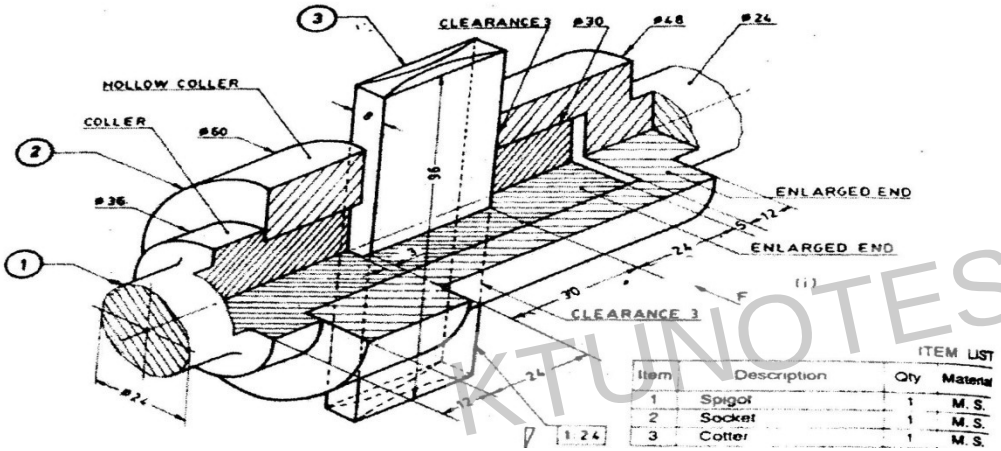
INTRODUCTION TO CAD

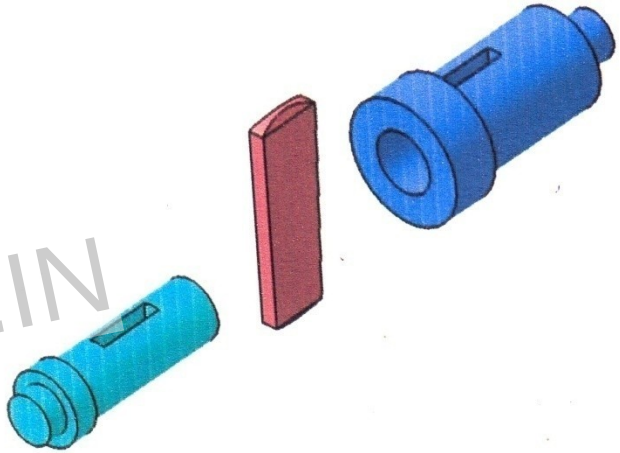
CAD - DEFINITION

- **Computer-aided design** (CAD) is the use of computer systems to assist in the creation, modification, analysis, or optimization of an engineering design.
- Computer assistance means a designer converts his or her ideas and knowledge into a mathematical and graphical model of representation in computer.

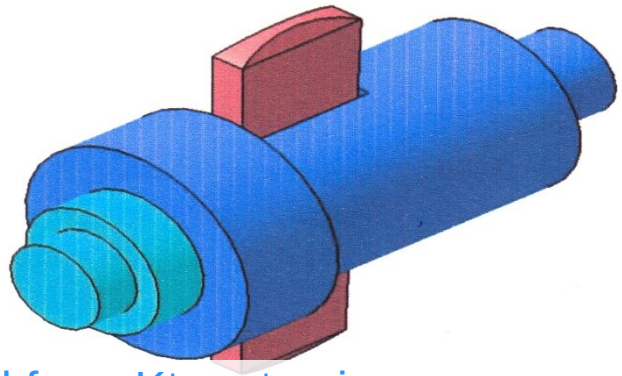
DESIGN OF SOCKET & SPIGOT COTTER JOINT USING CAD SOFTWARE

- **CREATION OF PARTS**





- **ASSEMBLY OF PARTS**

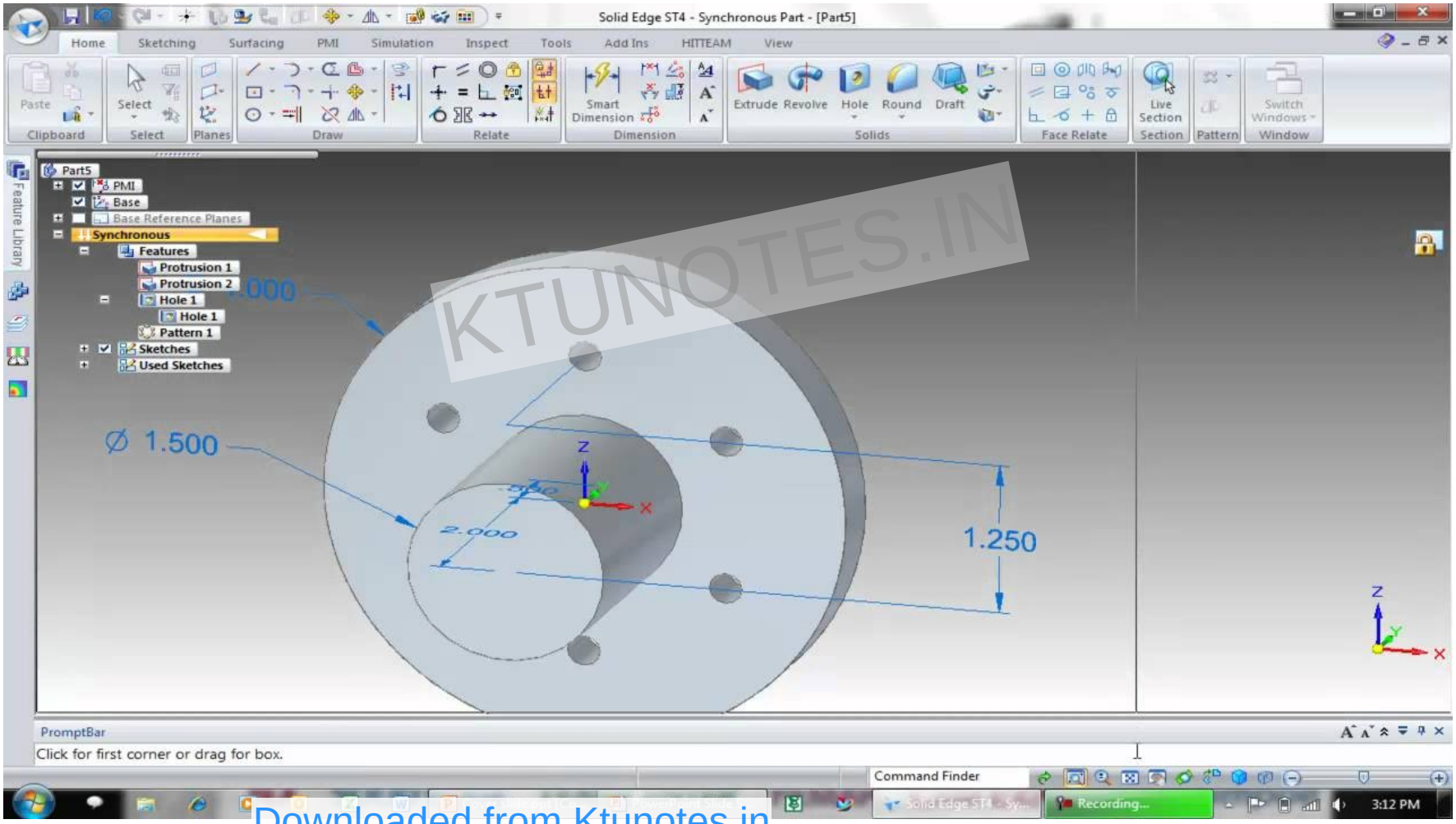


CAD

- There are 3 different types of CAD (2D, 2.5D and 3D).
- **CAD software** is used to create and design models of these types and test them.

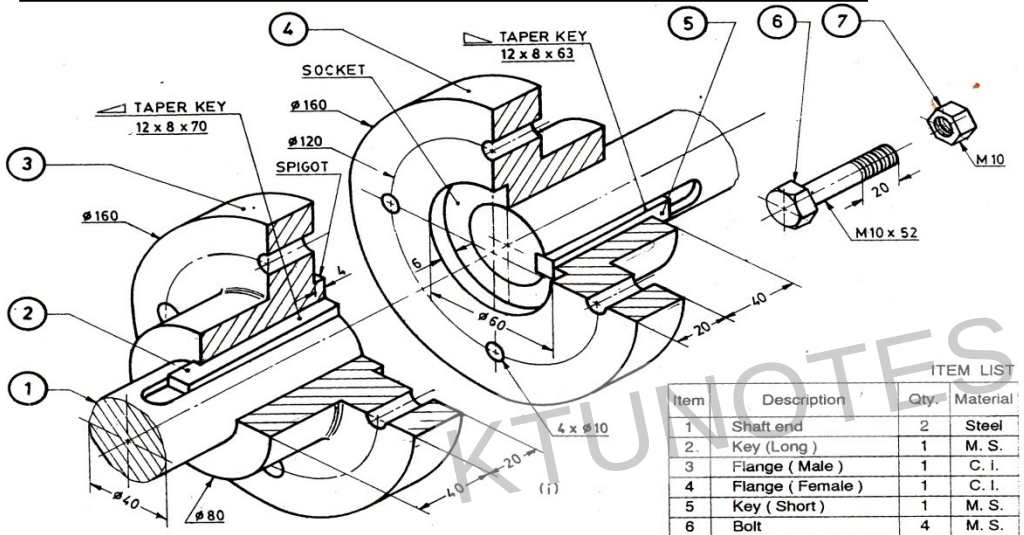
3D DESIGN IN SOLID EDGE CAD SOFTWARE

- **FLANGED SHAFT COUPLING**



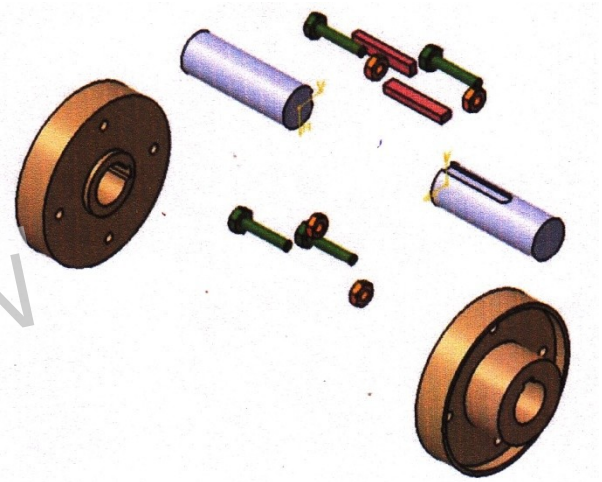
DESIGN OF FLANGED COUPLING USING CAD SOFTWARE

- ## CREATION OF PARTS

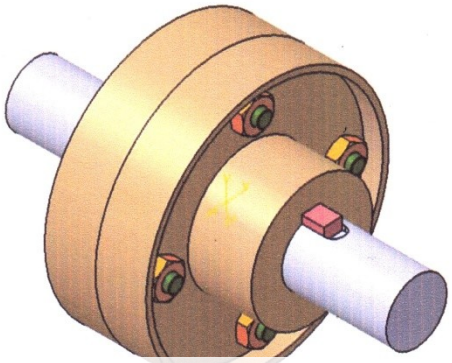


ITEM LIST

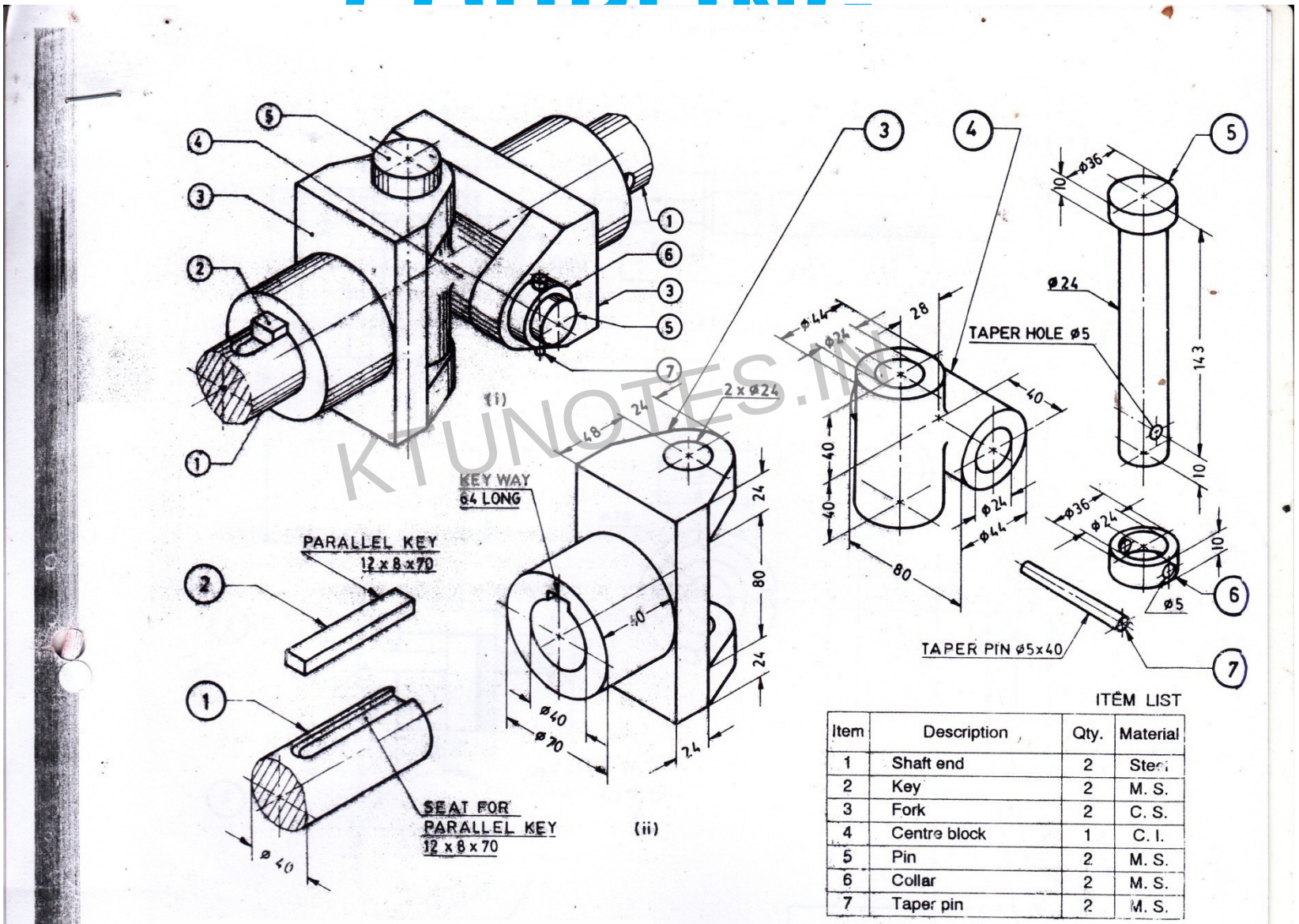
Item	Description	Qty.	Material
1	Shaft end	2	Steel
2.	Key (Long)	1	M. S.
3	Flange (Male)	1	C. I.
4	Flange (Female)	1	C. I.
5	Key (Short)	1	M. S.
6	Bolt	4	M. S.
7	Nut	4	M. S.



- ## ASSEMBLY OF PARTS



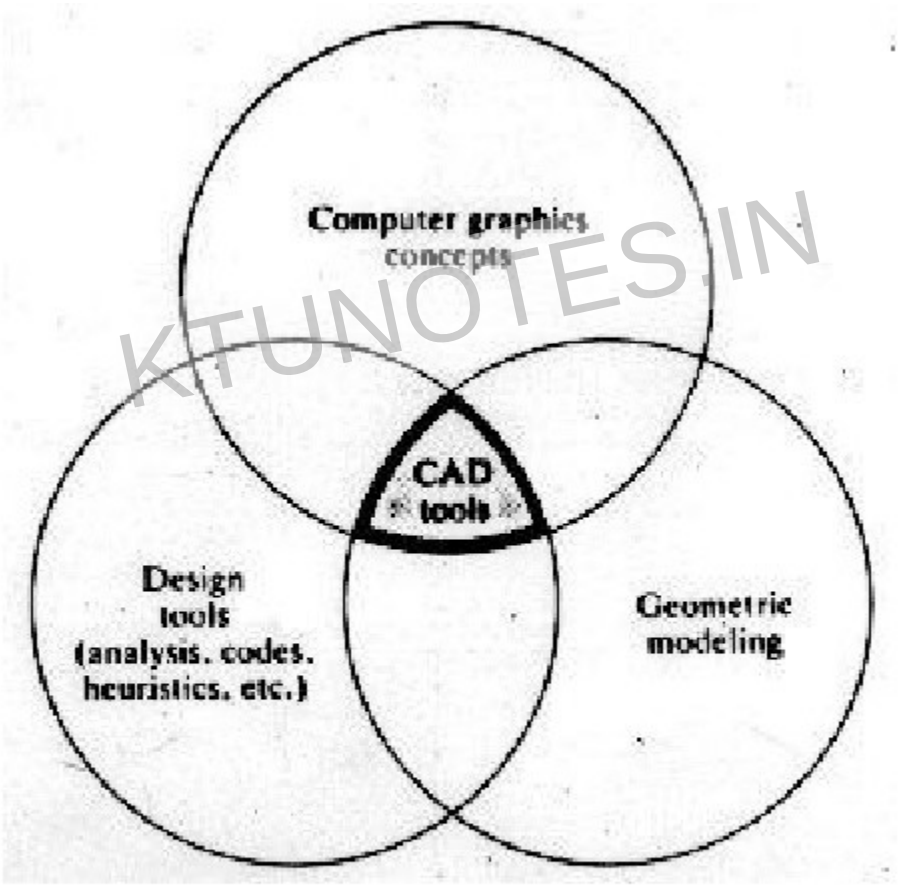
DESIGN OF UNIVERSAL COUPLING



ITEM LIST

Item	Description	Qty.	Material
1	Shaft end	2	Steel
2	Key	2	M. S.
3	Fork	2	C. S.
4	Centre block	1	C. I.
5	Pin	2	M. S.
6	Collar	2	M. S.
7	Taper pin	2	M. S.

CAD Tools



Definition of CAD tools based on constituents

Computer-Aided Design (CAD)

- **CAD tools used for:**
  - Mass property calculations
  - Finite-element modeling and visualization
  - Tolerance analysis
- Defines the geometry of the design

FUNDAMENTALS OF CAD

- Computer-Aided Design (CAD) involves any type of design activity which makes use of computer to develop, analyze or modify an engineering design.
- Modern CAD system are based on interactive computer graphics(ICG)
- ICG denotes a user-oriented system in which the computer is employed to create, transform, and display data in the form of pictures or symbols.
- User is the designer, can communicate with computer through input devices
- Computer uses CRT for communication

ICG system

It is a user oriented system in which computers are used to create ,transform & display the data in the form of pictures or symbols.
Basically CAD = ICG + human designer

ICG is a combination of hardware & software

- Hardware: computer and input/output devices.
- Software → cg software + application programs
- Application software: CAD package.

BENEFITS/ADVANTAGES OF CAD

- Improved productivity of the designer
- Improved quality of the design
- Better communications
- Creating the manufacturing database
- Highly accurate design (error free)
- Precious time is saved.

BENEFITS/ADVANTAGES OF CAD

- Reduced engineering personnel requirements.
- Customer modifications are easier to make.
- Faster response to requests for quotation.
- Designs have more standardized.
- Better knowledge of cost involved.
- Cost saving in tool design.

LIMITATION OF CAD

- CAD doesn't incorporate real life concepts, such as gravity or friction.

Areas of application of CAD

- CAD is used to design a variety of different products for a variety of fields such as:
- **Mechanical engineering**
- Electronic design
- Architectural design
- Civil engineering
- Textile industry
- Medical Design

HISTORICAL DEVELOPMENTS OF CAD

HISTORICAL DEVELOPMENT OF CAD

There are 4 major phases of Development:

PHASES	YEAR	HISTORICAL DEVELOPMENT OF CAD
1950s		❖**Era of conceiving Interactive Computer Graphics(ICG).**
	1950	❖MIT produce simple pictures by a CRT(cathode ray tube) with a Whirlwind computer in 1950.
	1952	❖Concept of numerical control (NC) on 3- axis milling machine was demonstrated in 1952.
	1959	❖Automatically programmed tools (APT) was developed in 1959.
1960s		❖**Most critical research period for interactive computer graphics**.
	1962	❖Sketch pad system by Ivan Sutherland was developed to create drawing and alterations of objects interactively on a CRT.
	1964	❖General motors announced DAC-1 (design augmented by computers)
	1965	❖CAD was started to appear. ❖[illegible] initiated CADAM and Bell

HISTORICAL DEVELOPMENT OF CAD

Phase	Year	HISTORICAL DEVELOPMENT OF CAD
1970s	1970	❖ **Potential of Interactive Computer Graphics was realized by industry**
	1974	❖ SIGGRAPH national conference was held in Boulder. ❖National computer Graphics Association (NCGA) was formed.
	1979	❖Initial Graphic Exchange Specification (IGES) was developed. ❖Wireframe modeling and some surface modeling with basic design application were available.
1980s	1980s	❖**CAD/CAM heady years of research.** ❖Integration & automation of design ❖Solid Modeling, synthetic curves and surfaces.

- **1990s: Management of CAD/CAM capabilities**
  - CIM, EDB, PDM, CALS, VR
  - Improvement in communication medium and networking
  - Reduced cost of hardware and software
- **2000s:** Wireless transmission, Reduced cost of high performance computing, Reverse engineering - Rapid prototyping

INDUSTRIAL LOOK AT CAD

INDUSTRIAL LOOK AT CAD

- CAD/CAM is a technology (hardware & software) and application driven field.
- **Aerospace, automotive and shipbuilding industries** have influenced, to great extent, the development of lofted and sculptured surfaces.
- Therefore, understanding the utilization and implementation of CAD technology in industries helps to close the gap between creating the technology, managing it, using it and more importantly learning it.

INDUSTRIAL LOOK AT CAD

- The principle packages available consist of **geometric modeling & graphics, design, manufacturing and programming software's**.
- 3 available types of **Geometric Modeling** are
  - **Wire frames**
  - **Surface modeling**
  - **Solid modeling.**

INDUSTRIAL LOOK AT CAD

- **Graphics packages** encompass such functions such as geometric transformation, drafting and documentation, shading, coloring and layering.
- **Design application packages** includes
  - Mass property calculations,
  - finite element modeling & analysis,
  - tolerance stack analysis,
  - mechanisms modeling and
  - interference checking.

