ME 451
Computer Aided Design (CAD)

Introduction to CAD

By
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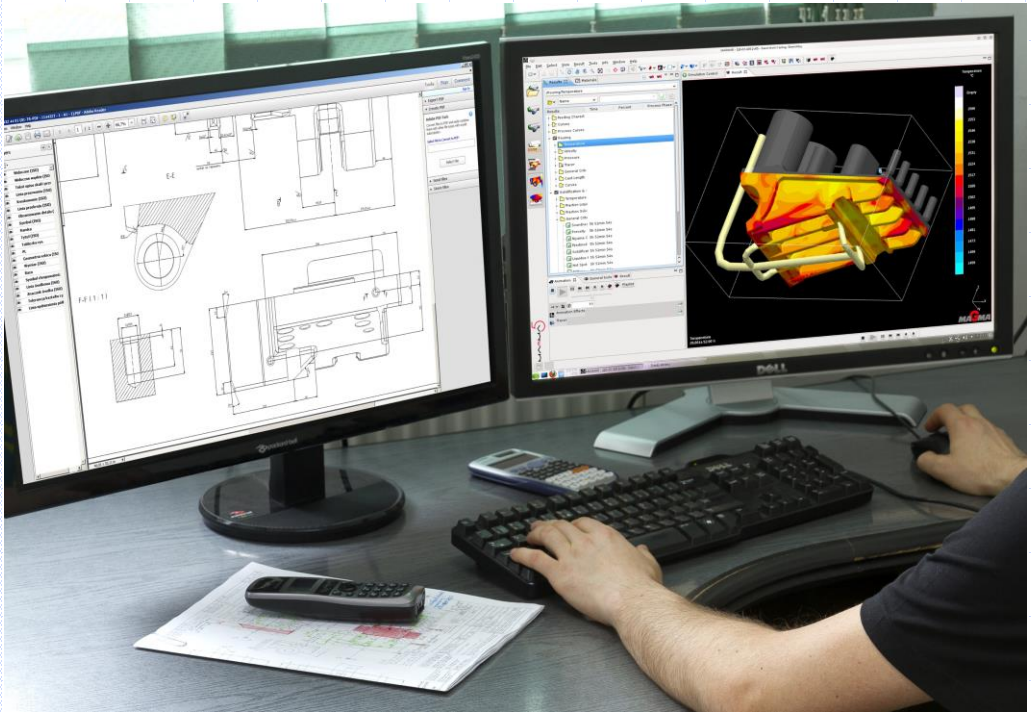
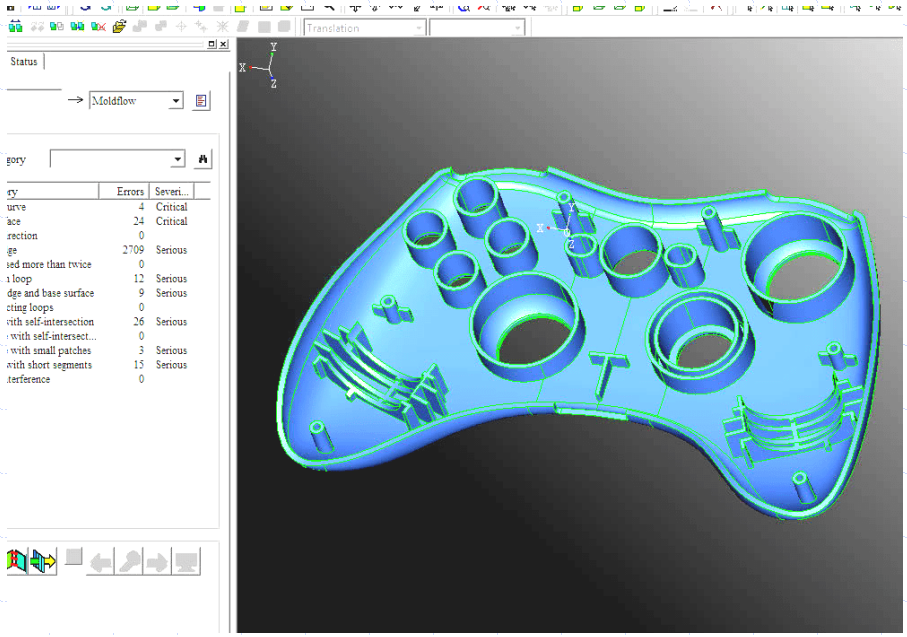
What is CAD?

- Originally CAD includes any techniques that use computers in the design process including drafting, stress analysis and motion analysis.



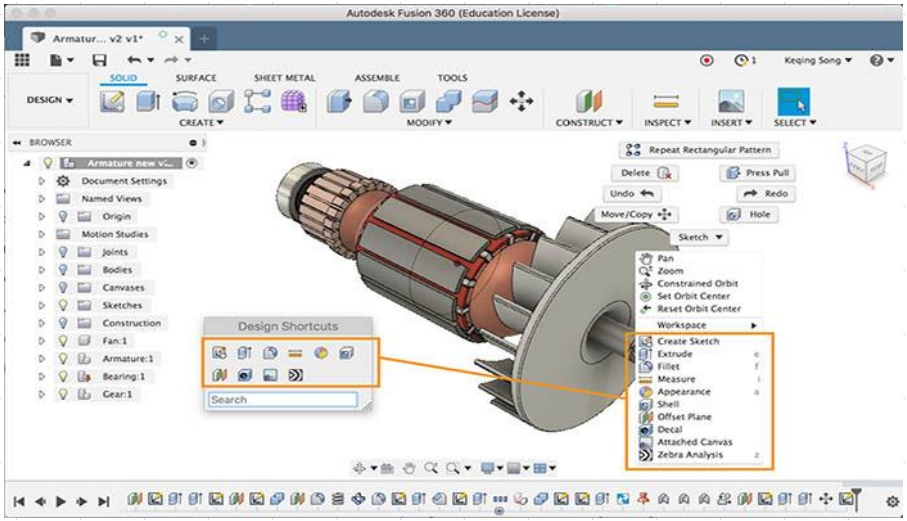
What is CAD?