INDUSTRIAL LOOK AT CAD

- Once the design is complete in CAD software's, drafting and documentation are performed on the model database.
- Then model is now ready for **CAM applications** such as process planning, tool path generation and verification, inspection & assembly.

COMPARISON OF CAD WITH TRADITIONAL DESIGNING

Traditional Design (before computer era)

Sketch with pencils

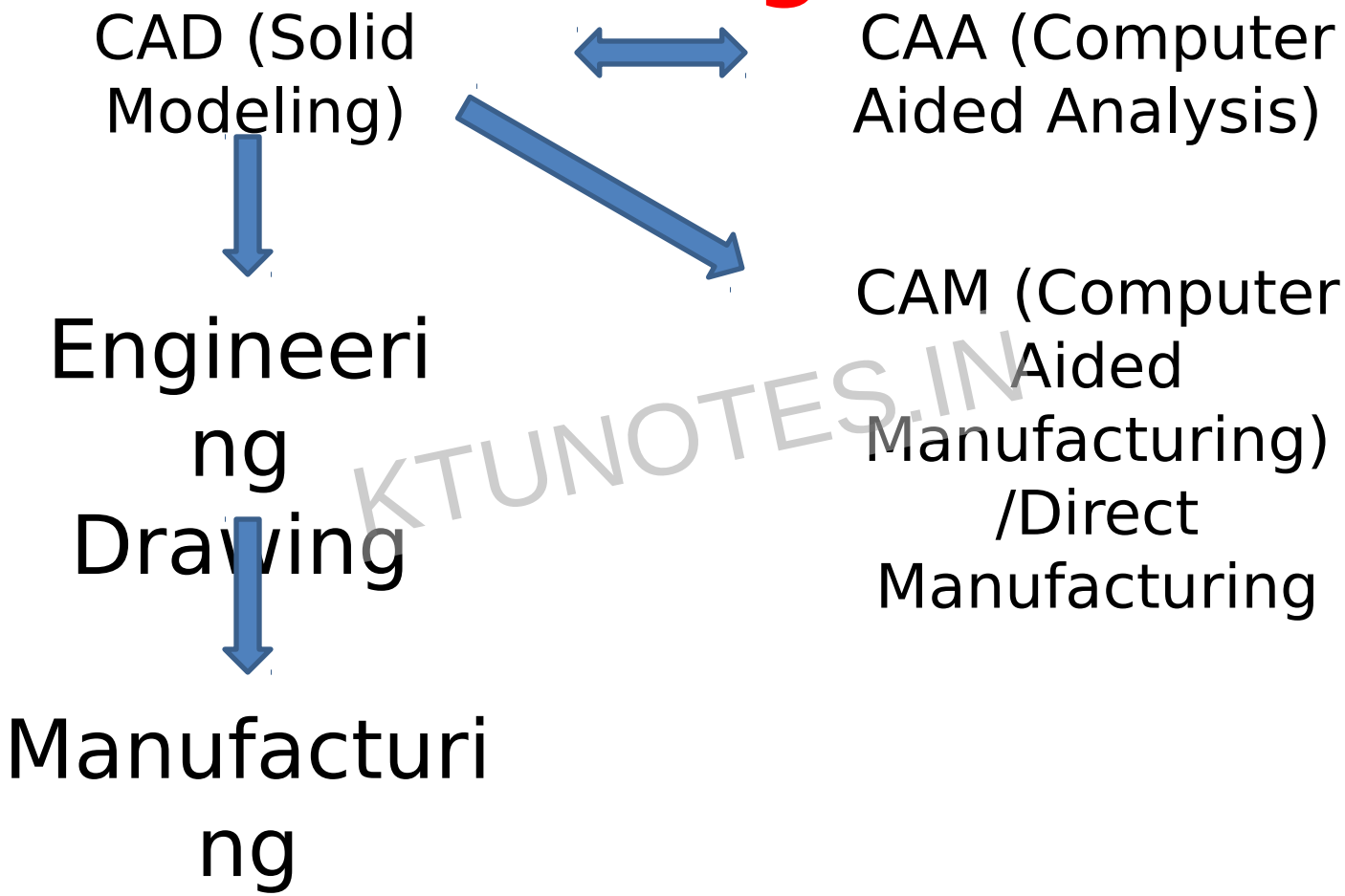
↓

Engineering Drawing with pencils

↓

Manufacturing

Now…. with CAD design



CAD is a starting point of everything!

COMPARISON OF CAD WITH TRADITIONAL DESIGNING

Sl No:	TRADITIONAL DESIGNING	CAD DESIGNING
1	•Less productivity, efficiency	•Improves the productivity, efficiency and accuracy of drawings.
	•Repetition of identical components is sometimes required.	•Enables drawings to be created, checked, and edited quickly.
2	•Less quality	•Improves the quality of products.
3	•Need more storage	•Minimizes storage space
4	•Drawings are drawn in drawing sheet	CAD drafting can be easily saved on the computer server and can be accessed from anywhere with internet connection.
5	•Less speed and time consuming	**Speed and Time** – Technologies are invented to make our work

COMPARISON OF CAD WITH TRADITIONAL DESIGNING

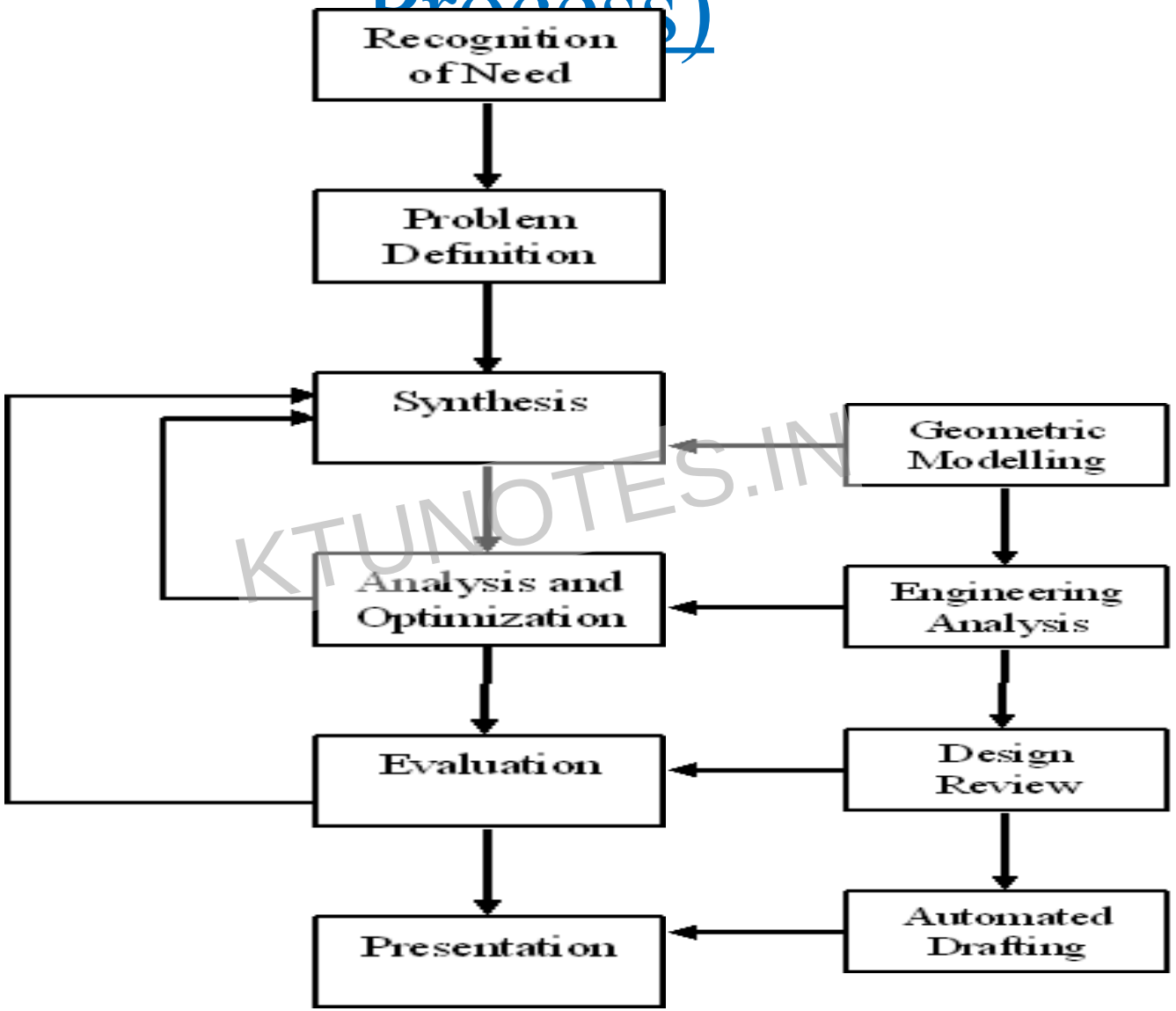
Sl No:	TRADITIONAL DESIGNING	CAD DESIGNING
6	With manual drafting, you can separate information onto individual transparent overlays.	**CAD Is Flexible To Organize Drawing Information**
7	On paper, you must erase and redraw to make revisions to your drawing manually.	CAD eliminates tedious manual editing by providing a variety of editing tools at any time.
8	Changing text can often involve re-lettering the whole drawing.	Changes to the model automatically update the dimension values.
9	With manual drafting, you must draw objects carefully to ensure correct size and alignment.	With CAD, you can use several methods to obtain exact dimensions.
10	With manual drafting, you use drawing tools that	In CAD, you can choose from a variety of drawing tools that

COMPARISON OF CAD WITH TRADITIONAL DESIGNING

SI No:	TRADITIONAL DESIGNING	CAD DESIGNING
11	**Accuracy** – In manual drafting, all the objects drawn must be of correct size and alignment. Each object need to be manually verified and dimensioned as the slightest error can be catastrophic to the entire project	With CAD, there are numerous techniques available to obtain exact dimensions thus leading to improved accuracy in the project.
12	In manual drafting, you need to erase and redraw to make any modification to your drawing.	CAD simplifies the revision process to a large extent with its various editing tools. With few clicks of mouse, you can undo, redo or delete your actions
13	Creating 3D view manually is a challenging, time-consuming and tire-some job	it becomes much easier with software like AutoCAD
14	Wit	the ability to producing **very**

APPLICATION OF COMPUTER IN DESIGN
(CAD PROCESS)

CAD PROCESS (Design Process)



Before CAD **After CAD**

STEPS IN TRADITIONAL DESIGN PROCESS

1.Recognition of needs (Creation of product concept)

- ✓ It involves the realization by someone (engineer, architects) that a problem exists for which a feasible solution is to be found out.

Example..

(a) Identification of defects in current machine (say engine) design activity by an engineer

(b)Perception of a new product marketing opportunity by a salesman.

STEPS IN TRADITIONAL DESIGN PROCESS

2. Definition of problem

- ✓ It involves the complete specification of the component to be designed.
- ✓ It involves both functional and physical characteristics, costs, quality, performance etc.. of design.

STEPS IN TRADITIONAL DESIGN PROCESS

3. Synthesis of design

- ✓ It is the conceptual design of prospective product.
- ✓ Various preliminary ideas are developed .
- ✓ Suitable mechanisms are designed according to our need.

STEPS IN TRADITIONAL DESIGN PROCESS

4. Analysis and optimization of design

- ✓ The conceptual ideas made are then analysed to determine their suitability for the specified design constraint.
- ✓ If the design fails to satisfy the constraint, they are redesigned or modified on the basis of feedback from the analysis.

STEPS IN TRADITIONAL DESIGN PROCESS

5. Evaluation of design

- ✓ Evaluating the design against the specification or standard established during the problem definition stage.
- ✓ Fabrication and testing of prototypes model is done to evaluate the performance.

STEPS IN TRADITIONAL DESIGN PROCESS

6. Presentation of design

- ✓ It includes documentation of design through drawing, material specifications, assembly lists etc.

APPLICATION OF COMPUTER IN DESIGN (CAD PROCESS)

APPLICATION OF COMPUTER IN DESIGN (CAD PROCESS)

- In CAD process, last 4 phases of design process are replaced by the following 4 phases:

1. **GEOMETRIC MODELLING**
    1. WIRE FRAME MODEL
    2. SOLID MODEL
    3. SURFACE MODEL
2. **ENGINEERING ANALYSIS**
3. **DESIGN REVIEW AND EVALUATION**
4. **AUTOMATED DRAFTING**

GEOMETRIC MODELLING

- It is concerned with the computer compatible **mathematical description of the geometry of an object**.
- During geometric modeling, the computer converts the command inputted by user into mathematical model, stores it in computer data file and displays it as an image on CRT screen.

1. GEOMETRIC MODELLING

- The designer constructs the graphical image of object on CRT screen on ICG system by inputting 3 types of commands:

1. Basic geometric elements (points, lines, circles, arcs etc..)
2. Transformation commands (scaling, rotation, translation etc..)
3. Assembly commands (Joints the different elements to desired shape of object)

2. ENGINEERING ANALYSIS

- Engineering analysis is required in formulation of design products
- **Various Engineering analysis are**:
  - **Stress strain calculations**
  - **Heat transfer calculations**
  - **Fluid flow problems**
  - **Static and dynamic analysis of complex structures**

2. ENGINEERING ANALYSIS

- Commercially available general purpose programs are:
- **Mass property analysis**
  - It analyse various mass properties such as mass, weight, volume, CG etc
- **Finite element analysis (FEA)**
  - The object is divided into large number of finite elements (rectangular or triangular element) which forms an inter connecting network of concentrated nodes.
  - Can analyse stress strain analysis, heat flow etc

3. DESIGN REVIEW AND EVALUATION

- In this phase, checking the accuracy of design by:
- Design review includes:

1. Layering

- **Layering is** overlaying the geometric image on top of the image of rough casting to ensure sufficient material is used to get final machined dimensions.

2. Interference checking

- **Interference checking is** checking whether the mating parts interfere with the other parts after assembling.
- It is a clearance analysis.

3. DESIGN REVIEW AND EVALUATION

Design Evaluation includes:

1. Kinematics

- It animates the model or mechanism to visualize the operation to ensure against interference within other component
- Eg.. Hinged components and linkages in machine parts

4. AUTOMATED DRAFTING

- Creation of hard copy engineering drawing directly from CAD database using printers, plotters.
- Possible features like:
  - **Automatic dimensioning**
  - **Sectional views**
  - **Isometric views**
  - **Scaling views**

Basics of GEOMETRIC MODELING
&
SOLID MODELING

Geometric Modeling

Geometric modeling refers to a set of techniques concerned mainly with developing efficient representations of geometric aspects of a design. Therefore, geometric modeling is a fundamental part of all CAD tools.

Geometric modeling

- Geometric data representation
  - **Compute a mathematical approximation of the physical shape of an object**
- Algorithms for manipulating geometry
  - Manipulate the variables defining the shape until we meet the objective.
- Geometry creation
  - Interactive.
  - Automatic creation.

Geometric modeling is the basic of many applications such as:

- Mass property calculations.
- Mechanism analysis.
- Finite-element modelling.
- NC programming.

Requirements of geometric modelling include:

- Completeness of the part representation.
- The modelling method should be easy to use by designers.
- Rendering capabilities (which means how fast the entities can be accessed and displayed by the computer)

Types of Geometric Modeling

- Wire frame modeling
- Surface modeling
- Solid modeling

GEOMETRIC MODELLING- TYPES OF MODELS

1. WIRE FRAME MODEL
2. SURFACE MODEL
3. SOLID MODEL

MODEL- COMPARISON

S. NO.	Wireframe model	Surface model	Solid model
1.	Confusion to the viewer	Less confusion	No confusion
2.	More ambiguity in identifying the surfaces	Less ambiguity	No ambiguity
3.	Cannot get required information	Can not get required information	More information
4.	Not suitable for automated application	To some extent suitable for automated applications	Best suitable for automated application
5.	Not possible for mass, volume, calculations, NC part programming, cross sectioning etc.	Not possible	Possible
6.	Need less memory	More memory	Still more memory
7.	No realistic look	Realistic surface look	Realistic solid look

GEOMETRIC MODELING TYPES:

1. Wire frame modeling

1. Wire frame modeling

- Wire frame modeling is the simplest and oldest method of modeling the object.
- Wire frame models can be considered as networks of interconnected lines to represent the edges of the physical objects being modeled.
- A typical wire frame may consist of points, lines, arcs, circles and curves.

Wire frame modeling

Three types of wire frame modeling:

- **2 D modeling**
  - Only x,y coordinates
  - Used for flat surfaces
- **2 .5 D modeling**
  - Resemble like 3D but no sidewalls details
- **3D modeling**
  - Has x,y & z coordinates
  - Used to model a solid model of an object completely.

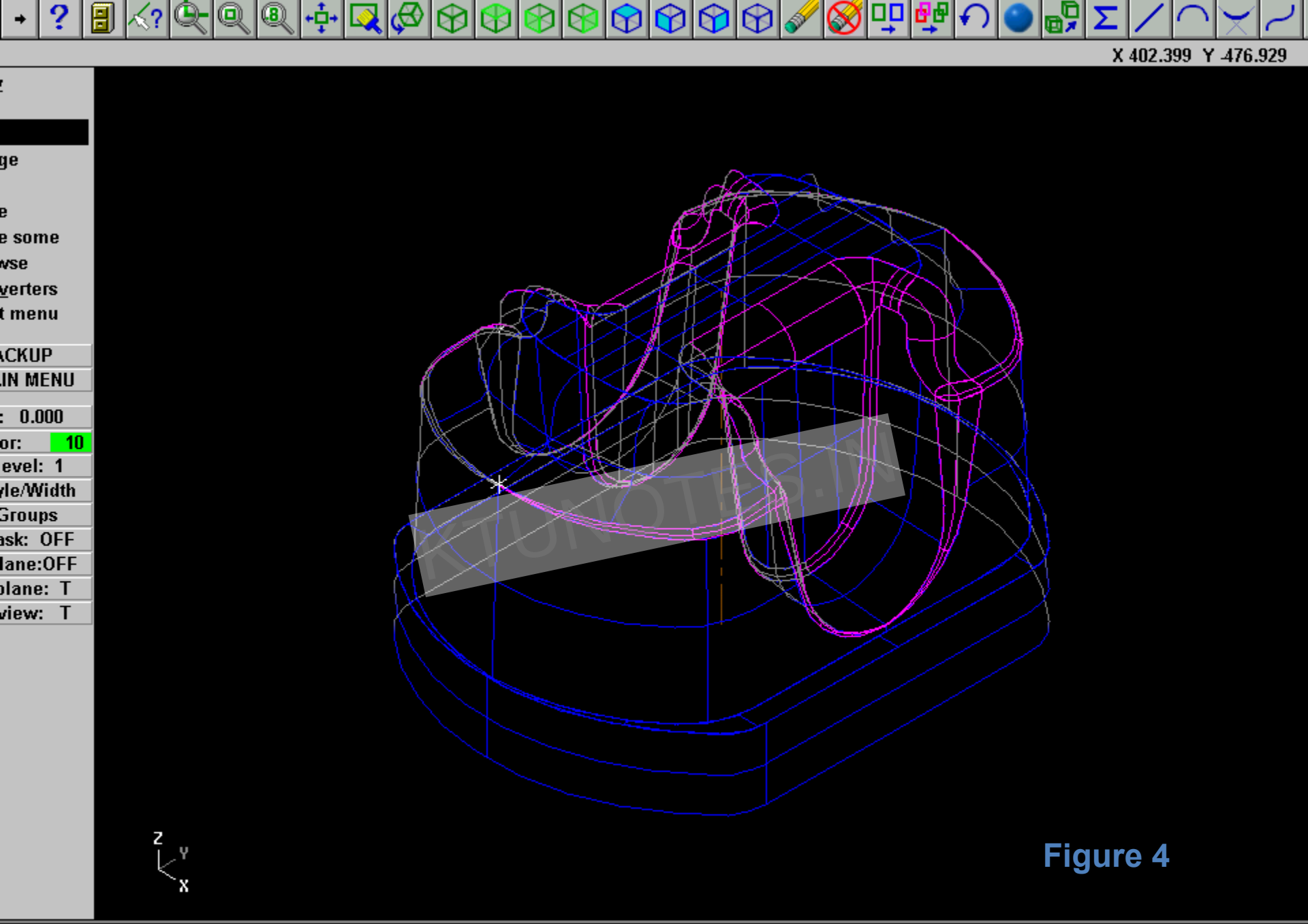


Figure 4

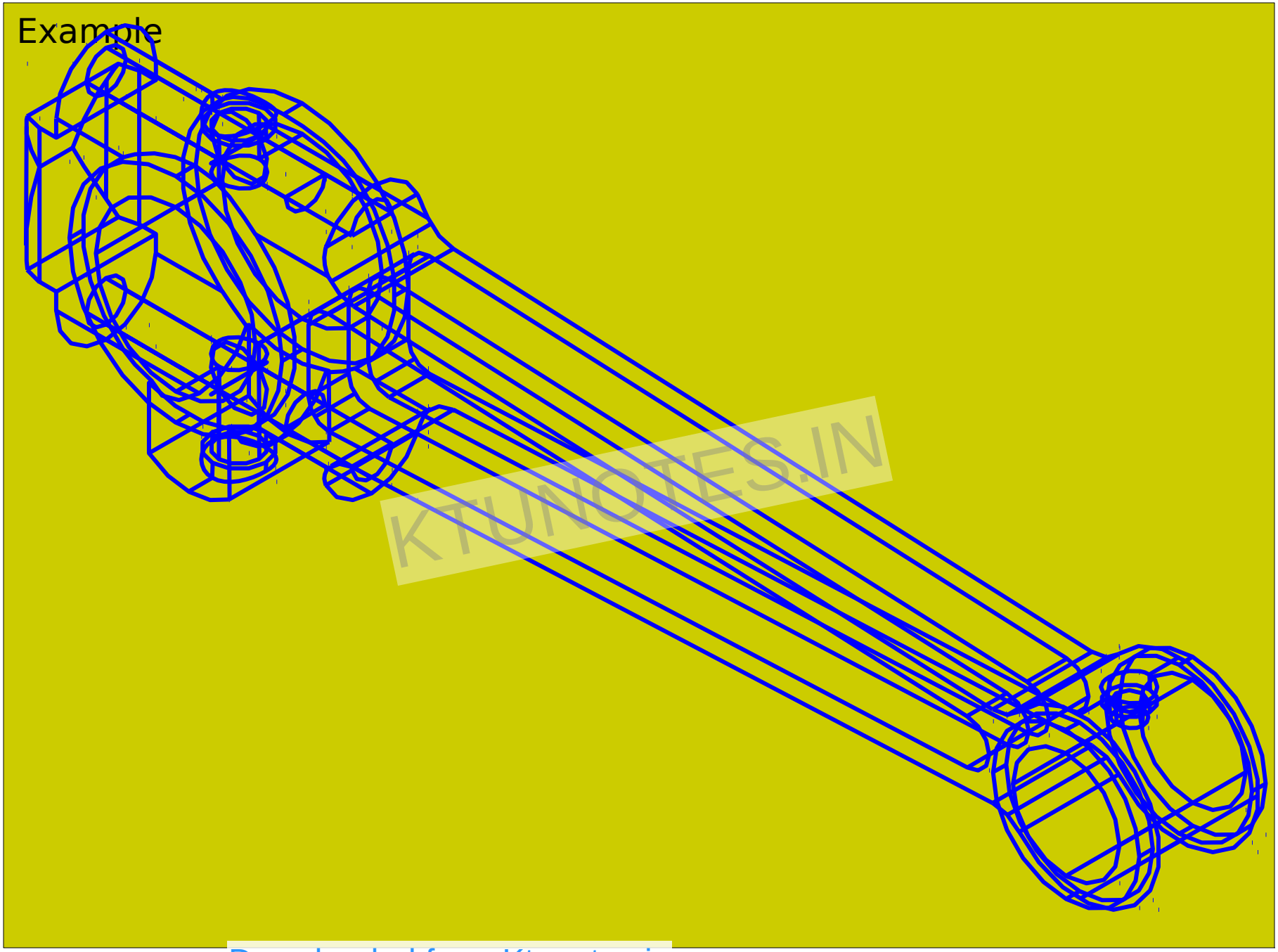
Wire-frame Modeling

Wire-frame modelling uses points and curves (i.e. lines, circles, arcs), and so forth to define objects.