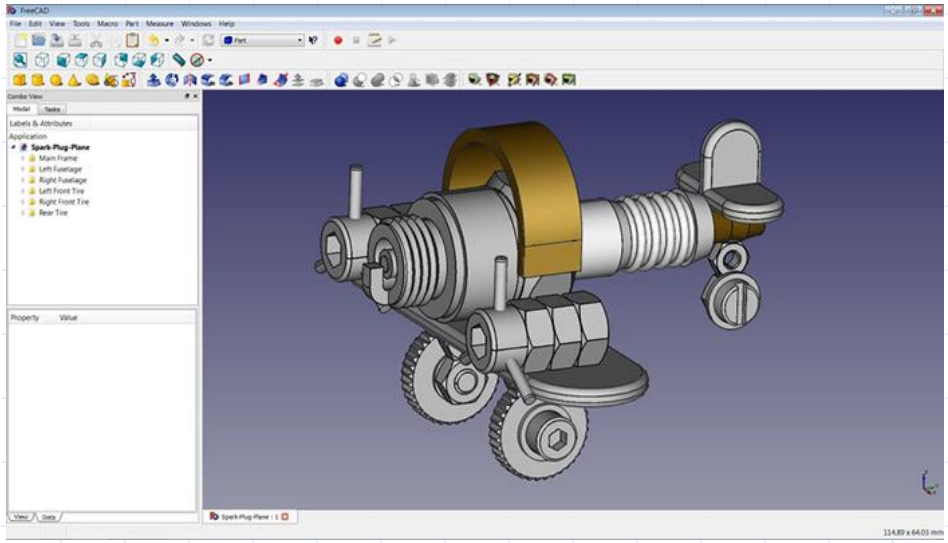
- But over the last 35 years, CAD has come to refer more specifically to Computer Aided Design and Drafting.



What is CAD?

- CAD program/software is an electronic tool that enables you to make quick and accurate drawings with the use of a computer.





What is CAD?

- Computer drawings are neat, clean, highly presentable, and can be modified easily.
- With CAD, parts or components can be modeled, visualized, revised, and improve on the computer screen before any engineering drawings have been created.

What is CAD?

- Parts that have been modeled can be assembled in the virtual environment of the computer. The relative motion of moving parts can be animated on the computer. The part can be analyzed computationally and redesigned. The machine tool path or mold filling flow to fabricate the part can be modeled on the computer. The part model can be downloaded to a rapid prototyping system that can create a physical model of the part in a few hours with virtually no human intervention.

Capabilities of CAD

Some of the important capabilities of using CAD are;

1) Presentations
   - You can create fine drawings with presentation symbols and text styles.
   - You can use CAD program to make on screen presentations.

Capabilities of CAD

2) Flexibility in editing

- CAD provides the flexibility to make quick alterations to drawings
- Some of the editing capabilities are such as; move or copy drawing elements, enlarge or reduce size of a drawing, make multiple copies of a drawing, change units of measure and etc.

Capabilities of CAD

3) Units and accuracy level
   - CAD program allows you to work with great accuracy. You can also work with different units of measure, such as architectural units, engineering units, scientific units and surveyor units.
4) Storage and access of drawings
   - It is quick and convenient to organize CAD drawings. You can have thousands of drawings on a computer's hard disk and you can open any one of them within seconds.

Capabilities of CAD

5) Sharing CAD drawings

- The drawings can be shared by a number of users, allowing them to coordinate projects and work as a team. This is accomplished by connecting different computers via a network. You can also publish your drawings on the Internet and collaborate CAD projects using a web site.

Capabilities of CAD

6) Project reporting

   - The computer can be used to prepare project reports

7) Engineering analysis

   - There is a separate category of programs called CAE that can use CAD drawings for engineering analysis.

Capabilities of CAD

8) Computer aided manufacturing (CAM)

- CAM is a common method of manufacturing used by large corporations.
- These systems import CAD drawings into CAM programs to automate the manufacturing process.

CAD Models

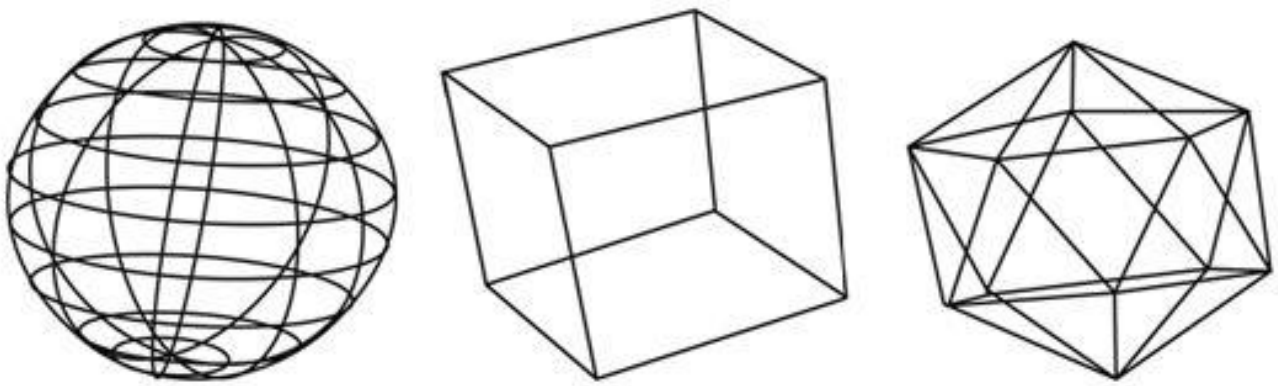
- A CAD model is a computer representation of an object or part
- It contains all of the design information including geometry, dimensions, tolerances, materials and manufacturing information.
- CAD models replace the paper blueprints and engineering drawings
- The simplest model used in CAD is a 2D model. This model is essentially the computer graphics equivalent to an orthographic projection