The user uses edges and vertices of the part to form a 3-D object

Wire-frame model
part

Example



Advantages of wire-frame models

- Easy to construct
- Most economical in terms of time and memory requirement.
- Used to model solid object.
- Often used for previewing objects in an interactive scenario.

Advantages--Wire frame modeling

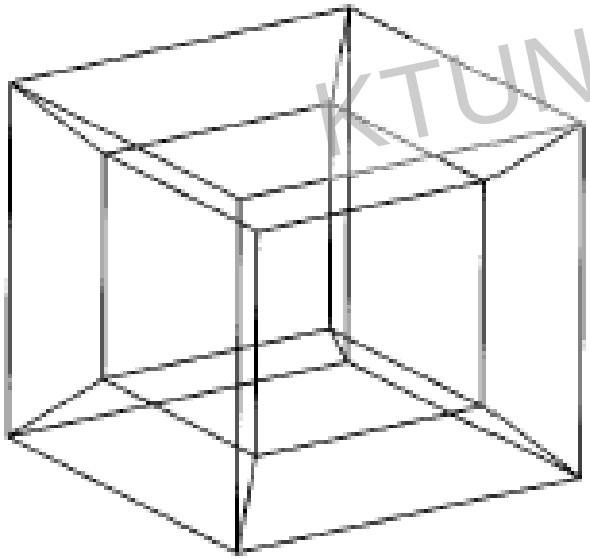
- Wire frame models are simple and easy to create, with little computer time and memory.
- Wire frame model form the basis for surface model.
- CPU time required to retrieve, edit or update a wire frame model is usually small compared with surface or solid models.

Disdvantages--Wire frame modeling

- Create Ambiguous (confusion) in minds of designer
- Inability to differentiate between inside and outside of objects.
- Non uniqueness present
- Not suitable for:
  - Mass property calculations
  - Hidden surface removal
  - Shaded images generation

Disadvantages of wire-frame

- Tend to be not realistic
- Ambiguity
  - complex model difficult to interpret.



What does this object look like?

Disadvantages of wire-frame

- Does not allow for use of photo realistic rendering tools. *(some software capable of hidden line removal on limited basis).
- No ability to determine computationally information on mass properties (e.g volume, mass, moment etc) and line of intersect between two faces of intersecting models.
- No guarantee that the model definition is correct, complete or manufacturable.

GEOMETRIC MODELING TYPES:

2. Surface modeling

2. Surface modeling

- It consists of wireframe entities plus surface entities.

  Surface model = wireframe entities + surface entities
- It is a set of faces (no thickness)
- It defines geometry but no topology.
- Shading pr coloring is possible

SURFACE MODELING

Surface modeling is more sophisticated than wireframe modeling in that it defines not only the edges of a 3D object, but also its surfaces.

In surface modeling, objects are defined by their bounding faces.

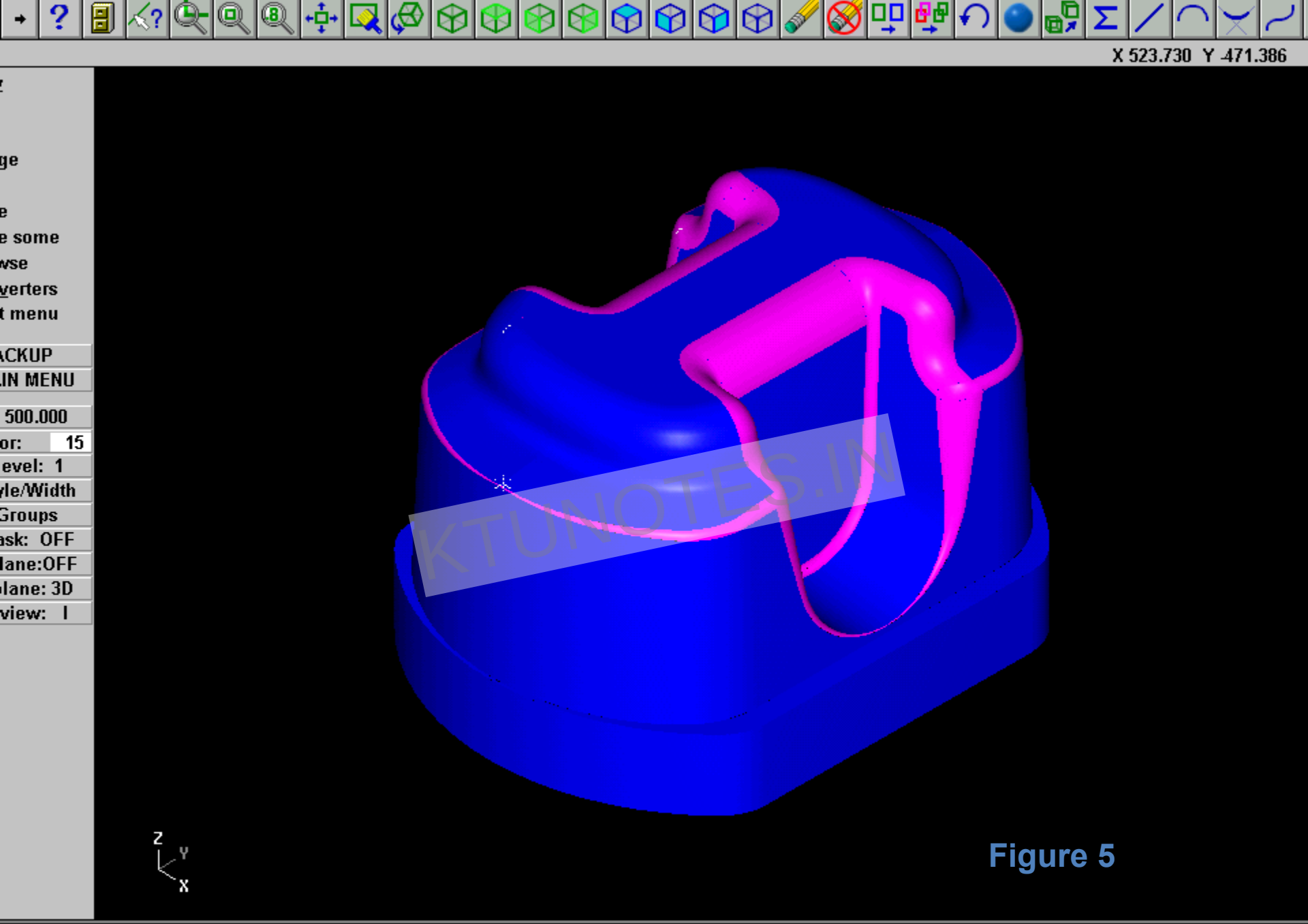


Figure 5

SURFACE ENTITIES

Similar to wireframe entities, existing CAD/CAM systems provide designers with both analytic and synthetic surface entities.

Analytic entities include :

- Plane surface,
- Ruled surface,
- Surface of revolution, and
- Tabulated cylinder.

Synthetic entities include

- Bezier surface,
- B-spline surface

Advantages--Surface modeling

- Less ambiguous than wire frame model
- Uniqueness present by hiding lines not seen
- Appear more realistic by providing hidden line and surface algorithm
- Support volume and mass calculations, FEA etc

Disdvantages--Surface modeling

- No information about inside (interior) of objects.
- Complicated computation, depending on number of surfaces
- Requires more CPU time and memory

GEOMETRIC MODELING TYPES:

3. Solid modeling

3. Solid modeling

- Solid modeling is the most powerful 3D modeling technique.
- The object is defined by vertices, edges, surfaces, weights and volume within the defined boundary.
- The boundary of model separates interior and exterior of model object.

Solid modeling

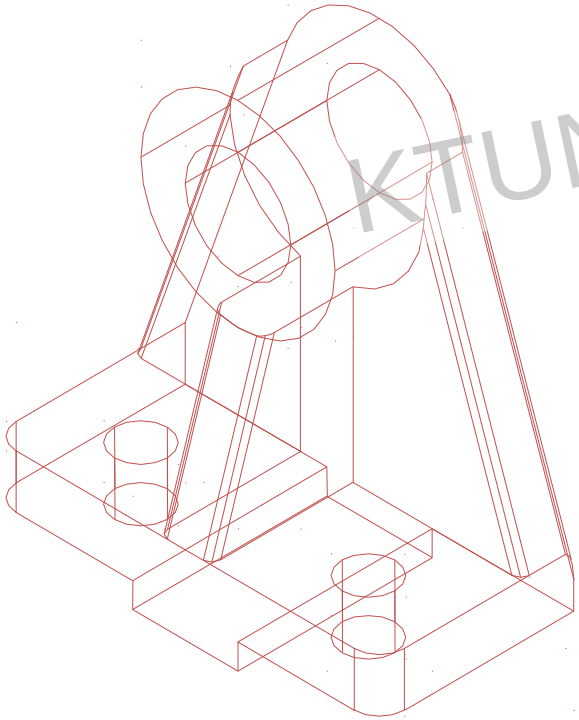
- It is complete, valid, unambiguous representation of model
- Store both geometrical and topological information

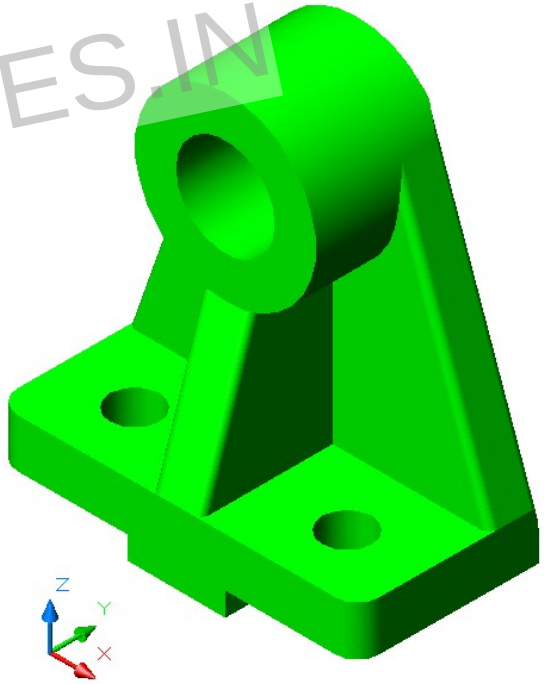
Solid modeling

- Use of solid modeling in design and manufacturing is rapidly increasing because of the,
  - reduced computing cost
  - fast computing hardware
  - Improved user interfaces
  - Software improvements

SOLID MODELING

Solid models give designers a complete descriptions of constructs, shape, surface, volume, and density.





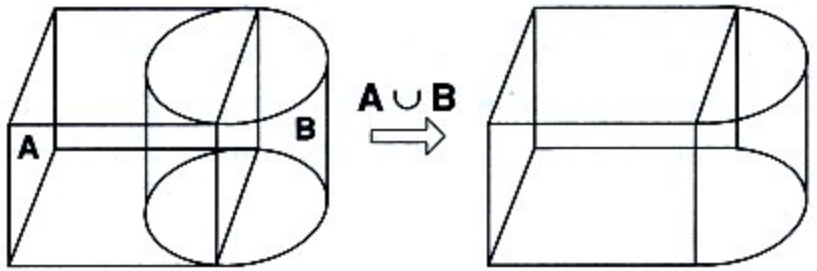
In CAD systems there are a number of representation schemes for solid modeling include:

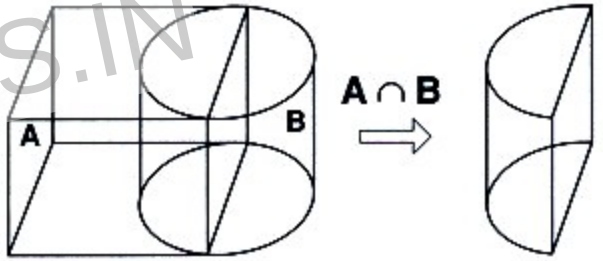
- Primitive creation functions.
- Constructive Solid Geometry (CSG)
- Sweeping
- Boundary Representation (BREP)

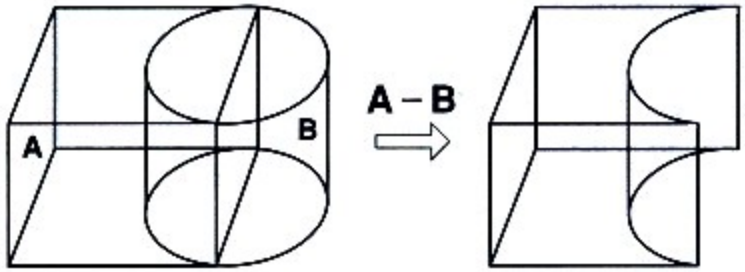
Constructive Solid Geometry (CSG)

CSG uses primitive shapes as building blocks and Boolean set operators

•(U union, difference, and ∩intersection) to construct an object.







Solid Modeling

- In order to reduce the level of complexity, solid modeling systems use functions such as ***primitive creation, Boolean operations, lifting, sweeping, swinging,*** and ***rounding*** which require a simpler input.
- Five groups of modeling functions are generally supported by most solid modeling systems.

Advantages--Solid modeling

- Non ambiguous
- Uniqueness present by hiding lines not seen
- Appear more realistic by providing hidden line and surface algorithm
- Support volume and mass calculations, FEA etc
- Improves quality of design
- Improves visualization
- Can be used in CIM, CAM etc

Disdvantages--Solid modeling

- More Complicated computation, than surface and wireframe models
- Requires more powerful computers.

SOFTWARE FOR CAD/CAM/CAE/CAPP

Software Components

- CAD software allows the designer to create and manipulate a shape interactively and store it
- CAM software plans, manages and controls the operations of a manufacturing site
- CAE software analyzes design geometry, allowing designer to study product behavior

Computer Aided technologies

- **CAD** – Computer aided design
- **CAM** – Computer aided manufacturing
- CAE – Computer aided engineering
- CAPP – Computer aided process planning
- CAQA – Computer aided quality assurance
- CAPPS – Computer aided production planning and scheduling
- CAST – Computer aided storage and transport

PACKAGES FOR CAD/CAM/CAE/CAPP

PACKAGES FOR CAD/CAM/CAE/CAPP

- Software packages used are

1. Modeling software

1. **SOLID EDGE**
2. **SOLID WORKS**
3. **CATIA**
4. **PRO/E**
5. **AUTODESK INVENTOR**
6. **AUTOCAD**

2. Analysis software

1. **ANSYS**
2. **NASTRAN**
3. **ABAQUS**

SOLID EDGE

1. MODELING SOFTWARES

1. SOLID EDGE

- SOLID EDGE is a three dimensional modeling software developed by **Siemens**
- It utilizes a parametric feature-based approach to create models and assemblies.
- It is a windows based system.
- It is a direct competitor for SOLID WORKS software.
- It has part modeling as well

2. SOLID WORKS

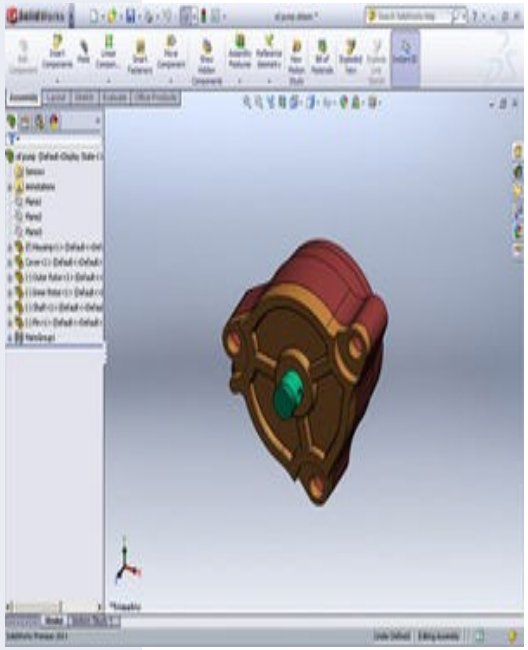
Developer(s)	Dassault Systèmes SolidWorks Corp.
Initial release	1995
Stable release	SolidWorks 2014 SP0 / October 7, 2013
Preview release	SolidWorks 2014 SP1.0 EV / November 13, 2013
Operating system	Microsoft Windows
Type	CAD

SolidWorks Corporation was founded in December 1993 by Massachusetts Institute of Technology graduate Jon Hirschtick

SOLID WORKS

- utilizes a parametric feature-based approach to create models and assemblies
- Parameters can be either numeric parameters, such as line lengths , or geometric parameters, such as tangent.
- Features refer to the building blocks of the part.
- drawings can be created either from parts or assemblies.

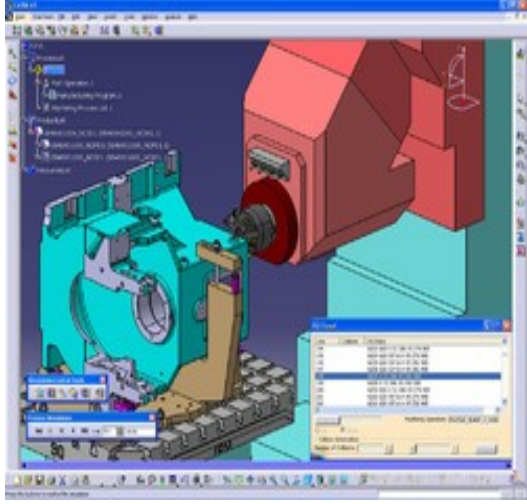
Name/Version	Version History Value	Release Date
SolidWorks 95	44	1995
SolidWorks 96	243	1996
SolidWorks 97	483	1996
SolidWorks 97Plus	629	1997
SolidWorks 98	817	1997
SolidWorks 98Plus	1008	1998
SolidWorks 99	1137	1998
SolidWorks 2000	1500	1999
SolidWorks 2001	1750	2000
SolidWorks 2001Plus	1950	2001
SolidWorks 2003	2200	2002
SolidWorks 2004	2500	2003
SolidWorks 2005	2800	2004
Solid Works 2006	3100	2005
SolidWorks 2007	3400	2006
SolidWorks 2008	3800	July 1, 2007
SolidWorks 2009	4100	January 28, 2008
SolidWorks 2010	4400	December 9, 2009
SolidWorks 2011	4700	June 17, 2010
SolidWorks 2012	5000	September, 2011
SolidWorks 2013	6000	September, 2012



3. CATIA (Computer Aided Three-dimensional Interactive Application)

- Developed by the French company Dassault Systemes.
- Initial release - 1977
- Latest - In June 2011, Dassault launched V6 R2012.
- supports multiple stages of product development (CAx), including conceptualization, design (CAD), manufacturing (CAM), and engineering (CAE)

CATIA-Industries



- aerospace and defence,
- automotive, and industrial equipment, to high tech, shipbuilding,
- consumer goods, plant design, consumer packaged goods, life sciences,
- architecture and construction, process power and petroleum, and services

4. Pro/E

- Created by Dr. Samuel P. Geisberg in the mid-1980s
- The Pro/ENGINEER name was changed to Creo Elements/Pro, also known as Wildfire 5.0 on October 28, 2010
- It is parametric, integrated 3D CAD/CAM/CAE solution, is used by discrete manufacturers for mechanical engineering, design and manufacturing.

Pro/E

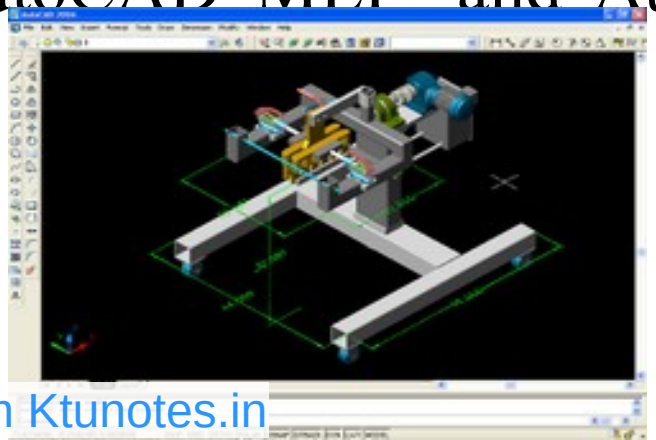
- It provides a complete set of design, analysis and manufacturing capabilities
- capabilities include Solid Modelling, Surfacing, Rendering, Data Interoperability, Routed Systems Design, Simulation, Tolerance Analysis, NC and Tooling Design.