CAD Models

- A 3D model is the most general model used in CAD software. This model is equivalent to an isometric view.
- basic types of 3D models are
  - Wire frame model
  - Surface model
  - Solid Model

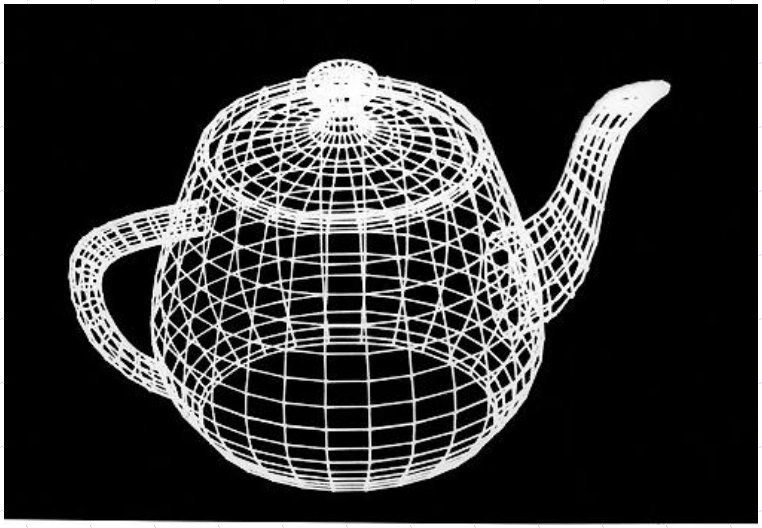
CAD Models-wireframe model

- Wireframe Model is a collection of polygons made of edges and vertices.
- An edge may be a straight line or a curved segment. Hence, this model is termed as a polygonal net or a polygonal mesh.



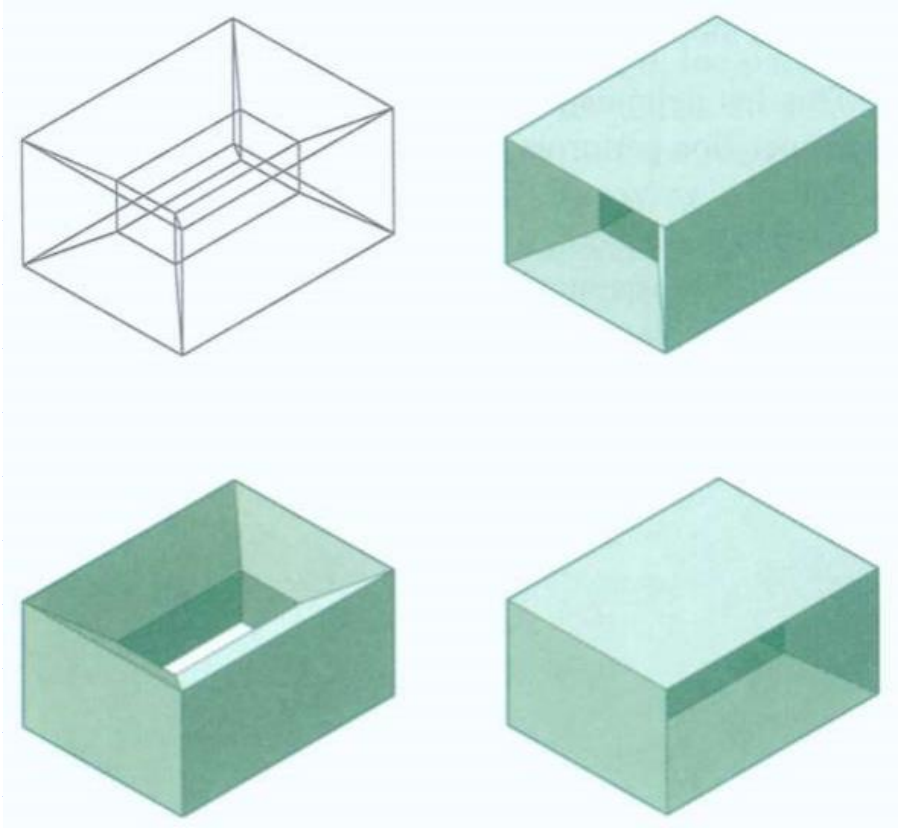
CAD Models-wireframe model

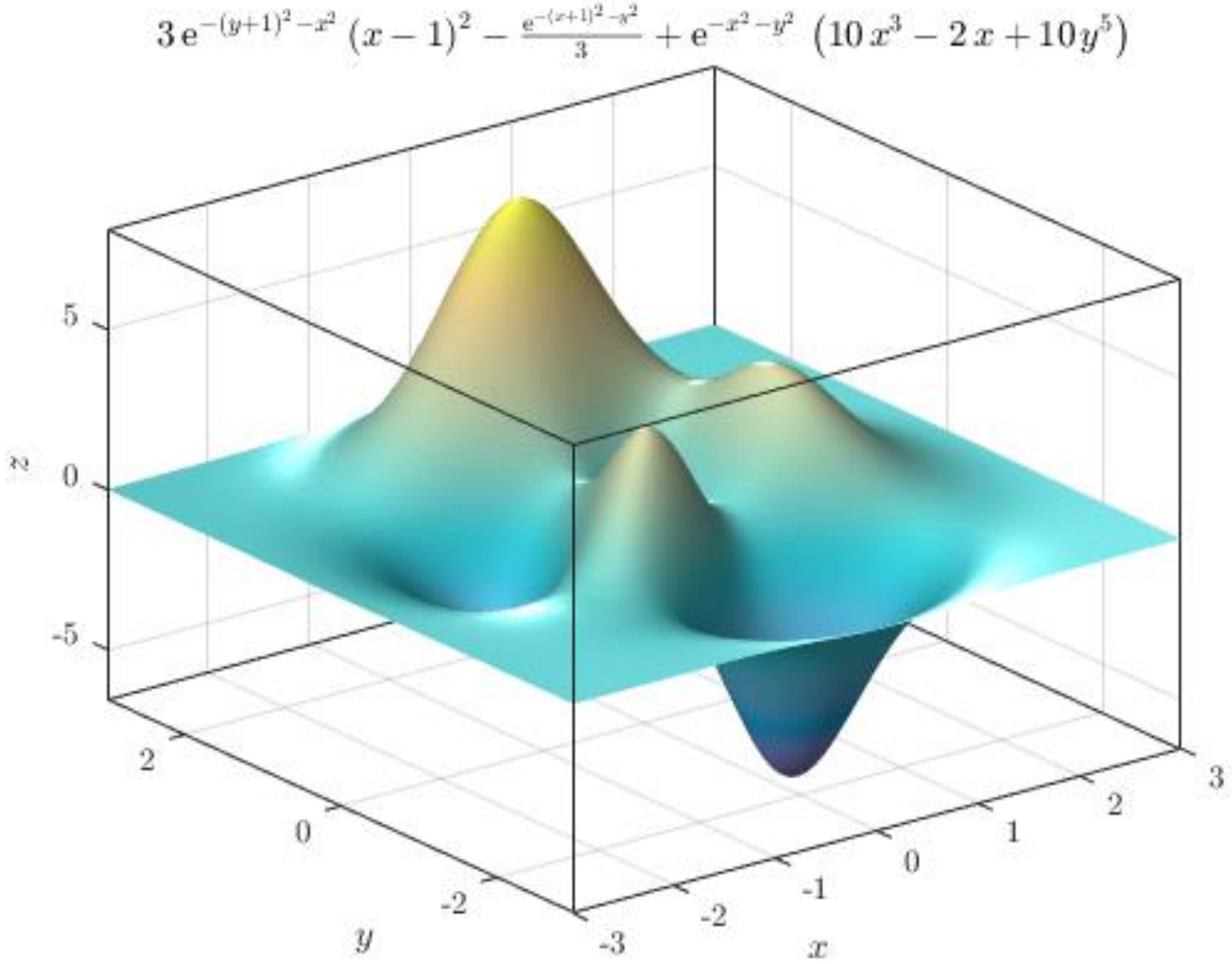
- Oldest form of 3D modeling
- Old technology - not used today
- Model Contains edges and vertices
- Cannot represent complex surfaces
- No details regarding interior of part
- Ambiguous



CAD Models-wireframe model

- Wireframe models are Ambiguous… What does this object really look like?

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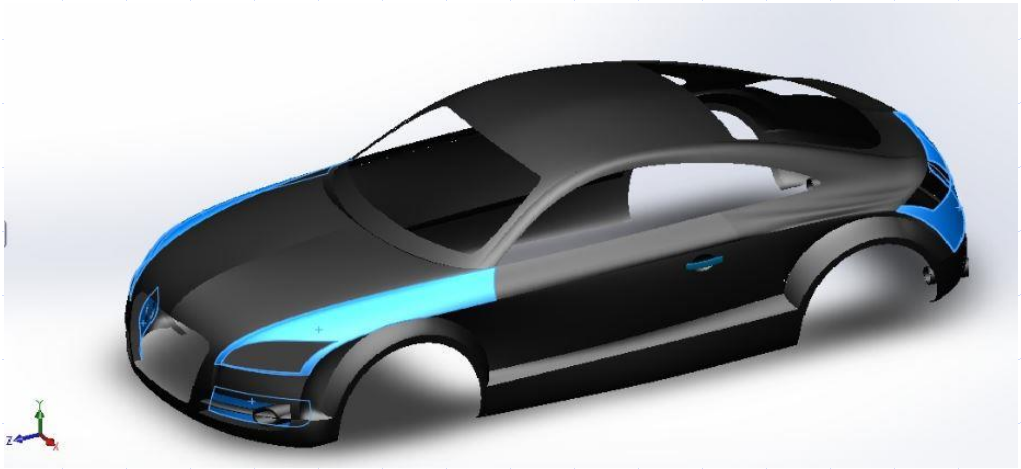
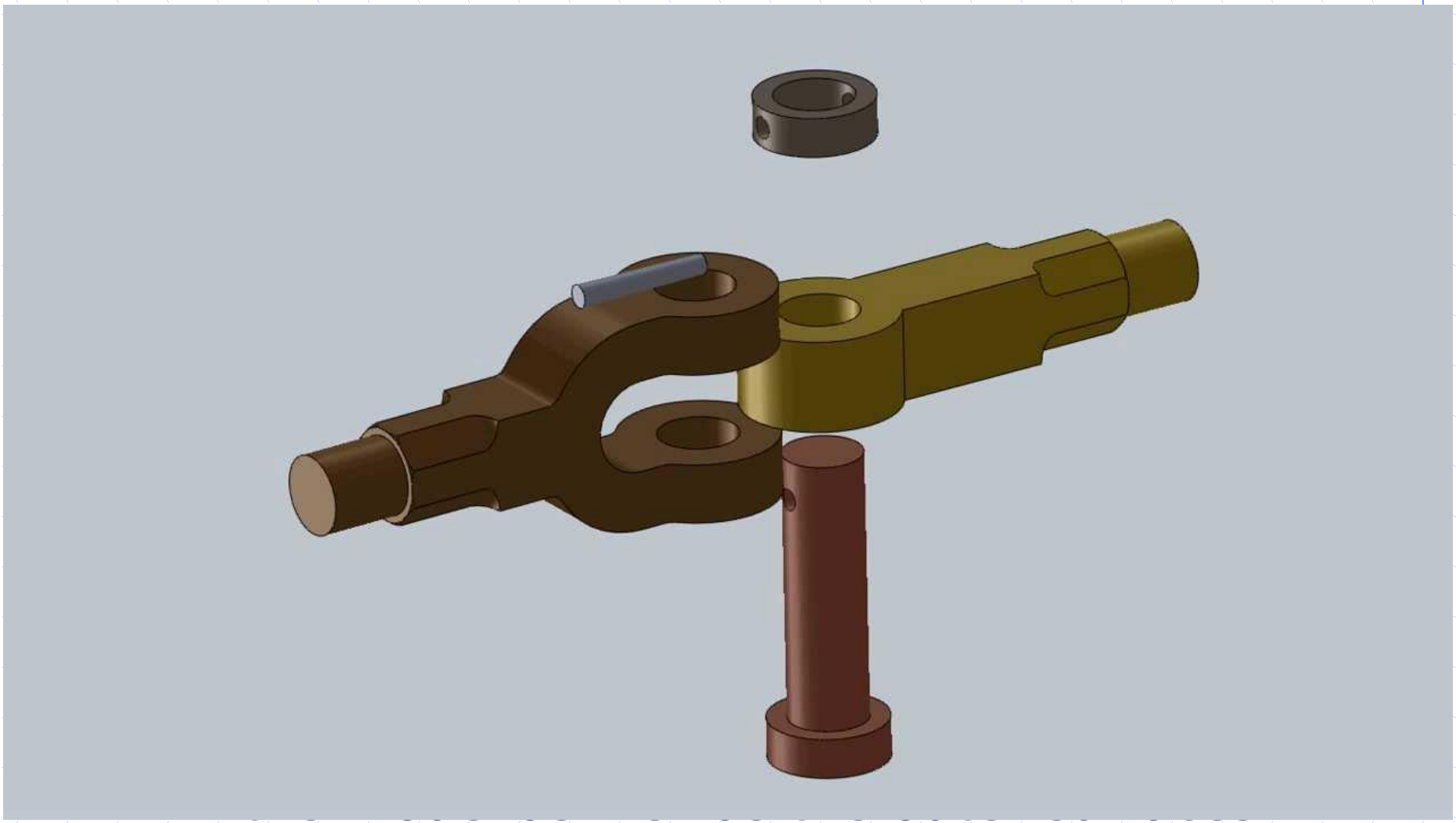
CAD Models-Surface model