Pro E

Name/Version	Build Number	Date	Internal version
Pro/ENGINEER (Autofact 1987 premier)	R 1.0	1987	?
Pro/ENGINEER	R 8.0	1991	?
Pro/ENGINEER	R 9.0	1992	9.0
Pro/ENGINEER	R 10.0	1993	10.0
Pro/ENGINEER	R 11.0	1993	11.0
Pro/ENGINEER	R 12.0	1993	12.0
Pro/ENGINEER	R 13.0	1994	13.0
Pro/ENGINEER	R 14.0	1994	14.0
Pro/ENGINEER	R 40	1995	15.0
Pro/ENGINEER	R 16.0	1996	16.0
Pro/ENGINEER	R 17.0	1997	17.0
Pro/ENGINEER	R 18.0	1997	18.0
Pro/ENGINEER	R 19.0	1998	19.0
Pro/ENGINEER	R 20.0	1998	20.0
Pro/ENGINEER	R 2000i	1999	21.0
Pro/ENGINEER	R 2000i^2	2000	22.0
Pro/ENGINEER	R 2001	2001	23.0
Pro/ENGINEER Wildfire	R 1.0	2002	24.0
Pro/ENGINEER Wildfire	R 2.0	2004	25.0
Pro/ENGINEER Wildfire	R 3.0	2006	27.0
Pro/ENGINEER Wildfire	R 4.0	2008	29.0
Pro/ENGINEER Wildfire	R 5.0	2009	31.0
Creo Elements/Pro	R 5.0 (as of M065)	2010	31.0
Creo Parametric	R 1.0	2011	32.0
Creo Parametric	R 2.0	2012	33.0

5. Autodesk Inventor

- An American multinational software corporation that focuses on acquiring 3D design software for use in the architecture,engineering, construction, manufacturing, media, and entertainment industries.
- The company was founded in 1982 by John Walker.
- Autodesk's architecture, engineering, and construction solutions include AutoCAD-based design and documentation software such as AutoCAD Architecture , AutoCAD MEP and AutoCAD Civil 3D



AUTODESK®
INVENTOR®

6. I-DEAS (Integrated Design and Engineering Analysis Software)

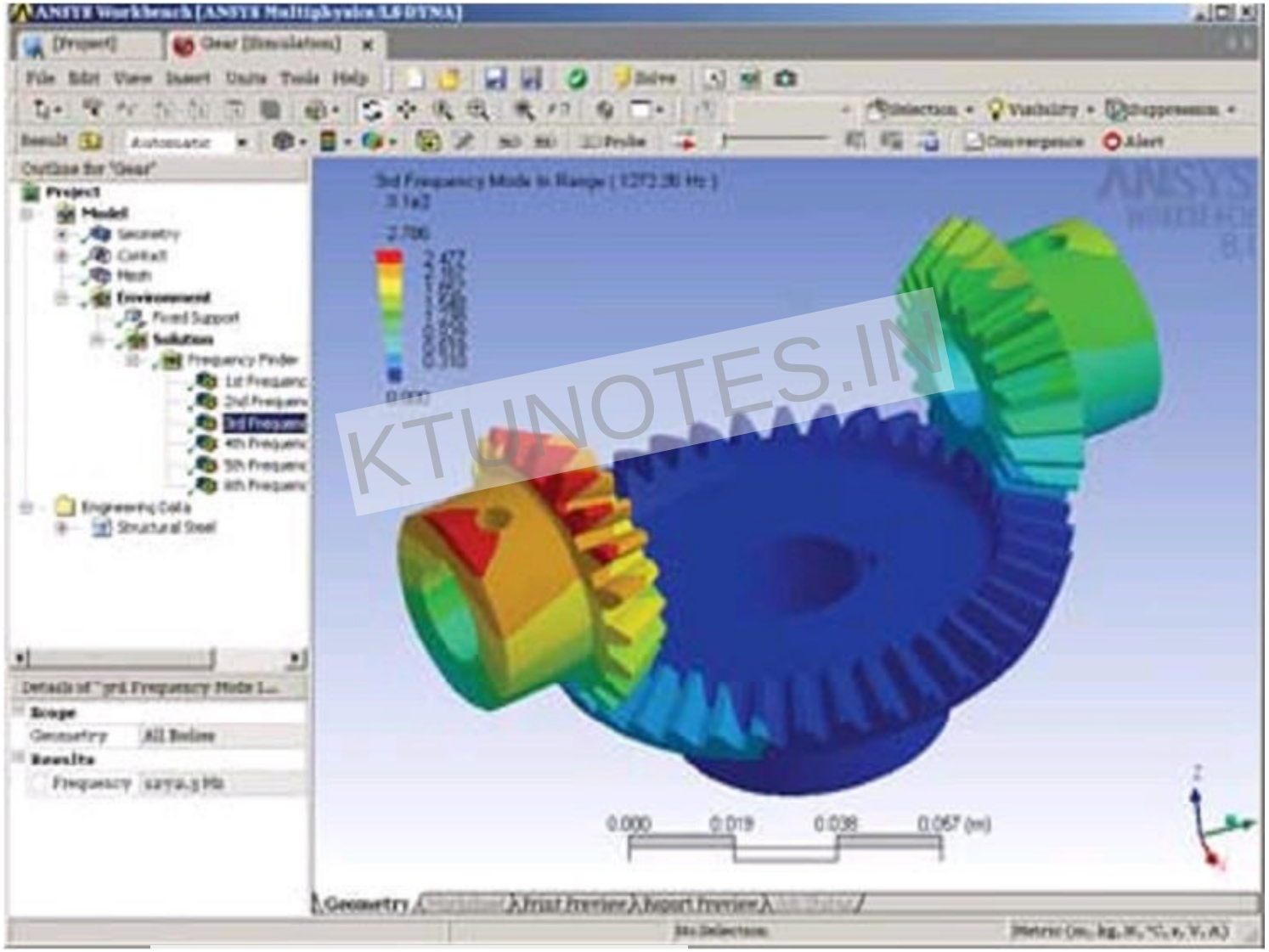
- Computer-aided design software package originally produced by Structural Dynamics Research Corporation in 1982
- **Developed by :- Siemens PLM software**
- I-DEAS was used primarily in the automotive industry most notably by Ford Motor Company and by General Motors

2. ANALYSIS SOFTWARE

1. ANSYS

- ANSYS is an analysis software.
- Ansys, Inc. is a public company based in Canonsburg, Pennsylvania. It develops and markets engineering simulation software.
- Ansys software is used to design products and semiconductors, as well as to create simulations that test a product's durability, temperature distribution, fluid movements, and electromagnetic properties.
- Ansys was founded in 1970 by John Swanson.

1. ANSYS

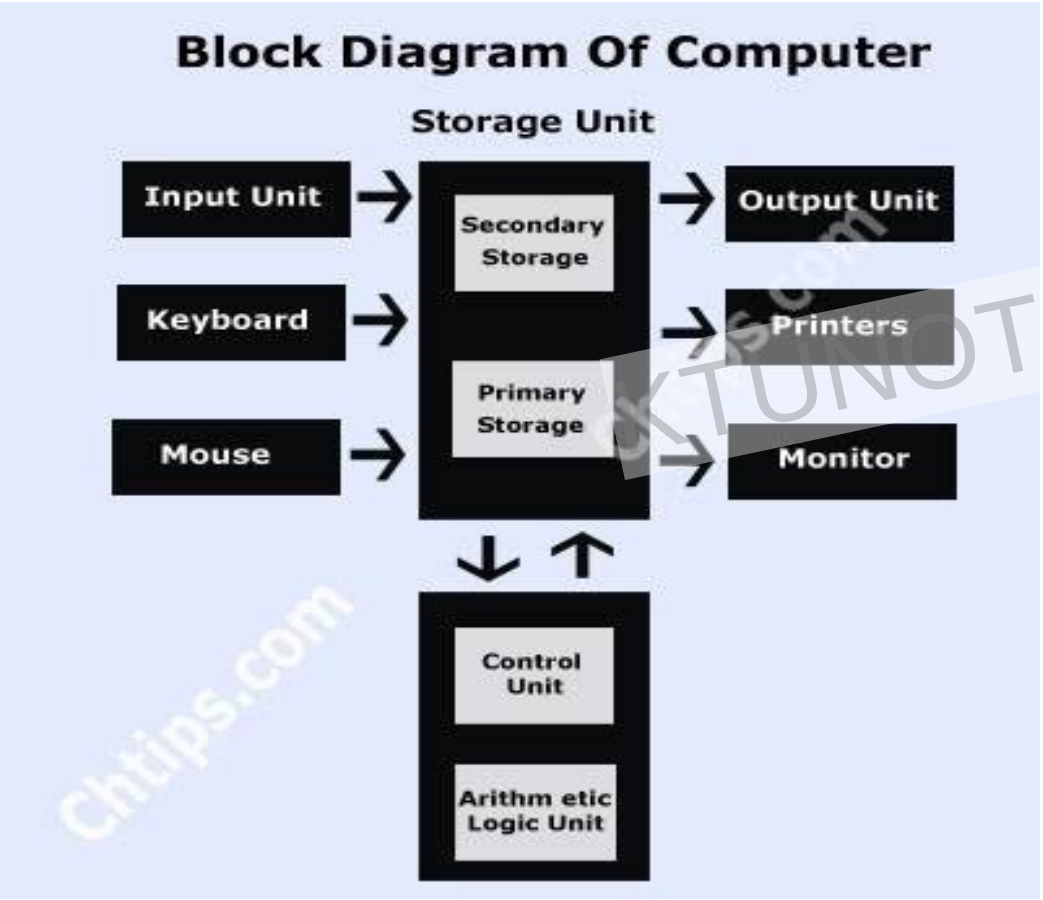


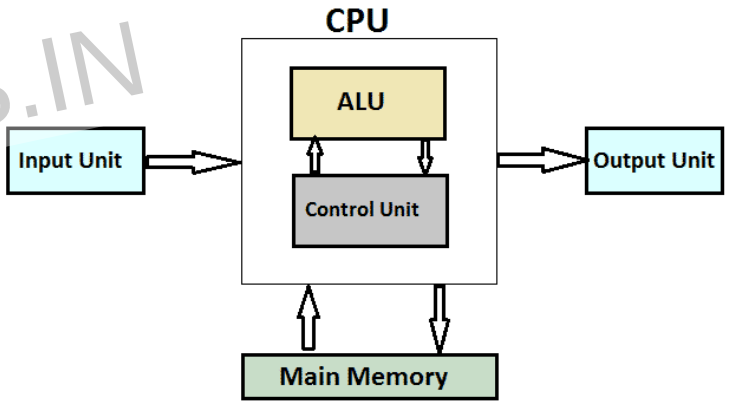
2. ABAQUS

- **Abaqus FEA**[(formerly **ABAQUS**) is a software suite forfinite element analysis and computer-aided engineering, originally released in 1978. The name and logo of this software are based on the abacus calculation tool.

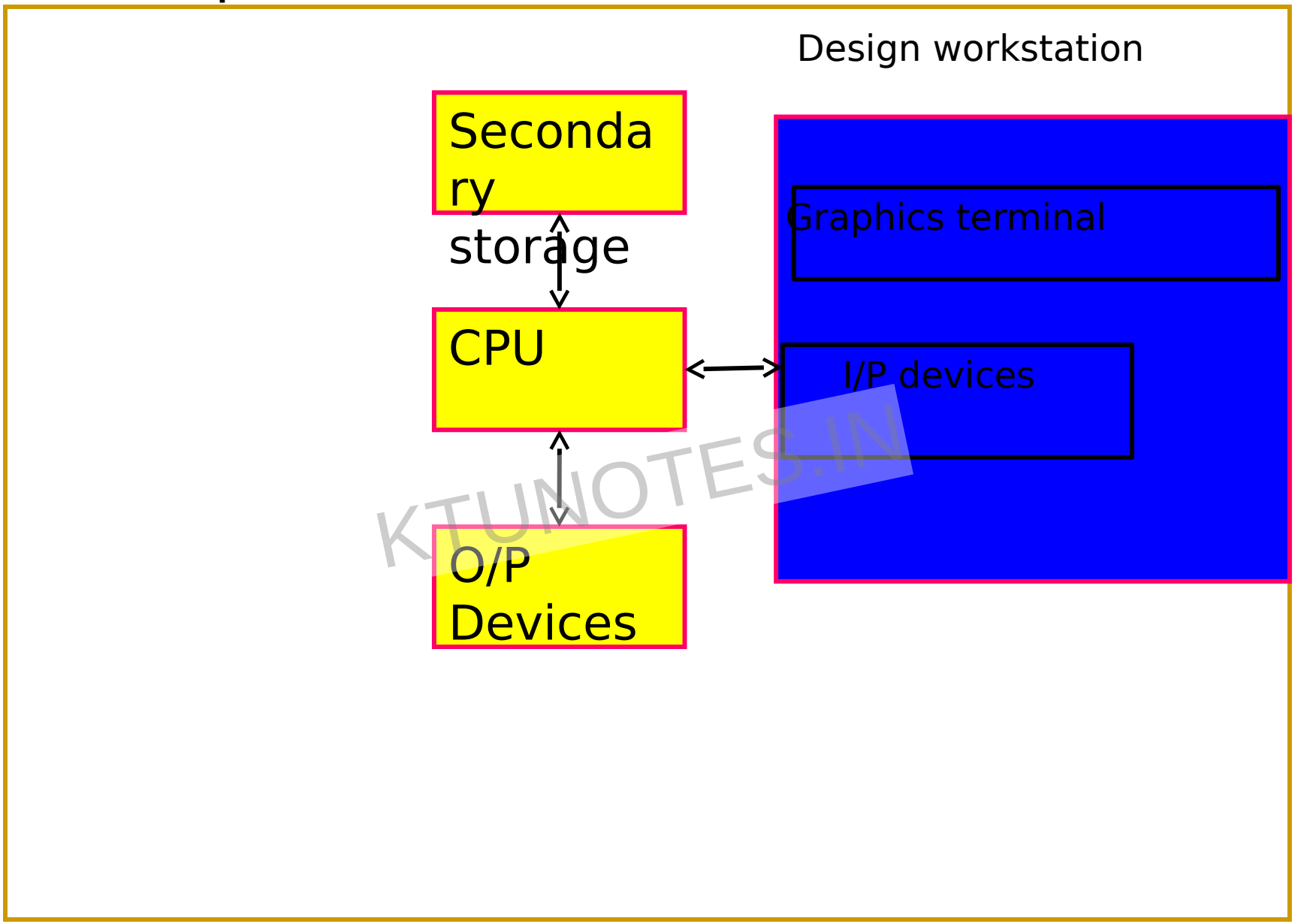
HARDWARE IN CAD COMPONENTS_

Hardware Components





Basic components in a CAD hardware



Hardware Components

- Hardware component for CAD are the physical part of the computer system

1. Input devices:

- Cursor control
  - Mouse
  - Thumbwheels
  - Lightpen
  - Joystick
  - Scanner
- Digitizer
- Keyboard





2. Output Devices:

- Graphics terminal (CRT Monitor)
- Plotters
- Printers



Hardware Components

3. Central Processing Unit (CPU)

- Airthematic Logic Unit (ALU)
- Control Logic Unit (CLU)

4. Storage/ Memory

- Primary memory (RAM/ROM)
- Secondary memory
  - Harddisk
  - Floppy
  - Cd
  - Pendrive

Hardware Components

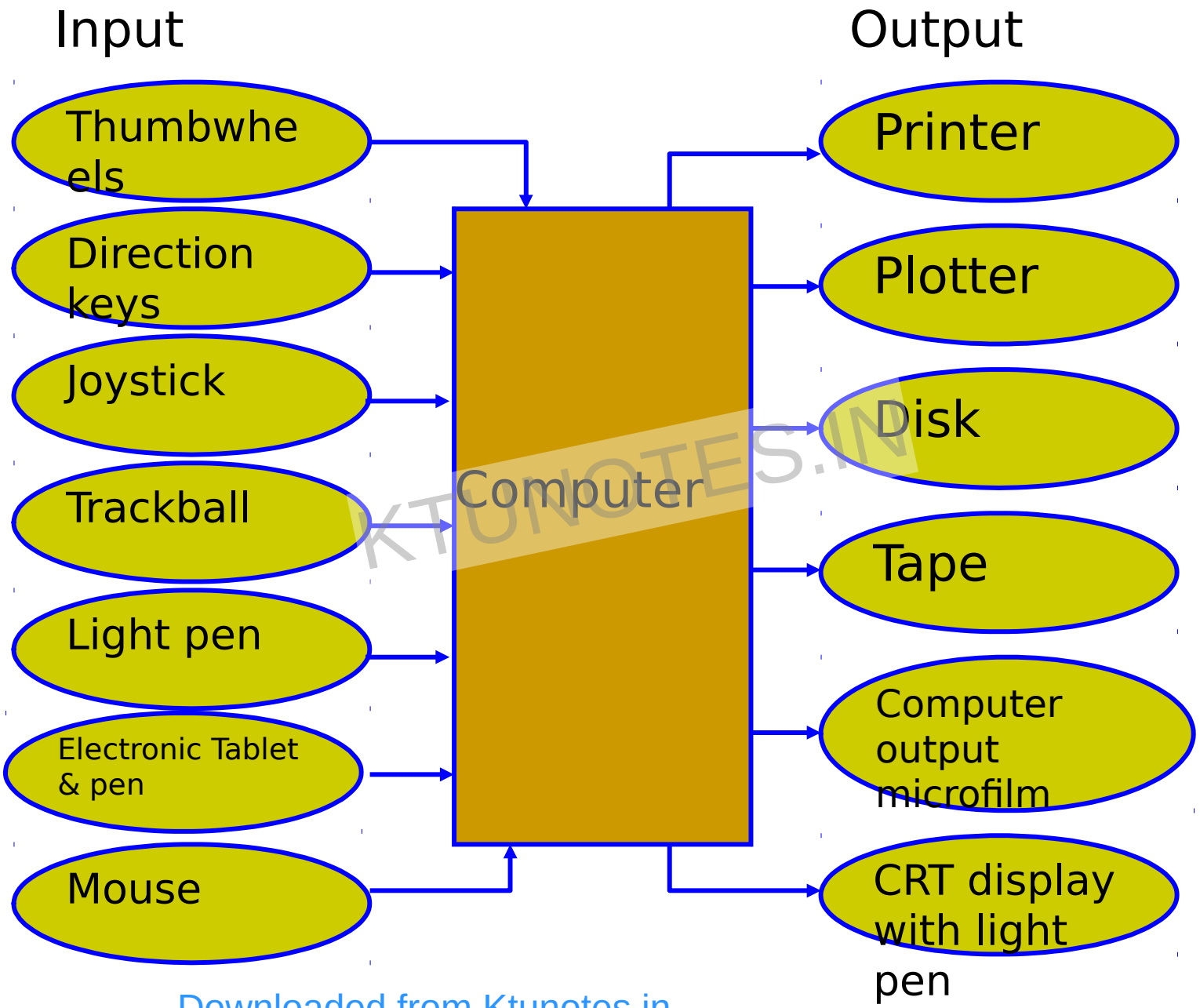
Basic parts of a Computer

USER INTERACTION DEVICES

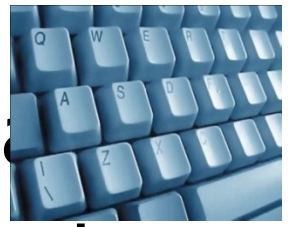
- The device used for interaction between user and the computer system is known as user interaction devices.

- **User interaction devi e:**
  1. **Output device**
  2. **Input device**

Operator I/O & O/P devices of a CAD system



1. INPUT DEVICES



- **Keyboards** – To input text data
- **Light pens** – A pointing device to select a displayed graphics item on screen by directly touching its surface of items. (for tracking, positioning, locating)

- **Digitizing tablets**– A pointing device and is a ace over which a stylus c oved by user.