- Contains edges and vertices and exterior surfaces
- Can represent complex exterior surfaces
- No details regarding interior of part
- Too ambiguous for engineering analysis





Use of solid models

- Can be used for stress analysis, heat transfer analysis, fluid flow analysis, and computer aided manufacturing.
- In the manufacturing process to automatically generate machine tool paths to machine an object.
- To simulate the removal of material from an initial block of material on the computer
- Can be linked to Computer Numerical Control (CNC) machine to carry out the removal of material automatically allowing many identical parts to be machined based directly on the solid models.

Solid Modeling Techniques

- Constructive Solid Geometry(CSG)
- Sweeping
- Boundary Representation(B-Rep)
- Feature-Based Modeling - uses feature-based primitives to conduct a design

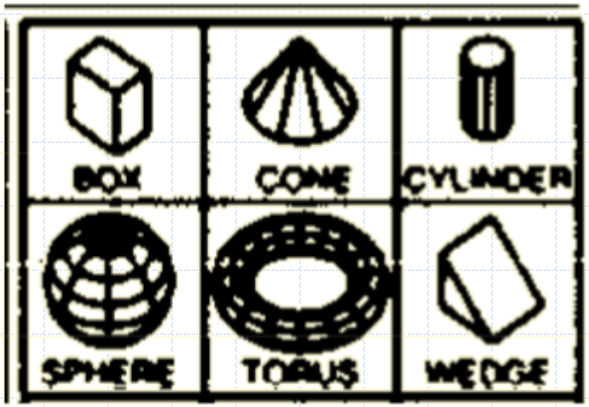
Constructive Solid Geometry (CSG)

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

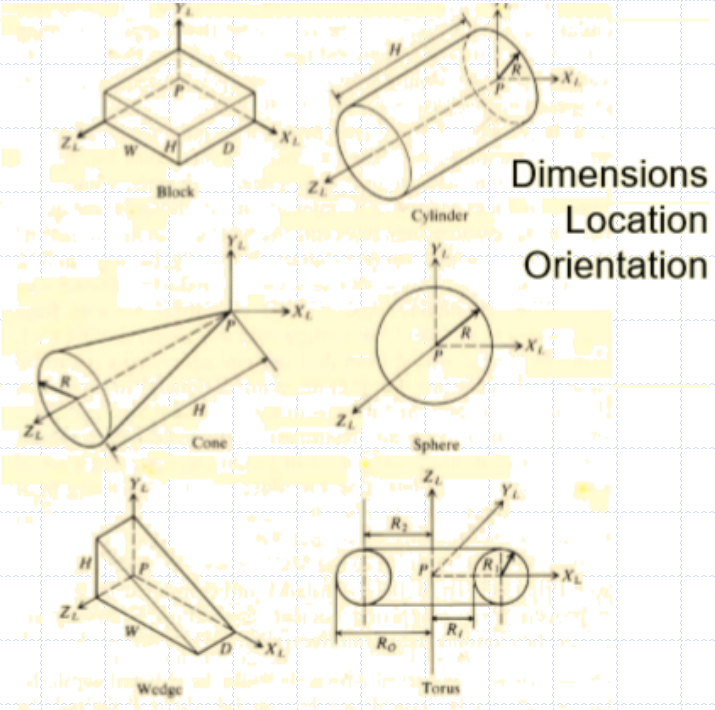
Constructive Solid Geometry (CSG)