1. INPUT DEVICES

- **Mouse system**– It is a location or pointing device.
- **Joysticks**- It is a locating device, works by pushing its stick in 4 directions.
- **Trackball** – It is a locating device used to navigate screen display cursor by rotating the ball.
- **Thumbwheels** – It is used to control horizontal and vertical positions

Input Devices

joystick

mouse

mic

camera

touch tablet

hand-held scanner

keyboard

flatbed scanner

2. OUTPUT DEVICES

1. Graphics Display Device (Monitor)

1. **Cathode Ray Tube (CRT)**
   - Refresh display
   - Raster display
   - Direct view storage tube (DVST)
2. **Liquid Crystal Display (LCD)**
3. **Raster display**

2. Hard copy Printers

1. **Impact printer**
   - Dot matrix printer
2. **Non Impact printer**
   - Inkjet printer
   - Laser printer

OUTPUT DEVICES

3. Plotters

1. **Pen plotters**
   - Flat bed plotter
   - Drum type plotter
2. **Electrostatic plotters**

DISPLAY DEVICES- COMPUTER GRAPHICS

1. Cathode Ray Tube (CI
2. Liquid Crystal Display (LCD)

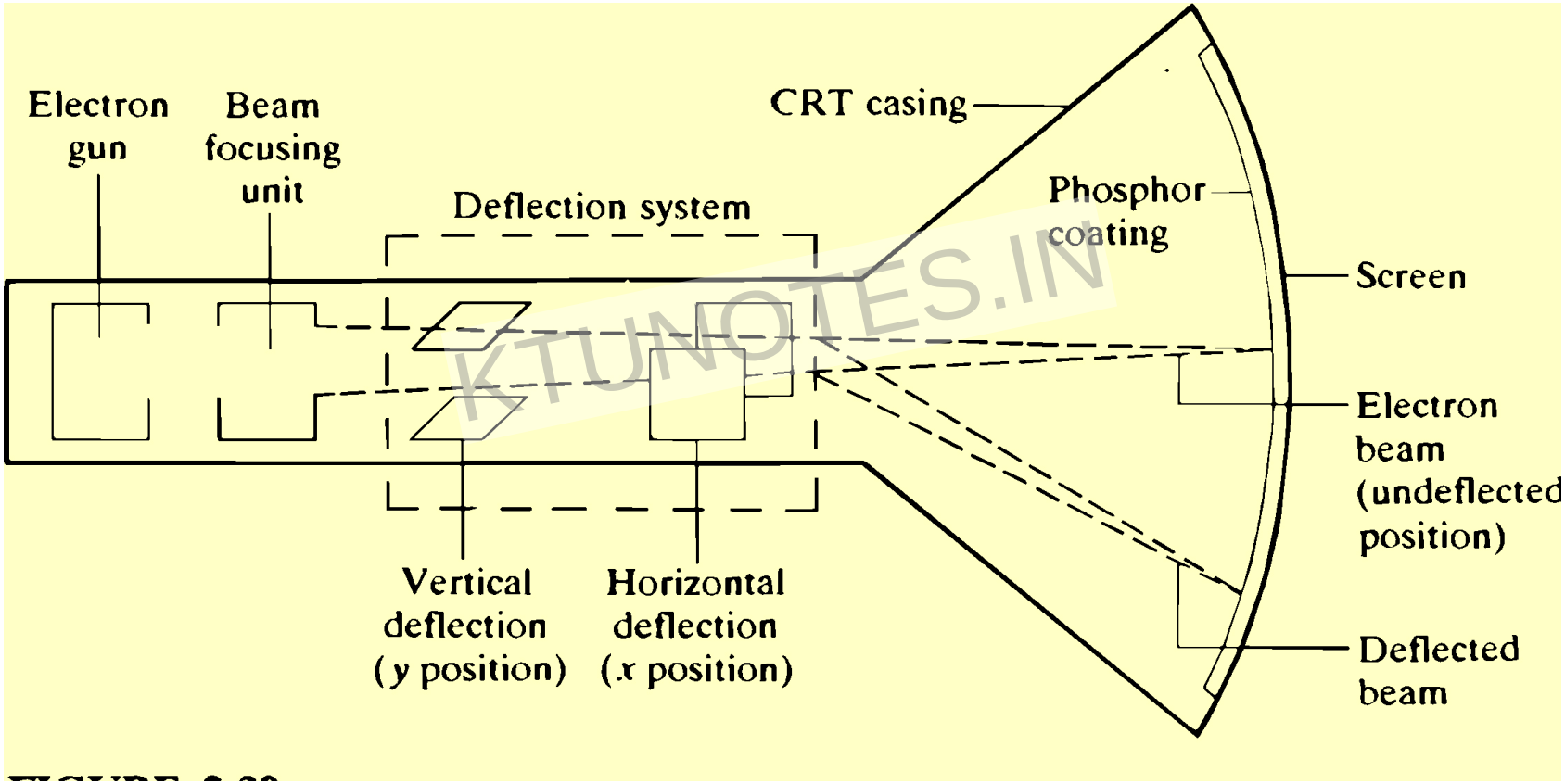
3. Plasma Display
4. Light Emitting Diode (LED)

1. CATHODE RAY TUBE (CRT)

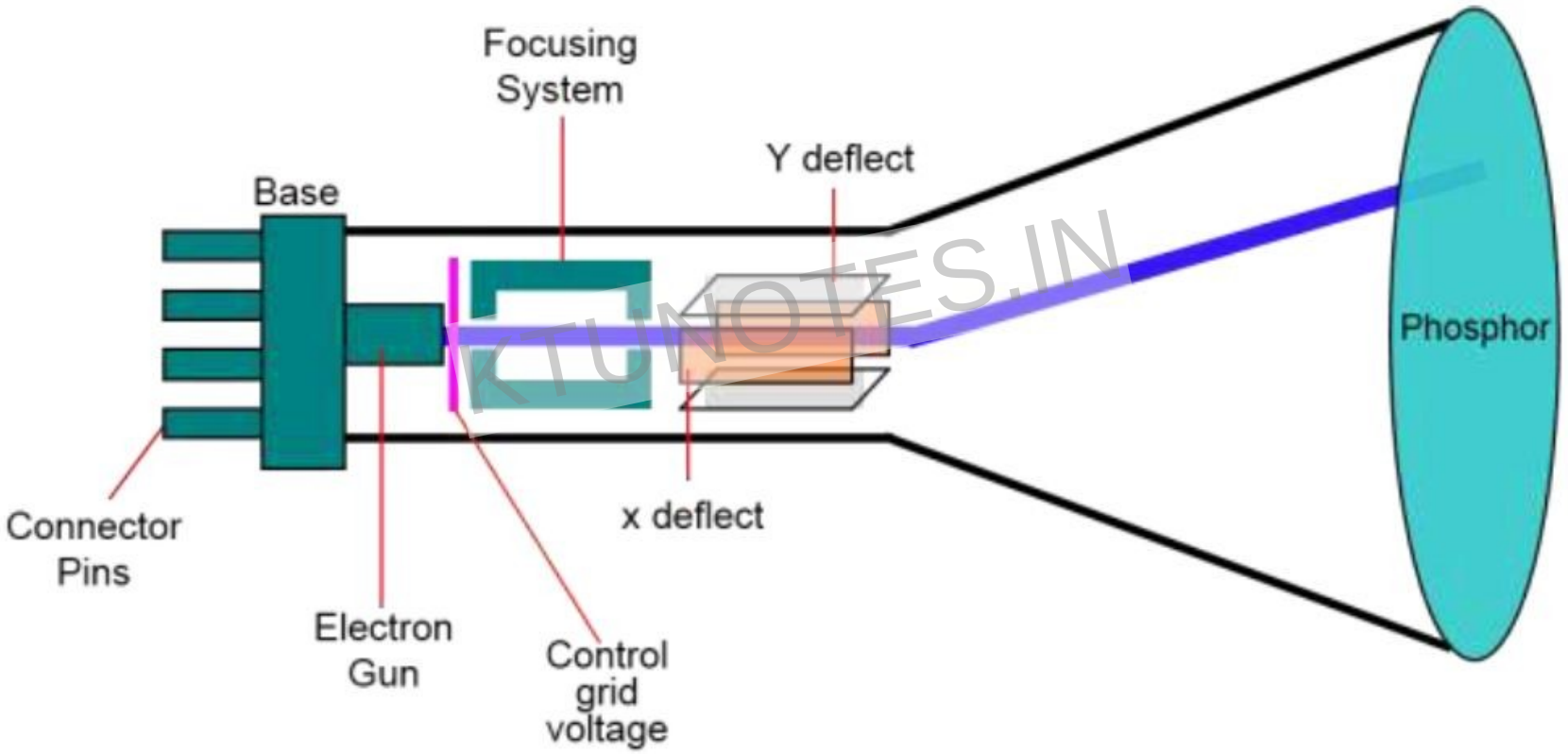
- CRT is the mostly used display technology
- It is the primary output devices in a graphical system.
- The cathode ray tube (CRT) is a vacuum tube that contains one or more electron guns and a phosphor screen, and is used to display images.
- It modulates, accelerates, and deflects electron beam(s) onto the screen to create the images.

CATHODE RAY TUBE (CRT)

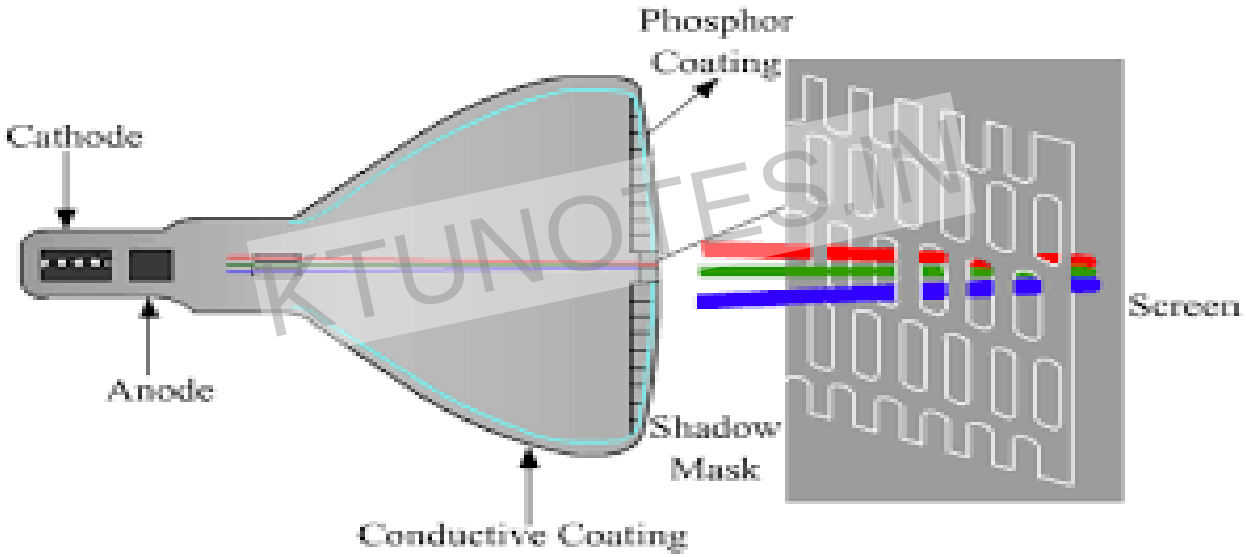
Schematic diagram of a CRT



CATHODE RAY TUBE (CRT)



CATHODE RAY TUBE (COLOUR CRT)



CATHODE RAY TUBE (CRT)

PARTS OF CRT

- Electron gun
- Beam focusing unit
- Deflection system
  - Horizontal deflection (X- position)
  - Vertical deflection (Y- position)
- Phosphor coated screen
- CRT casing

CATHODE RAY TUBE (CRT)

PRINCIPLE OF OPERATION

- It is based on the concept of energizing an electron beam that strikes the phosphor coating in screen at very high speed, causes it to illuminate and glow as the image to be displayed.

CATHODE RAY TUBE (CRT)

Working of CRT

- The electron gun emits an electron beam (cathode rays) when an electrical supply is given.

Working

- The electron gun generates the electrons.
- The focusing unit focuses the electrons into beam.
- The deflection system controls x and y, or the horizontal and vertical positions of the graphics information through the display controller, which typically sits between the computer and CRT.

The graphics display can be divided into two types based on the **scan technology** used to control the electron beam when generating graphics on the screen:

1. Random scan: the screen is not scanned in particular order.
2. Raster scan: the screen is scanned from left to right, top to bottom, all the times to generate graphics.

Basic **techniques used CG for generating images** on CRT screen

1. Stoke writing approach: the screen is not scanned in particular order.
2. Raster scan: the screen is scanned from left to right, top to bottom, all the times to generate graphics.

CATHODE RAY TUBE (CRT)

APPLICATION

- Computer monitors
- TV

CATHODE RAY TUBE (CRT)

ADVANTAGES

- Low cost
- High viewing angle

CATHODE RAY TUBE (CRT)

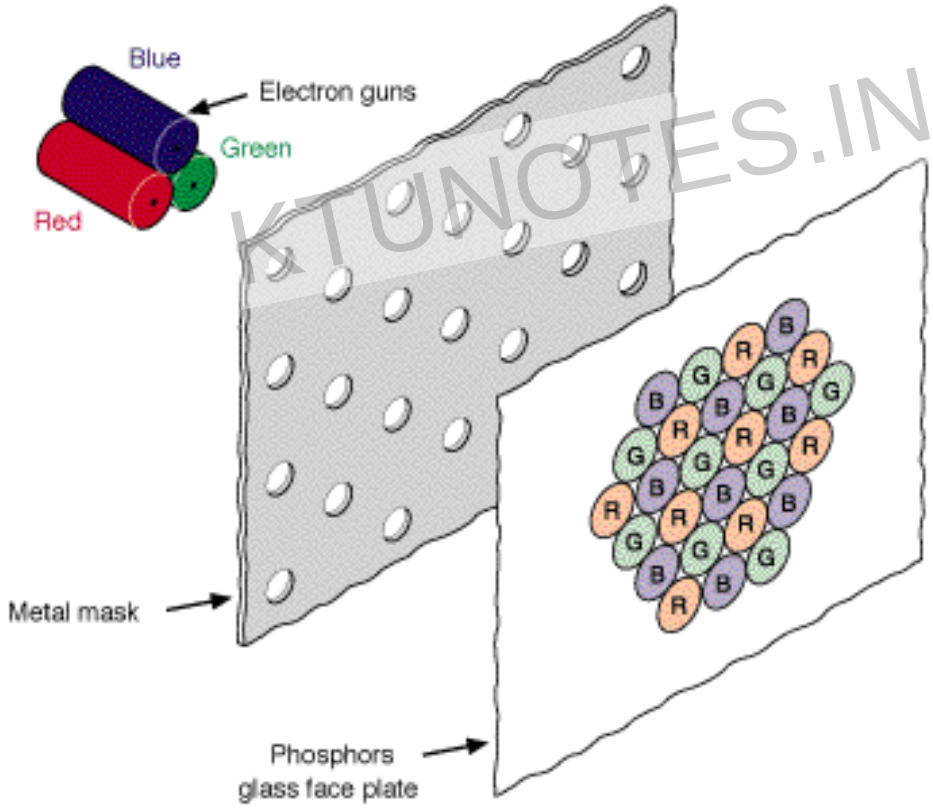
DISADVANTAGES

- Heavier and bulky
- More power consumption
- Has small pixel (0.2mm)

Colour CRT

- Used in raster scan system (including color TV)
- Designed as ***RGB*** monitors

The delta-delta method



2. LIQUID CRYSTAL DISPLAY (LCD)

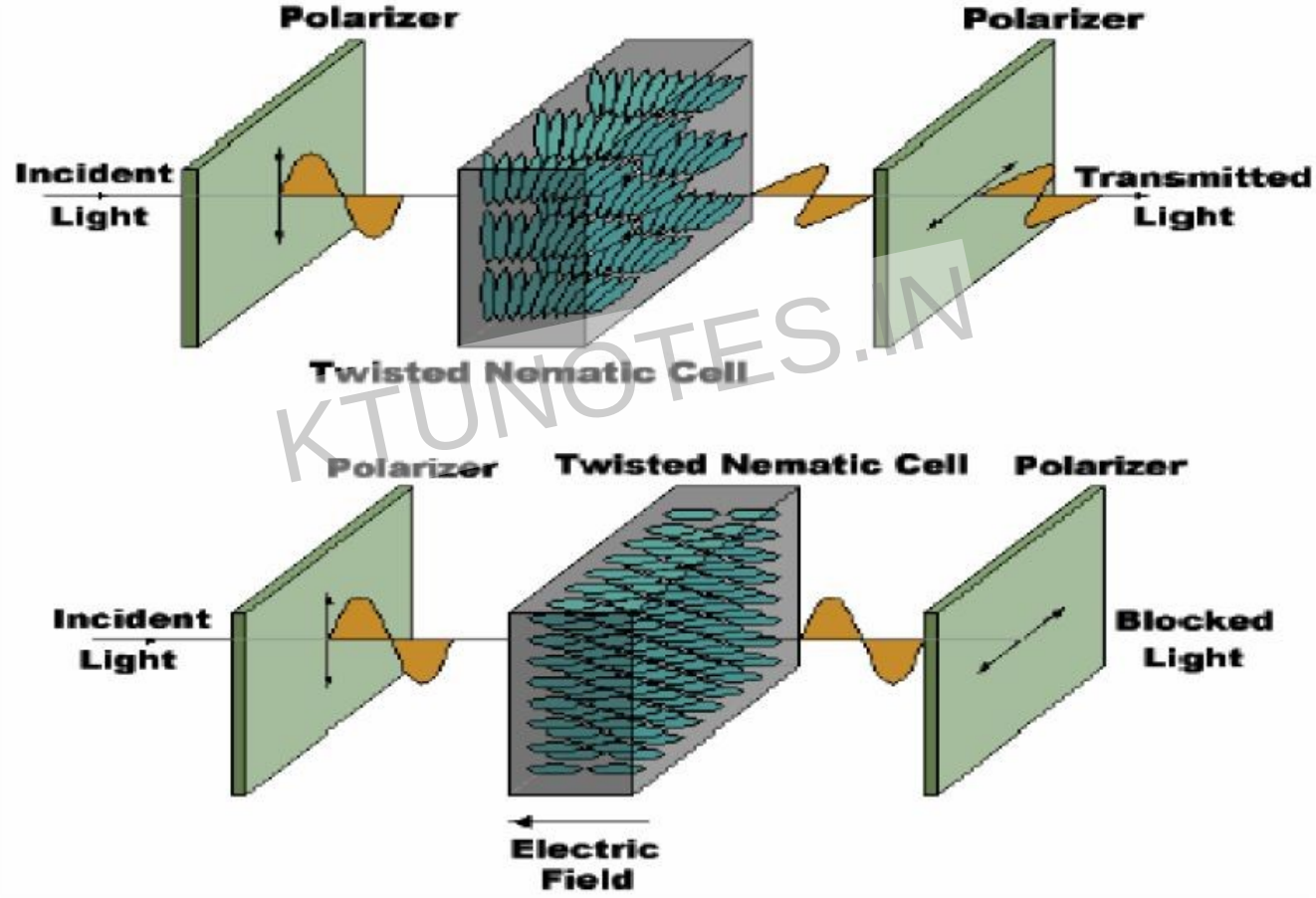
- It is a flat panel display that uses light modulating properties of liquid crystals
- It replaced the heavy CRT displays.

APPLICATION

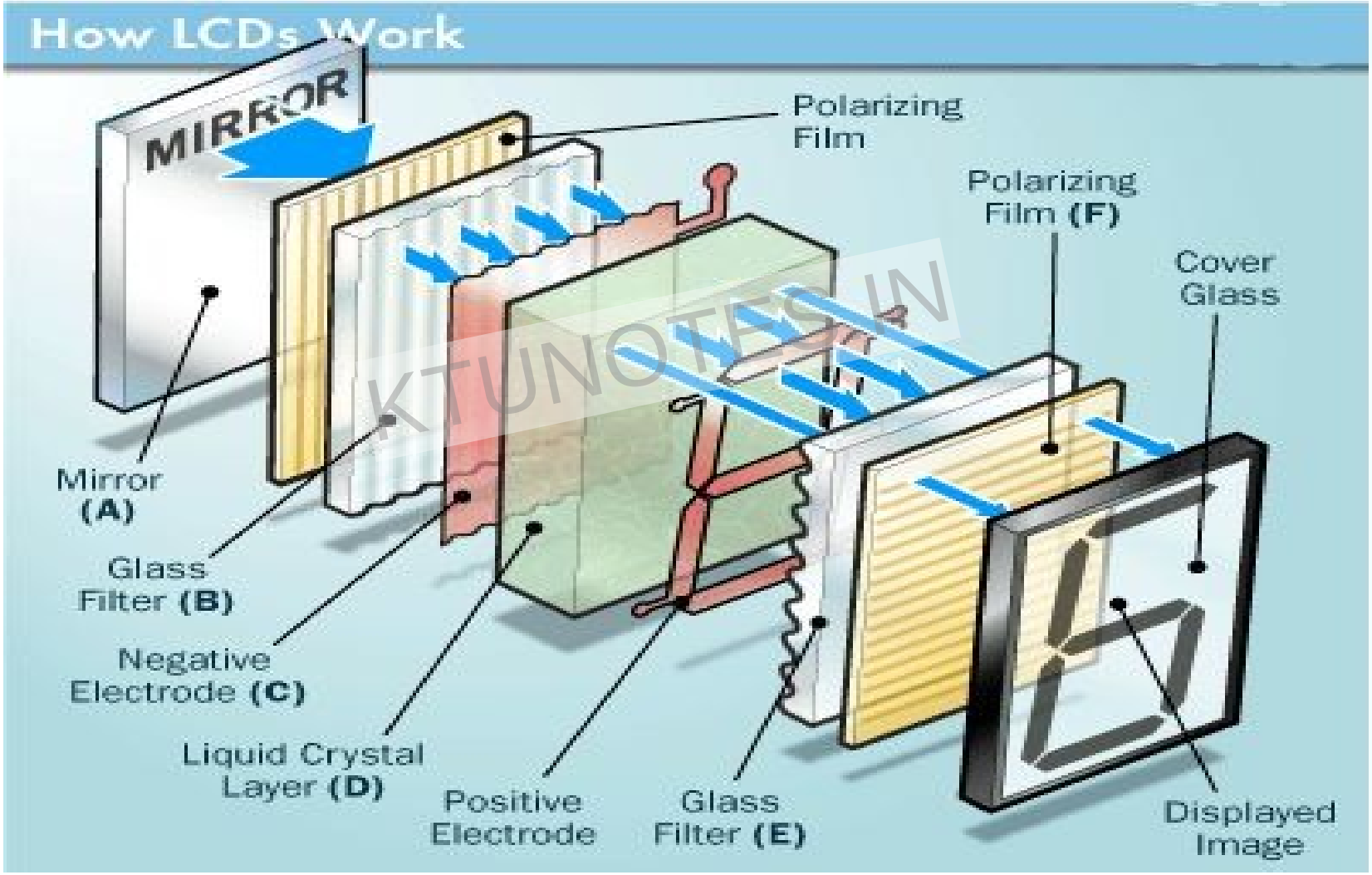
- Computer monitors
- Tv
- Instrument panels
- Watches
- Digital cameras
- Calculators

LIQUID CRYSTAL DISPLAY (LCD)