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

Low Level Geometric Primitives



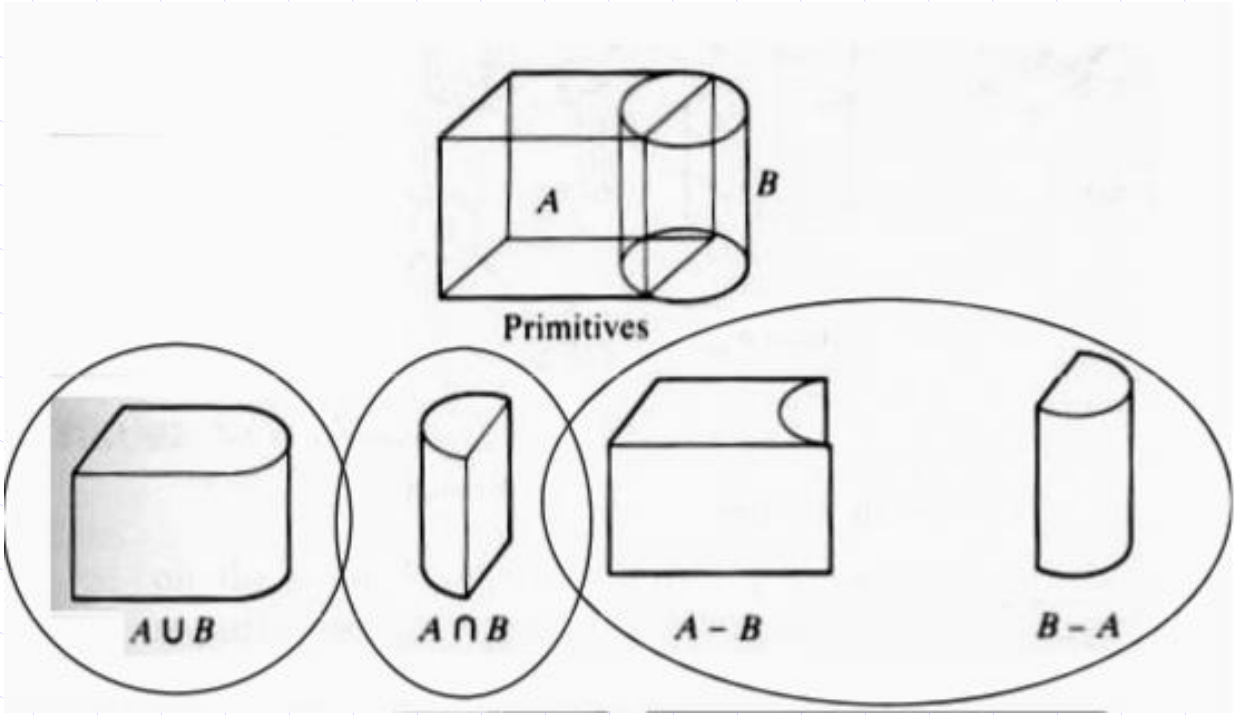
Defined Geometric Features



Dimensions
Location
Orientation

Constructive Solid Geometry (CSG)

- Boolean Operations in CSG
  - Union, U
  - Intersection, ∩
  - Difference or Subtraction −



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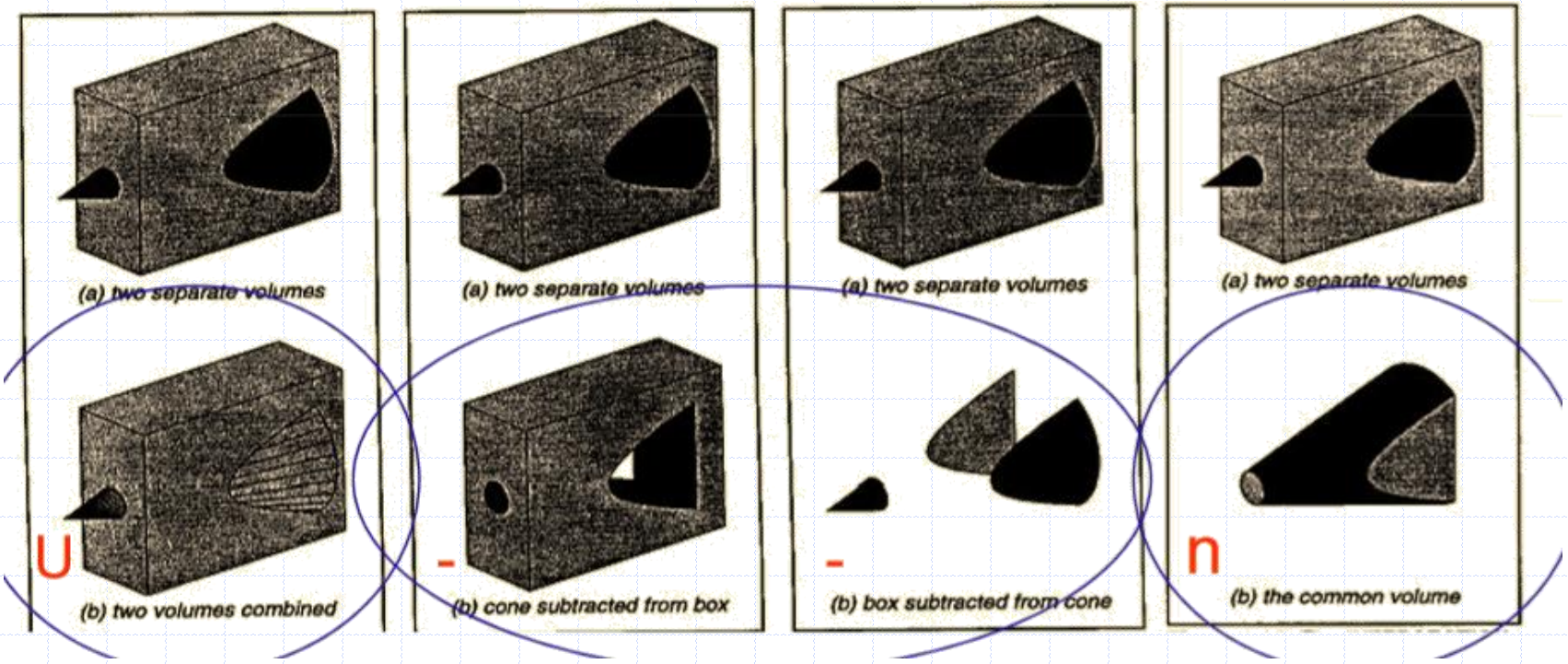
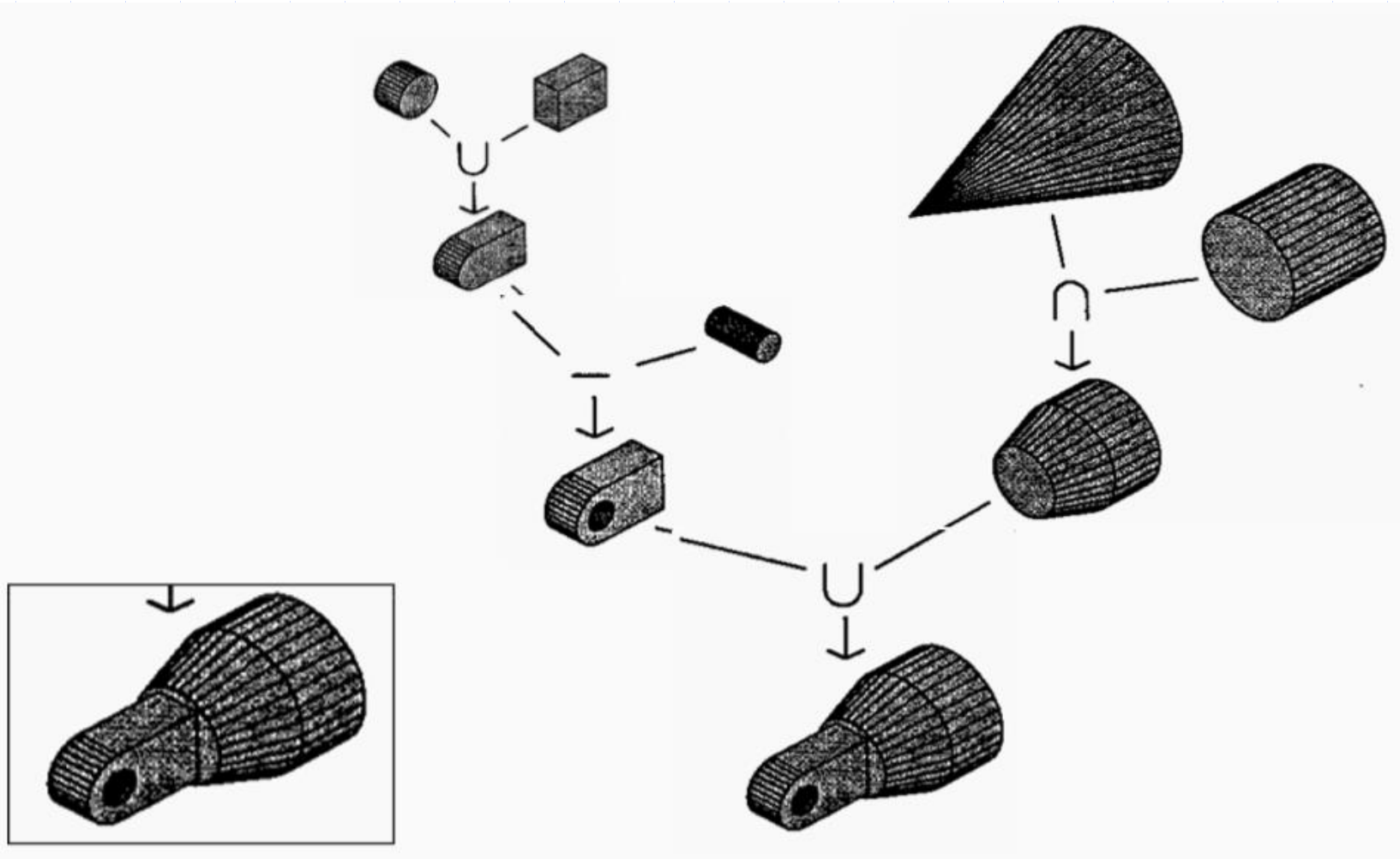
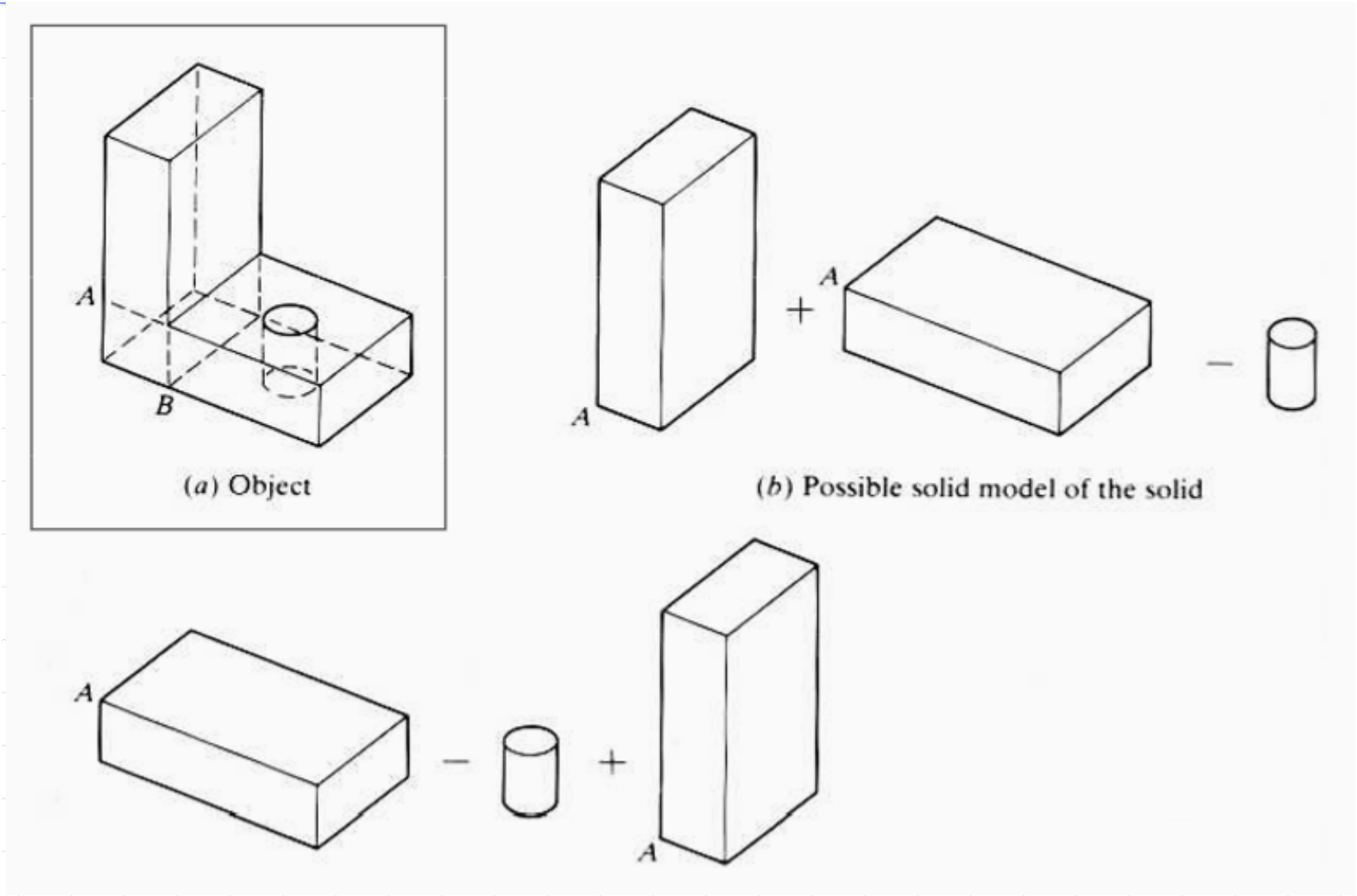