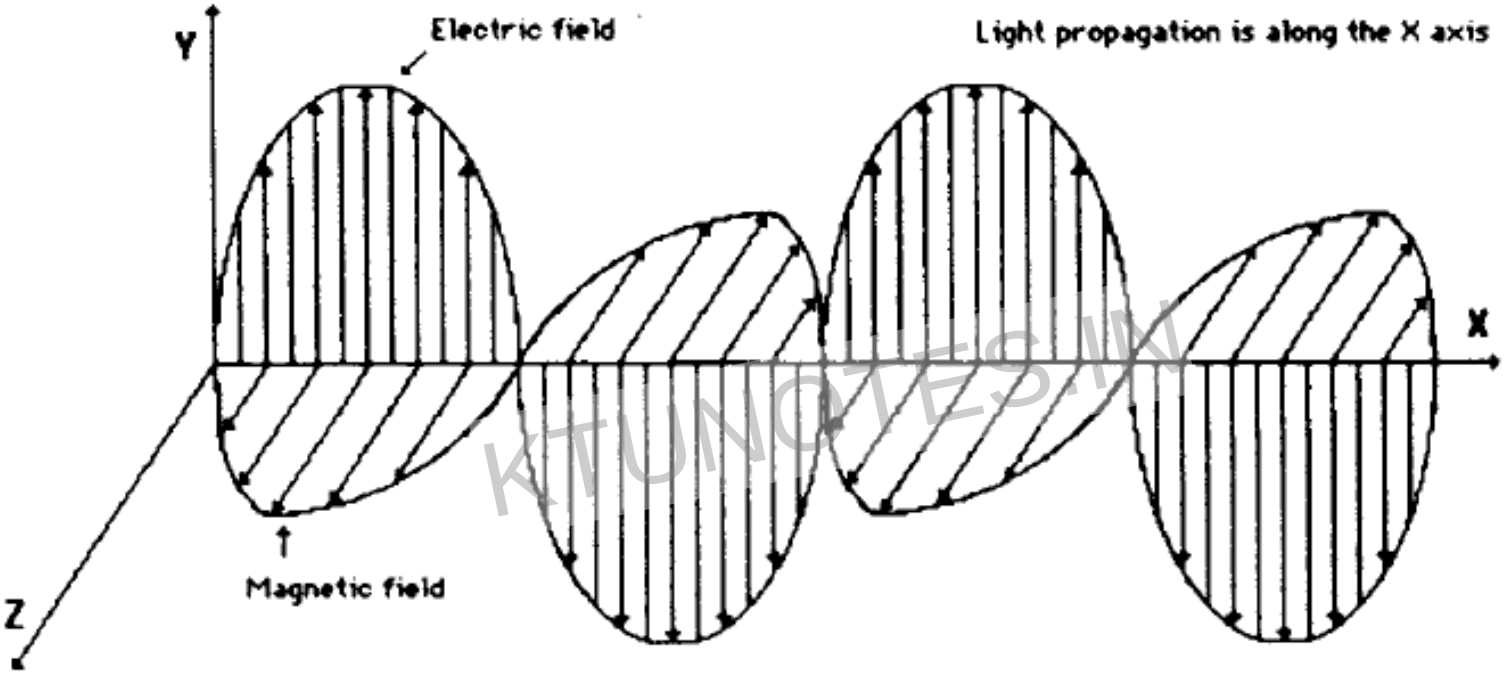
LIQUID CRYSTAL DISPLAY (LCD)



LIQUID CRYSTAL DISPLAY (LCD)



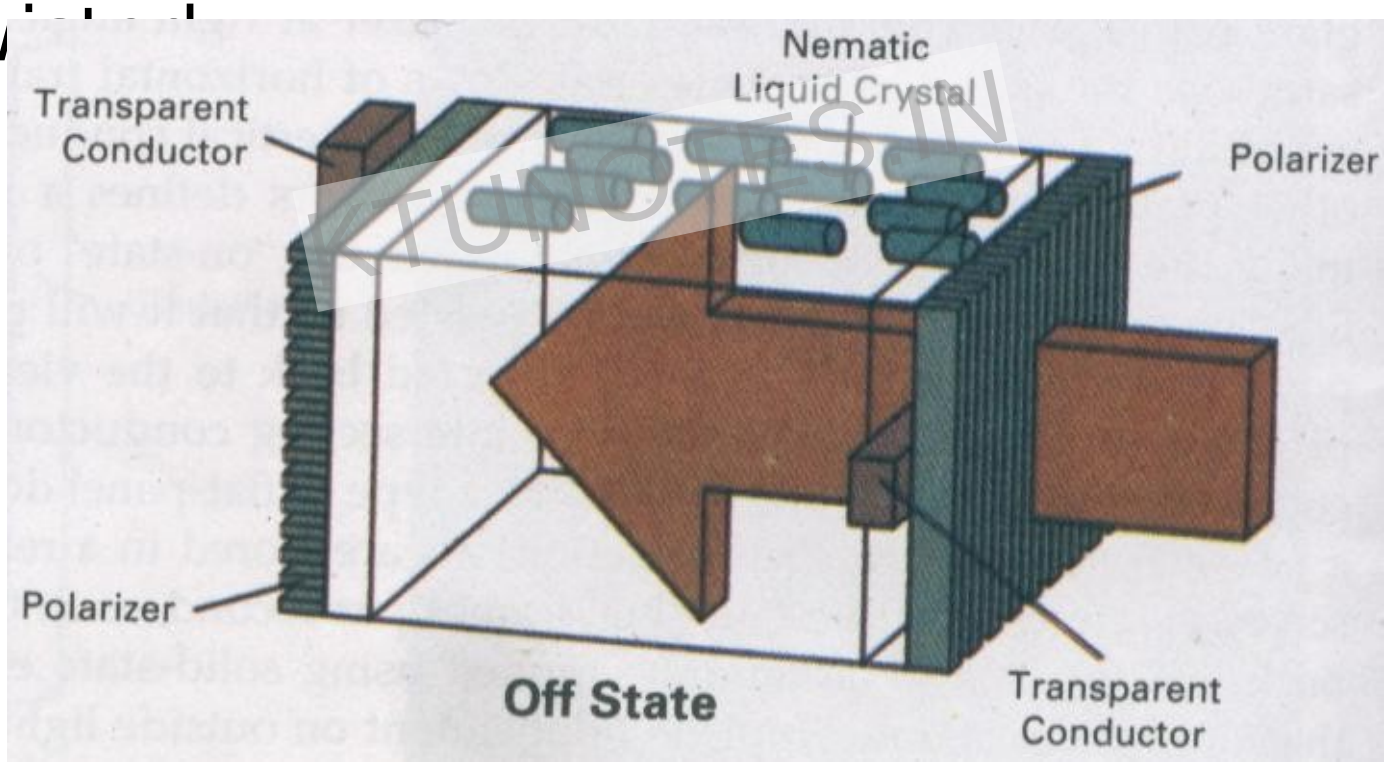
Polarization of light



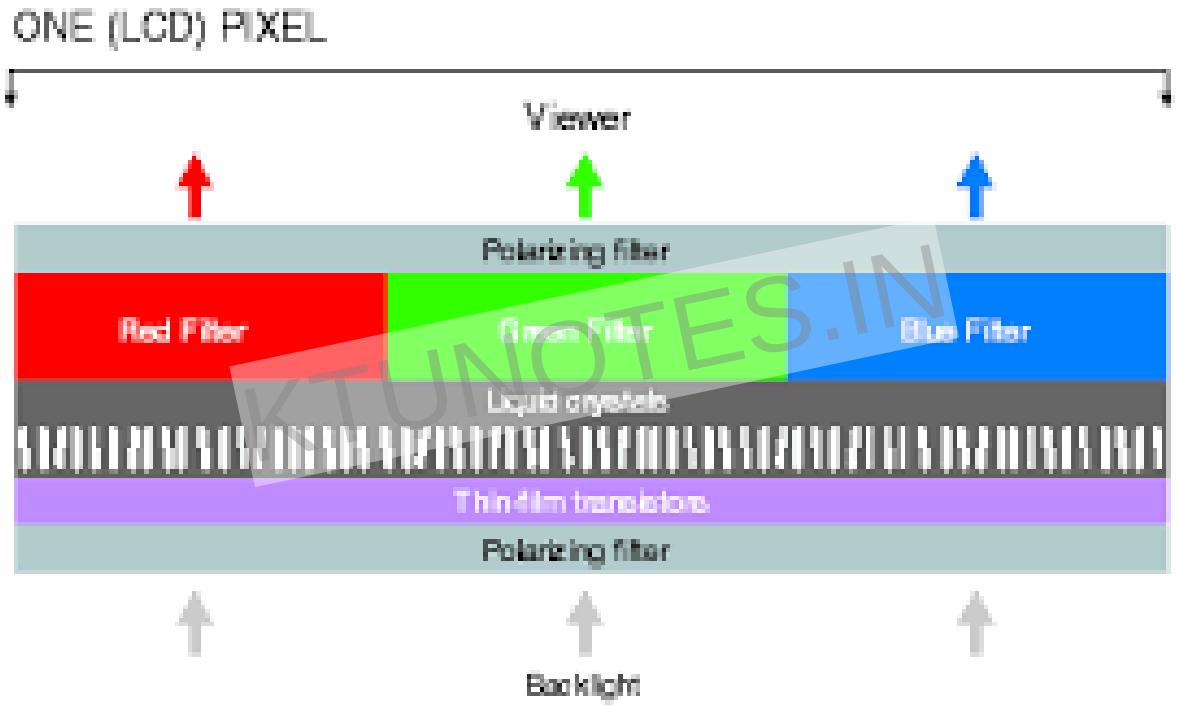
Polarization is in the XY plane

Liquid Crystal Displays (LCD)

To turn off the pixel, we apply a voltage to the two intersecting conductor to align the molecules so that the light is not twi



LIQUID CRYSTAL DISPLAY (LCD)



LIQUID CRYSTAL DISPLAY (LCD)

PRINCIPLE OF OPERATION

- When an electric current is applied to liquid crystal, light tend to twist.

LIQUID CRYSTAL DISPLAY (LCD)

Advantages

- It is more efficient, light weight, can be disposed more safely than CRT

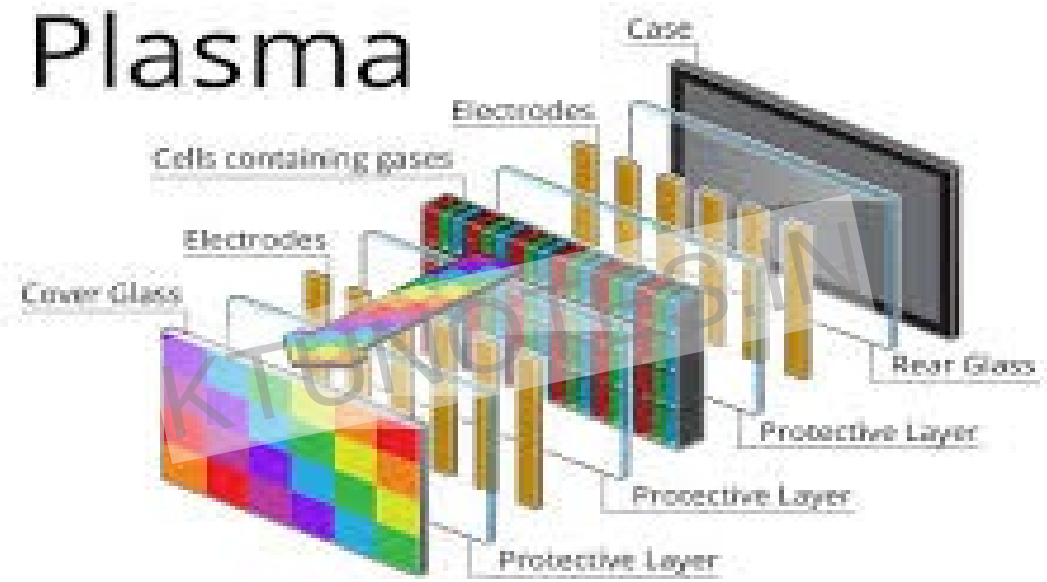
Disadvantage

- Limited viewing angle
- Low refresh rate
- Loss of contrast in high temperature experiments.

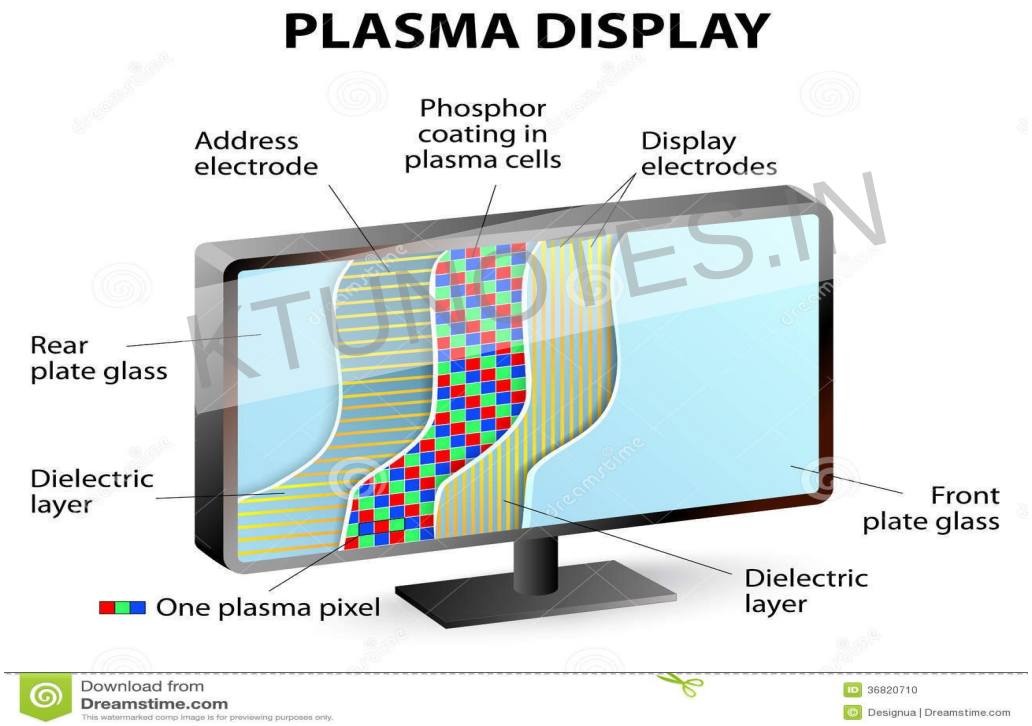
3. PLASMA DISPLAY

- It is a flat panel display which uses plasma cells containing electrically charged ionized inert gases (He, Xe), which are plasmas.
- High voltage discharge excites gas mixture (He, Xe) upon the UV light is emitted, finally UV light excites phosphors in the screen.
- Also called as gas discharge displays.
- It is an emissive type display

PLASMA DISPLAY

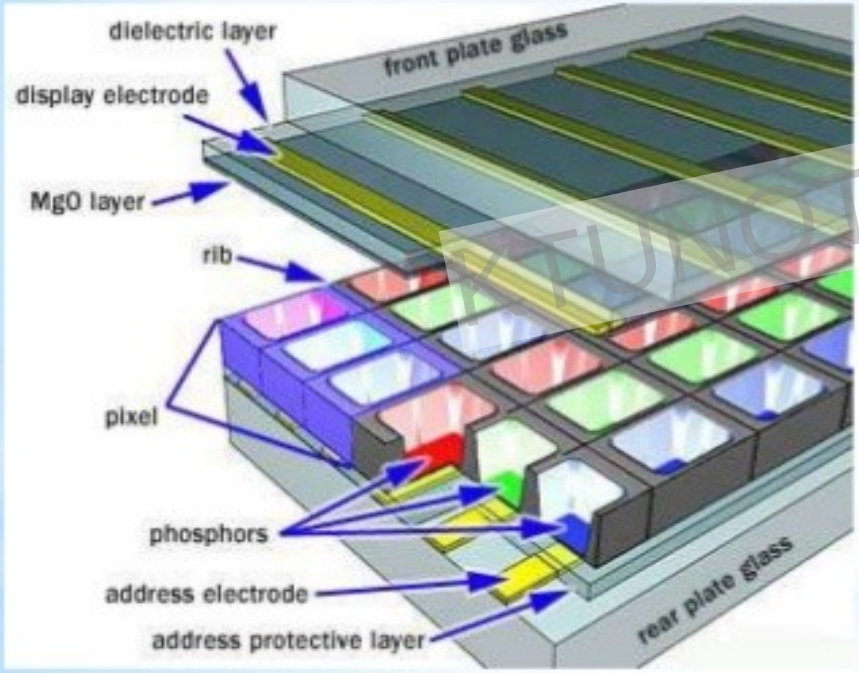


PLASMA DISPLAY



PLASMA DISPLAY

WORKING PRINCIPLE OF PLASMA DISPLAY PANELS:



Typical plasma displays consist of two glass plates, each with parallel electrodes deposited on their surfaces. The electrodes are covered with a dielectric film. The plates are sealed together with their electrodes at right angles, and the gap between the plates is filled with an inert gas mixture. A protective MgO layer is deposited above the dielectric film. The role of this layer is to decrease the breakdown voltage caused by the high secondary electron emission coefficient of MgO.

PLASMA DISPLAY

ADVANTAGES

- Large view angle
- More power and clarity than CRT
- Large pixels (1mm)
- Superior uniformity
- Less expensive than LCD

PLASMA DISPLAY

DISADVANTAGES

- More power consumption
- Heavier than LCD

Types of CRT DISPLAY

1. **Scan technique**
    a) Raster scan system
    b) Random scan system (vector scan)
2. **Graphics display types**
    a) Refresh display
    b) Raster display
    c) Direct view storage tube (DVST)

1. SCAN TECHNIQUES

- The electron beams are scanned or refresh again and again to display the image continuously in the screen without flickering using scan techniques.

a. Raster scan system

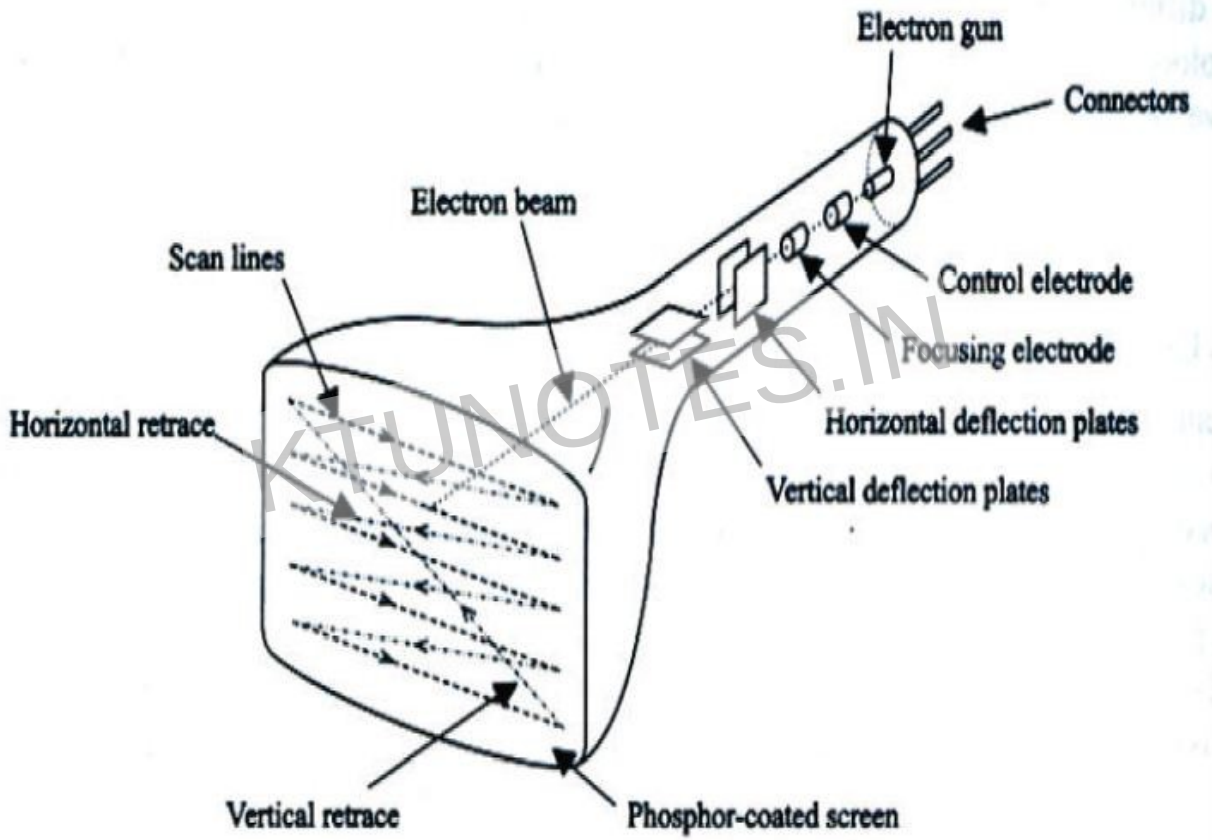
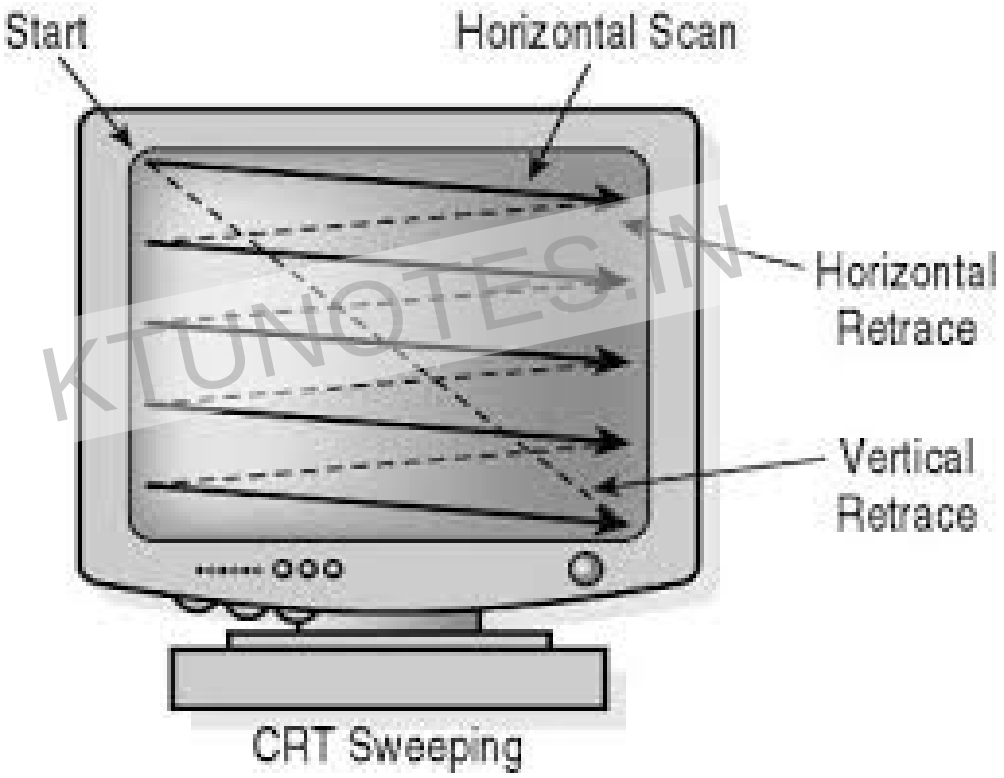