CSG Tree



CSG Tree

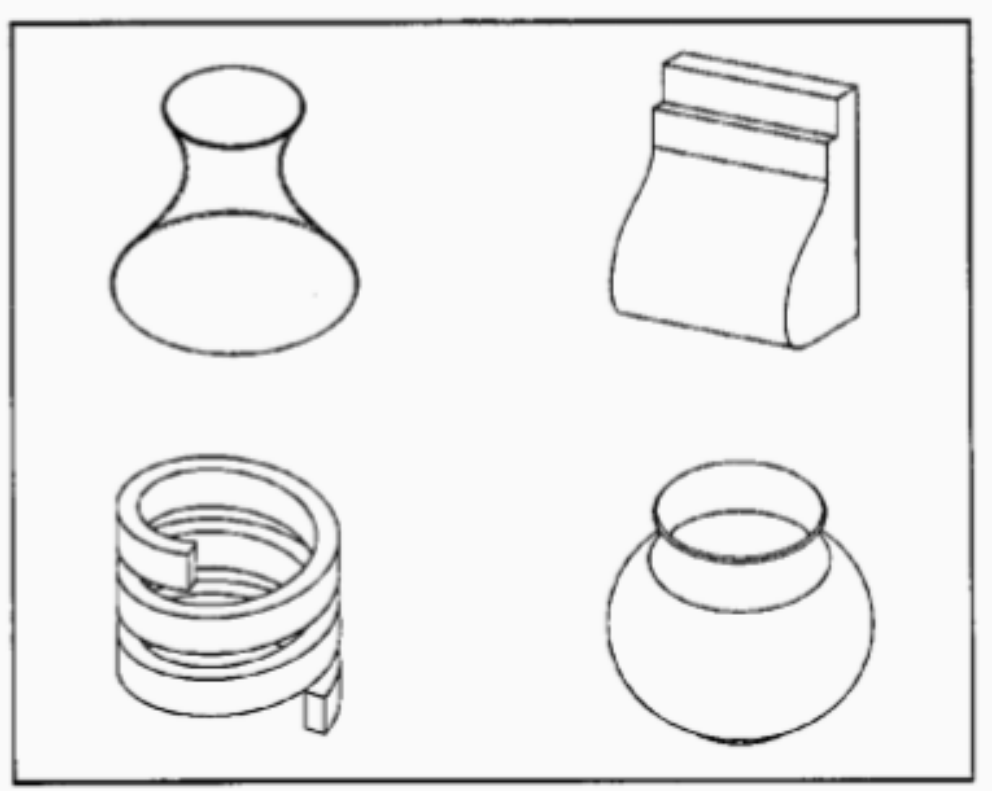


Sweeping

- 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.
  - 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

- Sweeping is most convenient for solids with translational or rotational symmetry.
- Sweeping also has the capability to guarantee a closed object.



Feature-based parametric Modeling

- Feature-based parametric Solid Modeling system represents the recent advance of computer geometric modeling.
- It is used as the foundation of solid modeling software's like Solid works etc.
- Feature-based parametric solid modeling eliminated the direct use of common geometric primitives such as cone, cylinder, sphere, etc. since these primitives only represent low-level geometric entities.

Feature-based parametric Modeling

- The modeling approach uses sweeping to form the main shape of the part, and build-in mechanical features to specify the detailed geometry of the model. These features include holes (through, blind, sink), rounds, chamfers, slots, etc.
- Operations to solid model, such as cut and shell (change a solid model into a hollow shell) are also supported.

Feature-based parametric Modeling

- To create the 2D cross-section for sweeping, a 2D sketch needs to be generated in the 2D Sketcher.
- A user can sketch the rough shape of the closed shape.
- The system will automatically assign a dimension value of the sketched feature.
- The dimensions of the sketched feature can be changed at any time by simply entering the desired value, or kept as a variable, allowing even more convenient change of its value.
- The user has to provide all necessary dimensions to pass the section of cross-section generation.
- Problems of under-or over-dimensioning can be identified.

Solid Works Model Generation

- Introducing Datum
- Primary Shape Definition
  - Drawing Rough 2D Cross-section in a 2D Sketcher
  - Defining the Precise Geometry
  - Building Solid Objects
    - Extrusion to Form Depth
    - Revolving to Form Rotational Features
    - Sweeps and Blends
- Adding Detailed Geometry
  - Making Holes and Cuts
  - Adding Rounds, Chamfers, Slots, and Shells