Figure 1.9 : Raster scan display

a. Raster scan system



a. Raster scan system

WORKING

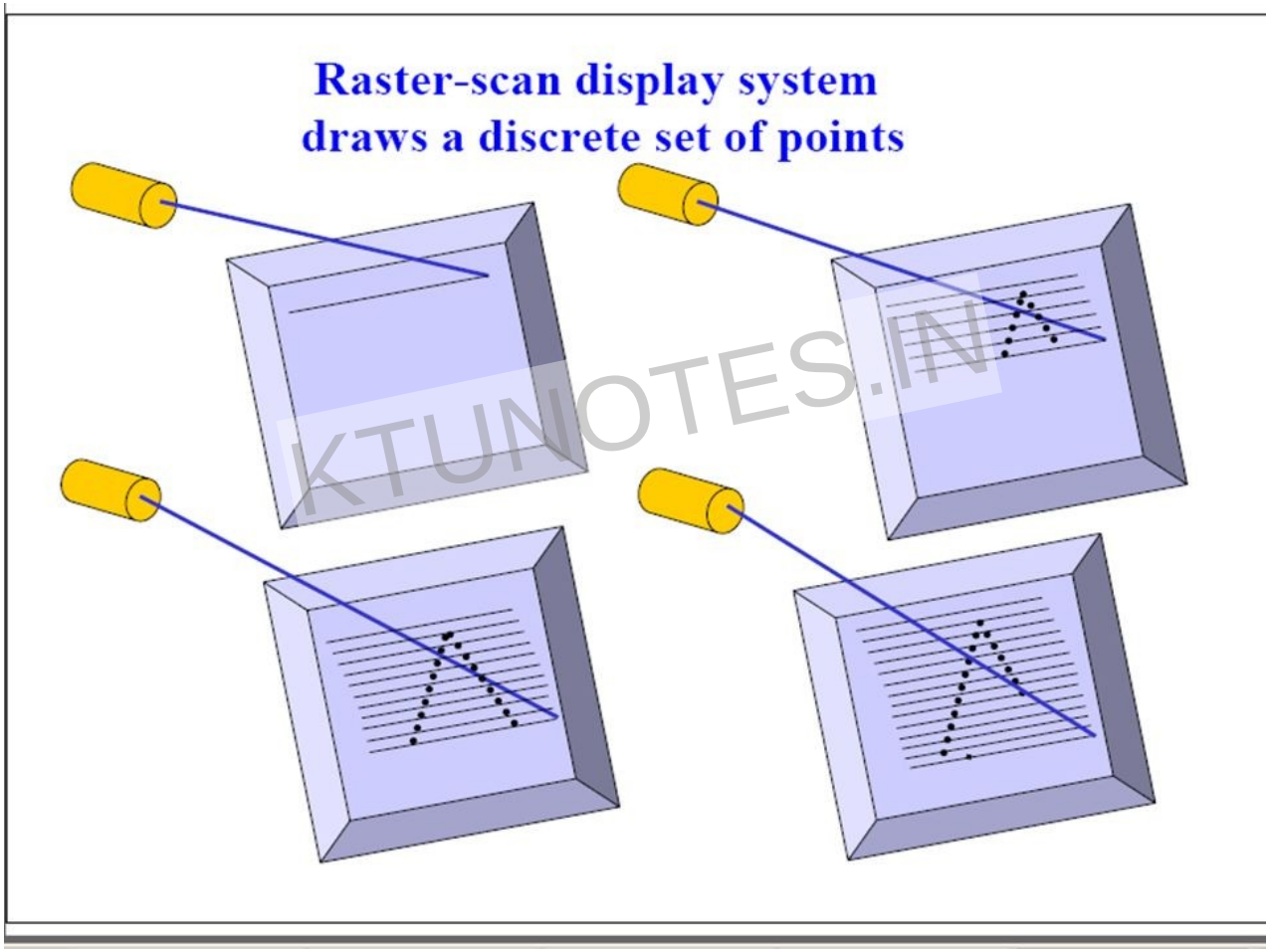
- In a raster scan system, the electron beam is swept across the screen, one row at a time from top to bottom.
- As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots.
- The return to the left of the screen, after refreshing each scan line is called **Horizontal retrace**.
- At the end of each frame the electron beam returns to the top left corner of the screen to begin the next frame is called **Vertical retrace**:

a. Raster scan system

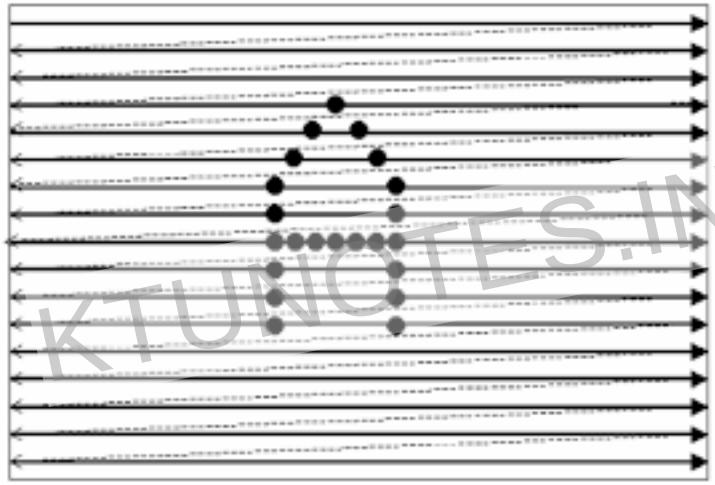
- It is based on television technology.
- Picture definition is stored in the memory area called refresh buffer or frame buffer.
- Refresh buffer holds the intensity values (pixel values) of each pixels.
- Bit value 1– electron beam intensity value turned ON
- Bit value 0– electron beam intensity value turned OFF

Eg. TV

a. Raster scan system



a. Raster scan system



b. Random scan system

- The electron beams are directed to the area of screen where image is to displayed.
- It draws one line at a time.
- It is called as stroke writing or vector display or calligraphic display.
- Refresh rate: 30- 60 frames per second, to maintain steady flicker free image
- Have high resolution

Eg.. Pen plotters

b. Random scan system

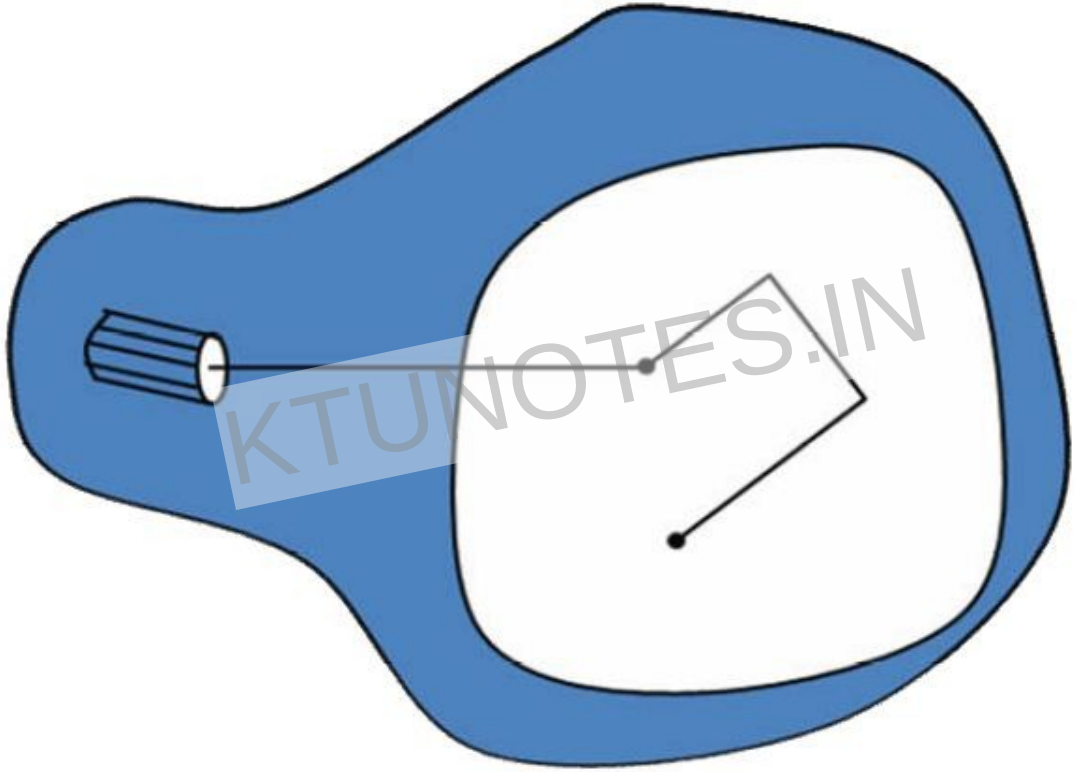
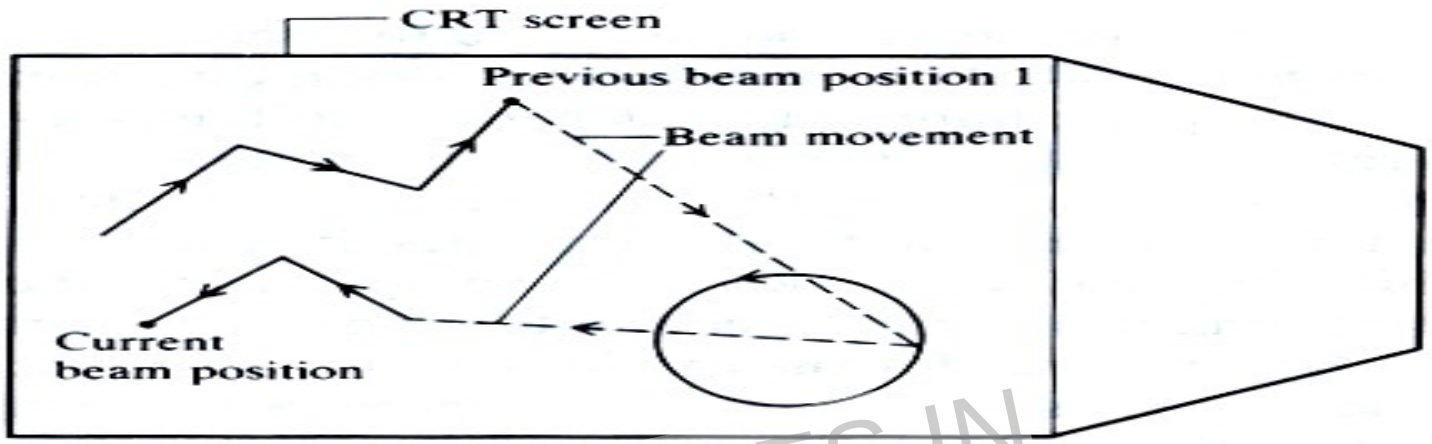
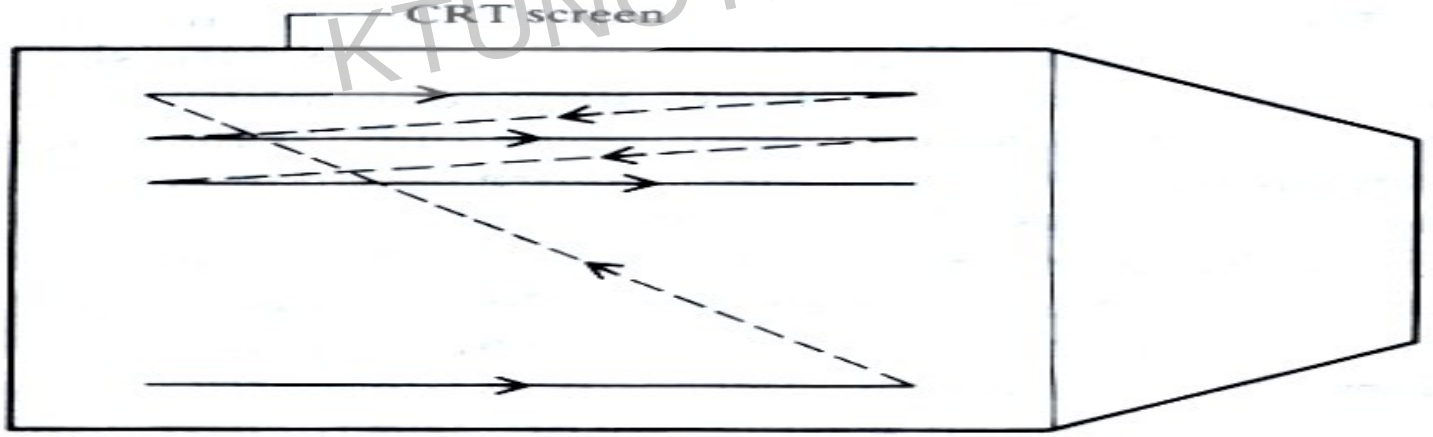


Figure 1.11: Random Scan display



(a) Random scan



(b) Raster scan

b. Random scan system

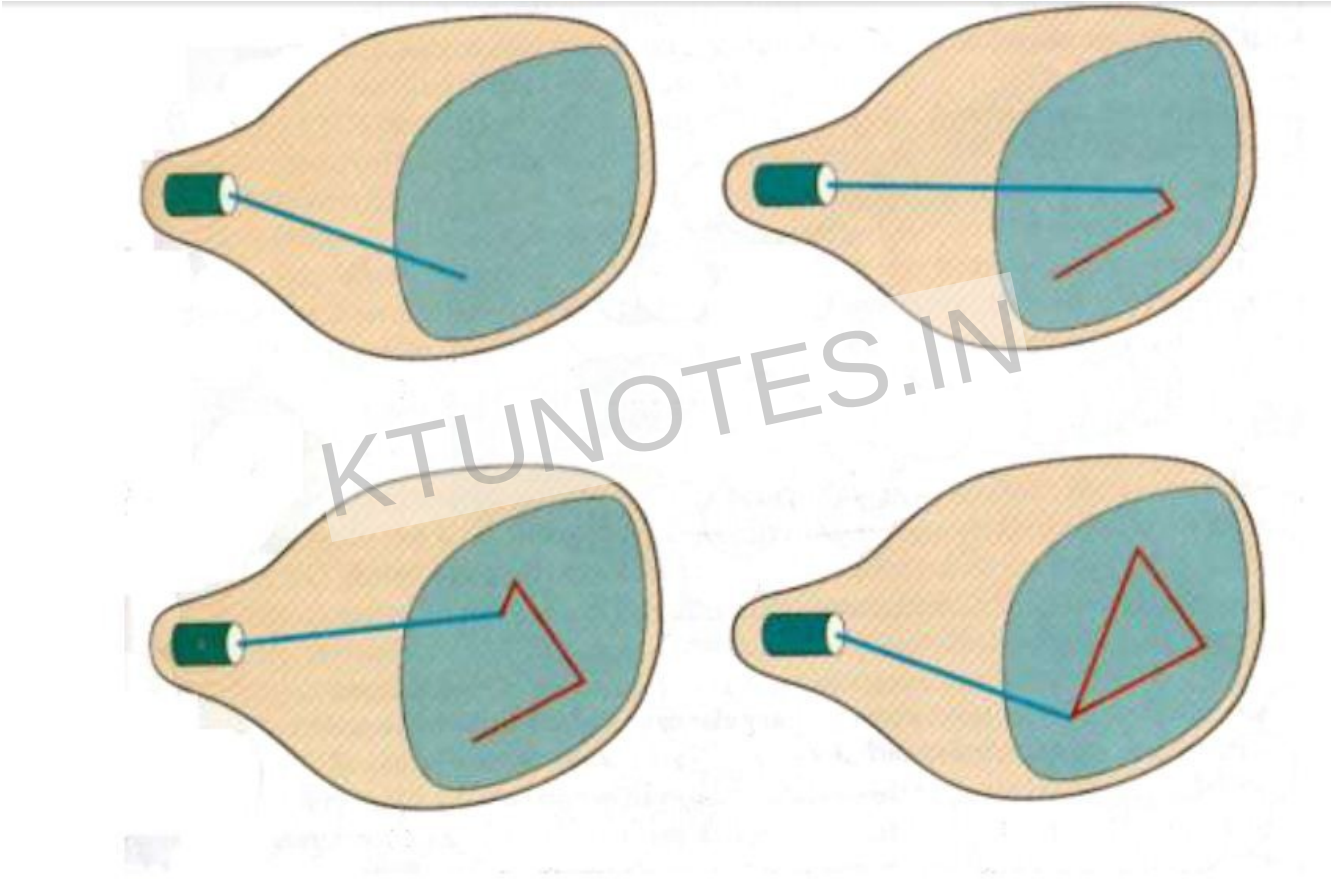


Figure: Random Scan

Difference

Random-Scan and Raster-Scan

- Random-Scan:
  - » Electron Beam directed only to the parts of the screen where a Picture is drawn.
  - » 60 Frames Per Second
  - » A pen plotter operates in a similar way.
  - » Example: Hard-Copy Device.

- Raster-Scan:
  - » Based Upon Television technology
  - » Electron beam is swept across the Screen, one row at a time from top to bottom.
  - » Each Pixel is Plotted into the Pixel.
  - » Example: Printer

Differences between Random and Raster Scan Display

RASTER SCAN DISPLAY	RANDOM SCAN DISPLAY
Picture with better contrast	Cannot produce contrast , memory doesn't store intensity value of pixel
Less resolution	High resolution
Capable of producing curves better	Smooth line drawings
Used in systems to display realistic images	Cannot draw realistic shaded scenes
Cost is less	Cost is more
Mainly used for point plotting	Line drawing , known as vector display
Ex . TV sets	Ex . Pen Plotter

Base of Difference	Raster Scan System	Random Scan System
Electron Beam	The electron beam is swept across The screen, one row at a time, from Top to bottom.	The electron beam is directed only to the parts of screen where a Picture is to be drawn.
Resolution	Its resolution is poor because raster system in contrast produces zig-zag lines that are plotted as discrete Point sets.	Its resolution is good because this system produces smooth lines drawings because CRT beam directly follows the line path.
Picture Definition	Picture definition is stored as a set of intensity values for all screen points, called pixels in a refresh buffer area.	Picture definition is stored as a set of line drawing instructions in a display file.
Realistic Display	The capability of this system to store intensity values for pixel makes it well suited for the realistic display of scenes contain shadow and color pattern.	These systems are designed for line-drawing and can't display realistic shaded scenes.
Draw an Image	Screen points/pixels are used to draw an image.	Mathematical functions are used to draw an image.

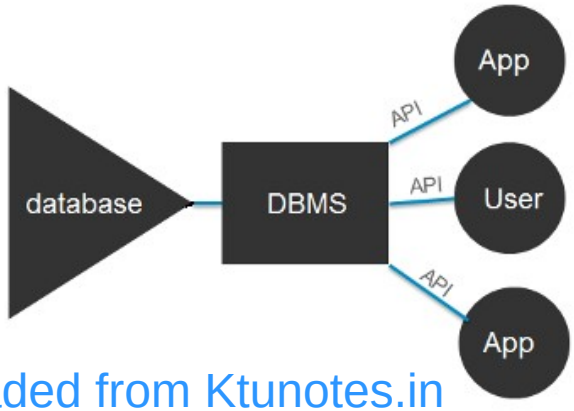
DESIGN DATABASE

DESIGN DATABASE

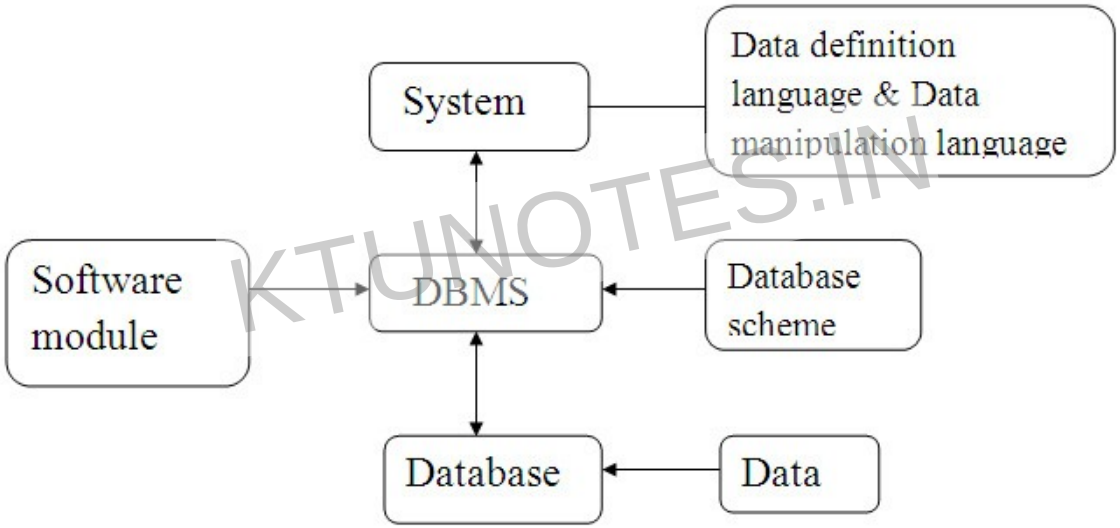
- The data regarding the complete geometric model of the image is stored in computer memory.
- It is stored in certain data exchange format (extension file).

DATABASE MANAGEMENT SYSTEM (DBMS)

- **DBMS** is defined as the software that allow access to use and modify data stored in a database.
- It protect data from users misuse.
- It forms a layer of software between physical database and the users of this data



(DBMS)



GRAPHICS STANDARD

GRAPHICS STANDARD

- **CAD/CAM** software may be perceived as an application program supported by a graphics system.
- **Graphics system** perform all related graphic techniques.
- Graphics standard planning committee (GSPC) was formed to address the graphics standards.

GRAPHICS STANDARD

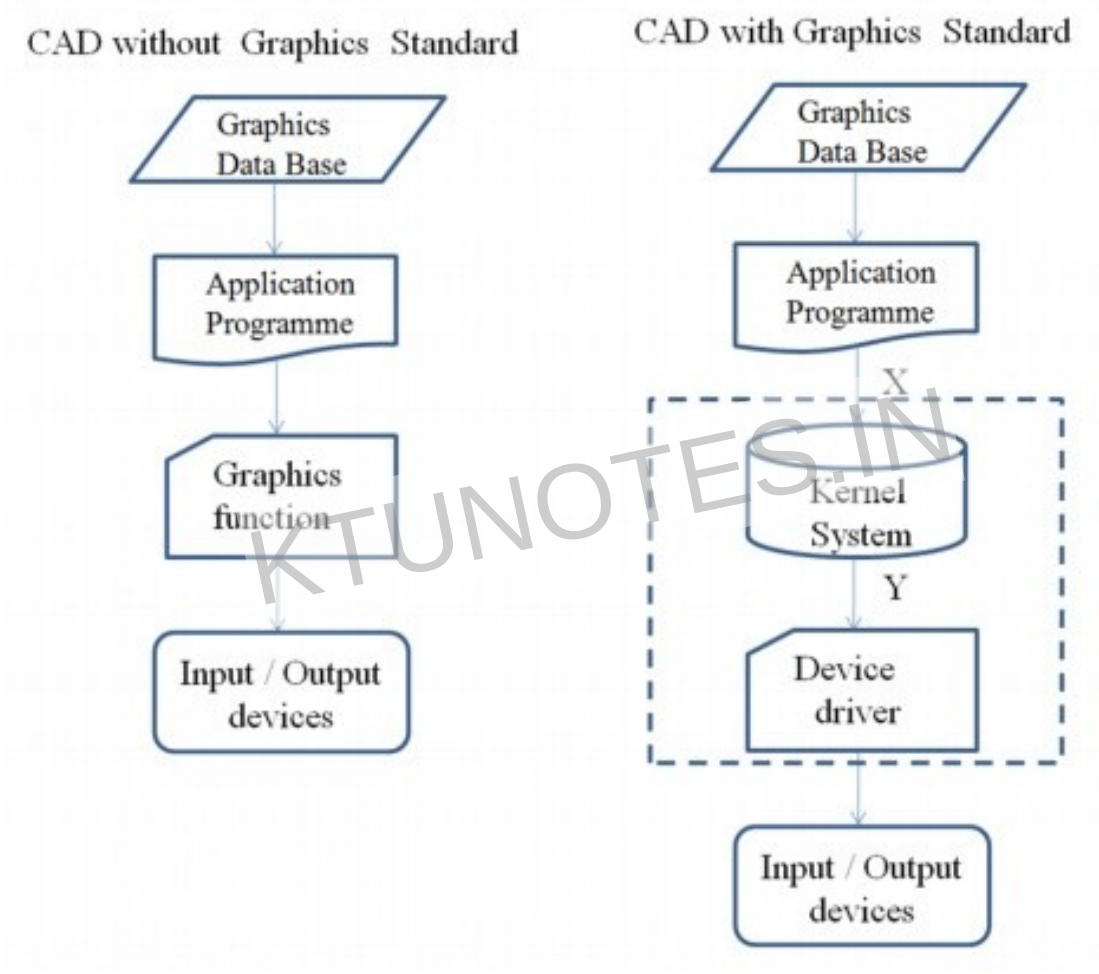


Fig.5.1. Graphics Standard

NEED of GRAPHICS STANDARD

- **Application program portability**
- **Picture data portability**
- **Text portability**
- **Object database potability**

GRAPHICS STANDARD

Goal: *portability*, standard graphics functions are *independent of programming language*, bindings are defined for various languages

- Early graphics packages
  - GKS (Graphical Kernel System)
  - PHIGS (Programmer's Hierarchical Interactive Graphics System)
- OpenGL
- Java3D
- Direct3D
- WebGL
- VRML (Virtual Reality Modeling Language)

Need for CAD data standardization

- Incompatibility among representations
- Complex CAD/CAM systems
- Shape, non-shape, design and manufacturing data
- Need to integrate and automate design and manufacturing processes to obtain maximum benefits from CAD/CAM systems
- Direct translators and neutral formats

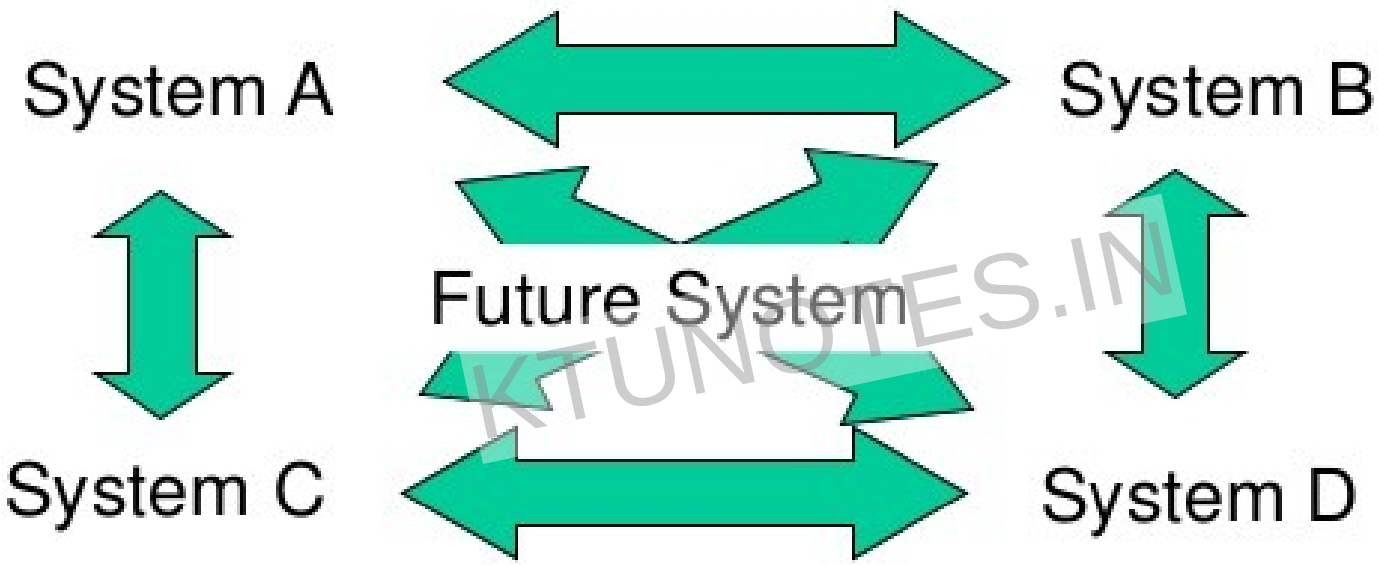
Standardization in Graphics

- GKS (Graphical Kernel System)
- PHIGS (Programmer's Hierarchical Interface for Graphics)
- CORE (ACM-SIGGRAPH)
- GKS-3D
- IGES (Initial Graphics Exchange Specification)
- DXF (Drawing Exchange Format)
- STEP (Standard for the Exchange of Product Model Data)
- DMIS (Dimensional Measurement Interface Specification)
- VDI (Virtual Device Interface)
- VDM (Virtual Device Metafile)
- GKSM (GKS Metafile)
- NAPLPS (North American Presentation Level Protocol Syntax)

EXCHANGE OF CAD DATA BETWEEN SOFTWARE PACKAGES

- Necessity to translate drawings created in one drafting package to another often arises.
- Several problems existed in earlier days with independent translators needed to exchange geometric data from one package into another.
- A solution to this problem of direct translators is to use neutral files.
- Three types of neutral files are discussed in this work they are: Drawing Exchange (**DXF**), **IGES** & **STEP** files.

Alternative approaches



Number of Direct translators = 2 (N-1)

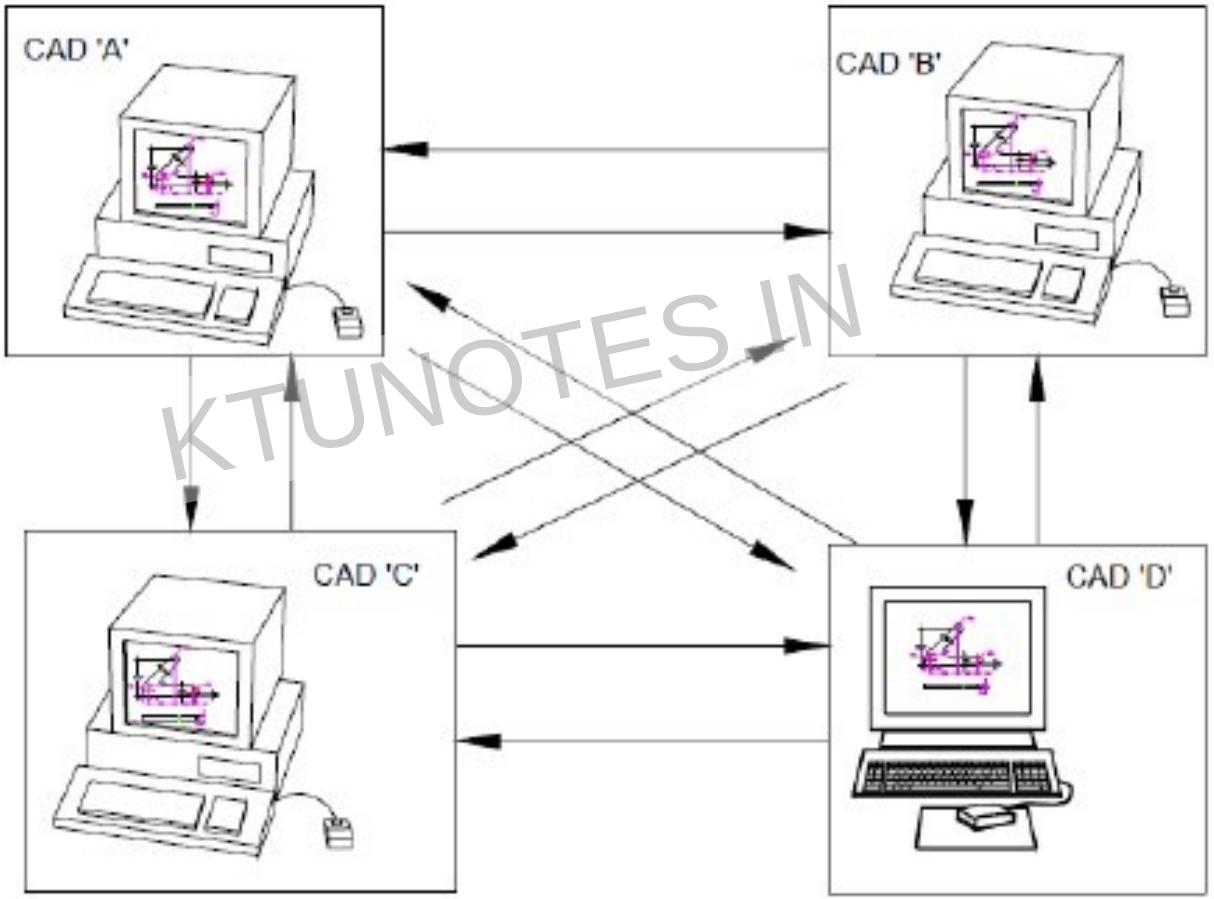
DATA EXCHANGE

- Process of exchanging data from a source to target.
- In CAD system there are many situations where we have to exchange data from one software package to another.
- We have to translate geometrical data, feature data , assembly structure, etc.
- In CAD data exchange many software technologies and methods are involved.

Data Exchange standards

- In order to transfer the data between different Systems, a neutral file is needed
- Neutral (mostly geometric) data exchange is needed between CAD and CAM
- Most widely used data exchange formats like IGES, DXF

Data exchange between various systems



Data Exchange Standards

- To address the problem, many standards for CAD data exchange have been developed
- CAD systems can import and export to many of these standard formats.
- To deal with all CAD systems, you must support I-DEAS, Unigraphics and CATIA ,Pro /E
- For small companies, this is very difficult.

CAD Data Exchange

Two important issues in this subject:

1. **Data representation.**
2. **Data exchange**
    - **Data translation between CAD systems**
    - **Data sharing on database**

- **DXF (Drawing eXchange Format)**
- **IGES (Initial Graphics Exchange Format)**
- **STEP (STandard for Exchange of Product data)**

DATA EXCHANGE FORMAT

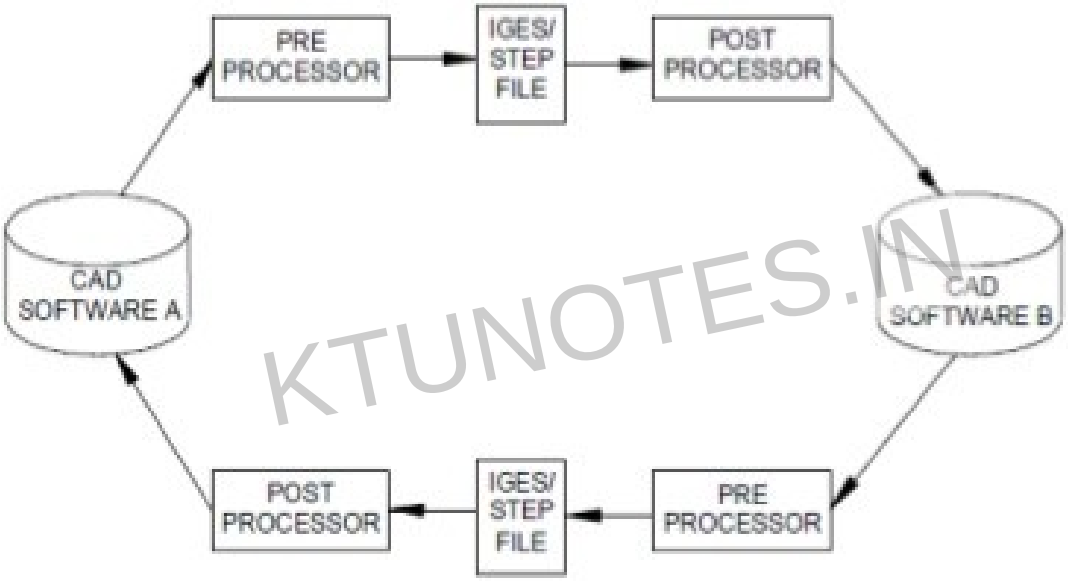
Why do we need Data Exchange?

- Design projects require data to be shared between suppliers
- Different companies often used different CAD systems
- All CAD systems have their own database formats
- They are mostly proprietary and often confidential
- Data is stored in different ways e.g. 1.0,2.0,3.0 or X1.0,Y2.0,Z3.0, etc.
- Data conversion between systems becomes necessary

Data Exchange Formats

- IGES (Initial Graphics Exchange Specification)
  - 1980 US NIST, National Institute of Standards and Technology
- DXF
- VDA – German Automotive Industry
- SET – Airbus
- PDES – American fore-runner of STEP
- STEP
- STL
- VRML

CAD DATA EXCHANGE USING NEUTRAL FILES



NEED OF NEUTRAL FILE FORMATS

- It is difficult to enforce the use of a common set of CAD/CAM tools in different companies.
- Because of the lack of any common set of tools, a common format for neutral file exchange is needed.
- Usage of neutral standard for transferring information drastically reduces the requirements for translators.
- Thus cost incurred for data translation is reduced.

COMMON NEUTRAL FORMATS

- DXF (DRAWING EXCHANGE PROGRAM)
- IGES (INITIAL GRAPHICS EXCHANGE SPECIFICATIONS)
- PARASOLID
- STEP (Standard for the Exchange of Product model data)

1. DXF

Drawing Exchange Format (DXF)

- The DXF format has been developed and supported by Autodesk for use with the AutoCAD drawing files.

2. IGES Format

IGES

- Abbreviation of Initial Graphics Exchange Specification.
- Initiative of USAF-ICAM (United States Air Force – Integrated Computer Aided Manufacturing).
- It was the first specification for CAD data exchange.
- Got published in 1980 by NBS (National Bureau of Standards).
- The main objective during the development stage of IGES was the exchange of drafting data like 2D and 3D wireframe models, text, dimensioning data and a limited class of surfaces.

IGES File

- IGES (Initial Graphics Exchange Specification) is a standard used to exchange graphics information between commercial CAD systems.
- The IGES file can precisely represent CAD models. It includes not only the geometry information (Parameter Data Section) but also topological information (Directory Entry Section).
- In the IGES, surface modeling, constructive solid geometry (CSG) and boundary representation (B-rep) are introduced.
- Especially, the ways of representing the regularized operations for union, intersection, and difference have also been defined.

IGES

- Initial Graphics Exchange Specification is designed to exchange engineering characteristics.
- Exchange between CAD software, Reverse Engineering, RP machines, CAM systems etc.
- Fundamental unit of data in this file is entity.
- Entities can be geometric or non geometric

Data Exchange in IGES

- IGES stands for International (originally 'Initial') Graphics Exchange Standards and a neutral data format that allows the digital exchange of information among CAD systems.

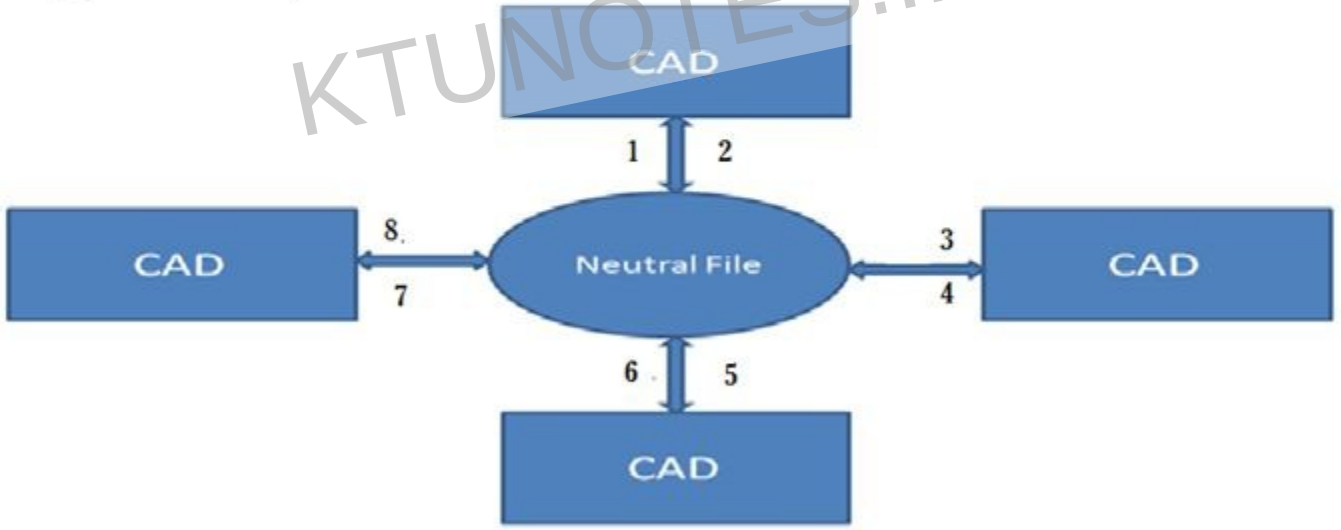


Figure 1. Data exchange using neutral file

3. STEP Format

What Is STEP?

STEP (*Standard for Exchange of Product Data*)

- Formally known as ISO10303

- Improving CAD data exchange
- Replacing IGES, SET and VDAFS
- More then one million CAD stations use STEP
- All major CAD systems have STEP interfaces

STEP {STANDARD EXCHANGE OF PRODUCT DATA}

- The Standard for the Exchange of Product Data (STEP) is the enabler for such seamless data exchange.
- It provides a worldwide standard for storing, sharing and exchanging product information among different CAD systems.
- It covers border functionalities. It includes methods of representing all critical product specifications such as shape information, materials, tolerances, finishes and product structure.

STEP

- **STEP AP203 / AP214** format (Standard for the Exchange of Product model data)
- It supports geometry and assembly structures and handles topology (shells, solids) on export and import.
- STEP files are human readable
- Other STEP APs are available, e.g. electronics data

4. STL Format (Stereolithograaogic)

STL

- **STL** format was developed by 3D Systems as a neutral format to input geometric data into their 3D printing systems
- It represents the geometry as a series of triangular facets
- It is now being used for other purposes besides 3D printing
- It is simple to create but has little overall structure

VIRTUAL REALITY

What is Virtual Reality?

Virtual reality is..

a computer technology that replicates an environment, real or imagined, and simulates a user's physical presence and environment to allow for user interaction. (Wikipedia)

- Defining Characteristics
  - Environment simulation
  - Presence
  - Interaction

VIRTUAL REALITY TECHNOLOGY

- Virtual Reality is technology for presentation of complicated information, manipulations and interactions of person with them by computer.
- Virtual Reality is a computer-generated interactive three-dimensional environment to simulate reality.
- Virtual reality with ability to show data 3D and attach sounds and touch information increases extraordinarily data comprehensibility.
- Virtual reality has entered into the public awareness as medial toy with equipment „helmet-glove“, which was preferentially determined for wide public and the price of this system had also to correspond to this fact, so price could not be very high.

WHAT IS VIRTUAL REALITY?

- **Virtual Reality** refers to a high-end user interface that involves real-time simulation and interactions through multiple sensorial channels.

- **Virtual Reality** means feeling an imaginary (virtual) world, rather than the real one. The imaginary world is a simulation running in a computer. The sense data is fed by some system to our brain.

- **Virtual Reality** allows a user to interact with a computer-simulated environment, be it a real or imagined one.

INTRODUCTION

- ***Virtual reality is a form of technology which creates computer generated worlds or immersive environments which people can explore and in many cases, interact with.***

- ***Virtual reality (VR), sometimes referred to as immersive multimedia, is a computer-simulated environment that can simulate physical presence in places in the real world or imagined worlds. Virtual reality could recreate sensory experiences, including virtual taste, sight, smell, sound, touch, etc.***

TYPES OF VIRTUAL REALITY

VR Systems can be divided into three groups

- **Non-immersive** systems (like workstations)
  See information about the real world, presented via computer - location based services, GIS .
- **Augmented reality** systems (like HMD)
  Stay in real world, but see simulated objects.
- **Immersive** systems (like CAVE)
  See *simulated world and "be" in that simulated world*.

THE TECHNOLOGY: VIRTUAL REALITY

Virtual reality

- Use of computer modelling and simulation to enable a person to interact with **an artificial three-dimensional visual** or other sensory **environment**.
- The illusion of **being in the created environment** (telepresence) is accomplished by motion sensors that pick up user's movements... usually in real time.

APPLICATIONS OF VIRTUAL REALITY

Business:

- Virtual reality is being used in a number of ways by the business community which include:
- Virtual tours of a business environment.
- Training of new employees.
- A 360 view of a product.

DEVICES USED FOR VIRTUAL REALITY

Head Mounted Display

Cyber grasp

Binocular Omni-Orientation Monitor

Cave Automatic Virtual Environment

Uses of Virtual Realiity

Virtual Reality in Military

Virtual Reality in Sports

Virtual Reality in Education

Virtual Reality in Business

Virtual Reality in Medical

Virtual Reality in Media

DISADVANTAGES

- New technologies have also revealed new problems.
- VR in medical treatment is going through some growing pains.
- There are limitations with VR devices as well in regards to usability.
- Lack of standardization of hardware and protocols.
- Most troublesome are the side effects it can induce, like disorientation, dizziness and nausea.
- People often find navigating in 3-D spaces and performing actions in free space extremely difficult.
- Practical problems in spatial cognition research

THANK U