Solid Modelling

Unit -5

CAD

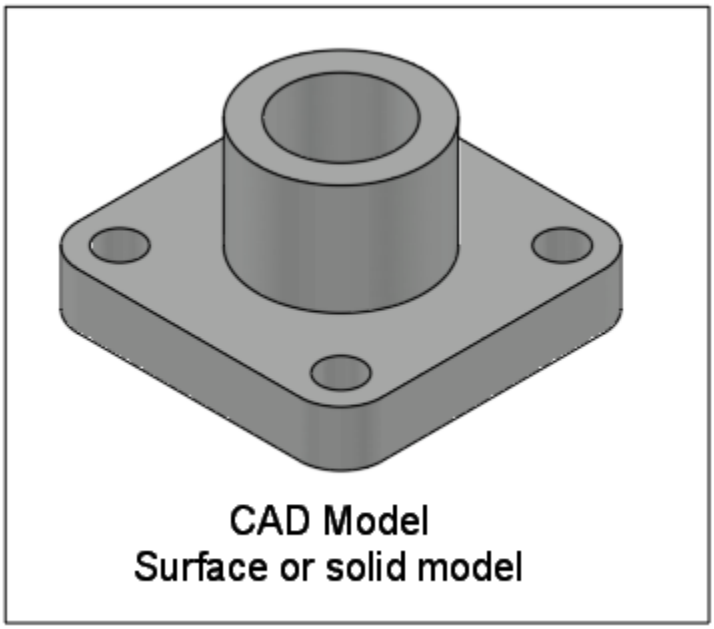
Evolution of Geometric Modeling

A wireframe representaion of an object is done using edges (lines curves) and vertices. Surface representation then is the logical evolution using faces (surfaces), edges and vertices. In this sequence of developments, the solid modeling uses topological information in addition to the geometrical information to represent the object unambiguously and completely

Introduction: A solid model of an object is a more complete representation than its surface (wireframe) model. It provides more topological information in addition to the geometrical information which helps to represent the solid unambiguously.

Solid modeling techniques are based on informationally complete, valid and unambiguous representations of objects. Simply stated, a complete geometric data representation of an object is one that enables points in space to be classified relative to the object, if it is inside, outside, or on the object

It is the representation of a design artifact (e.g. a part) as a topologically closed geometric model.



Solid modeling represents both the surface of a part, and it's mass properties.

Solid models are commonly built using constructive solid geometry (CSG), or boundary representation (BREP) methods

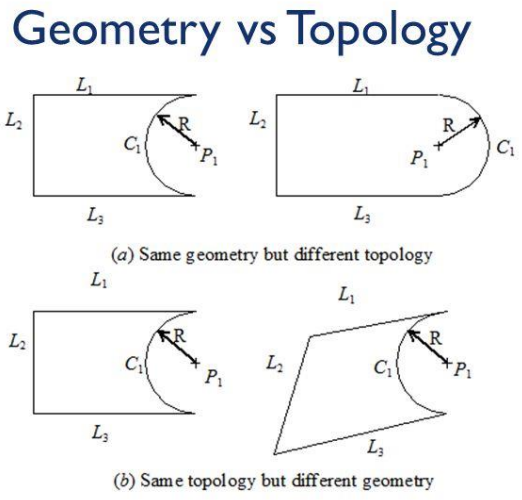
Solid models represent the real physical properties such as volume, and are better for creating precise shapes and mechanical assemblies. Solid modelers can be parametric, which makes modifications easy by simply typing in new dimensions

Advantages of Solid Models

Unlike wireframes and surface representations which contain only geometrical data, the solid model uses topological information in addition to the geometrical information to represent the object unambiguously and completely. Solid model results in accurate design, helps to further the goal of CAD/ CAM like CIM, Flexible manufacturing leading to better automation of the manufacturing process.

Geometry Vs Topology

Geometry: Metrics and dimensions of the solid object. Location of the object in a chosen coordinate system



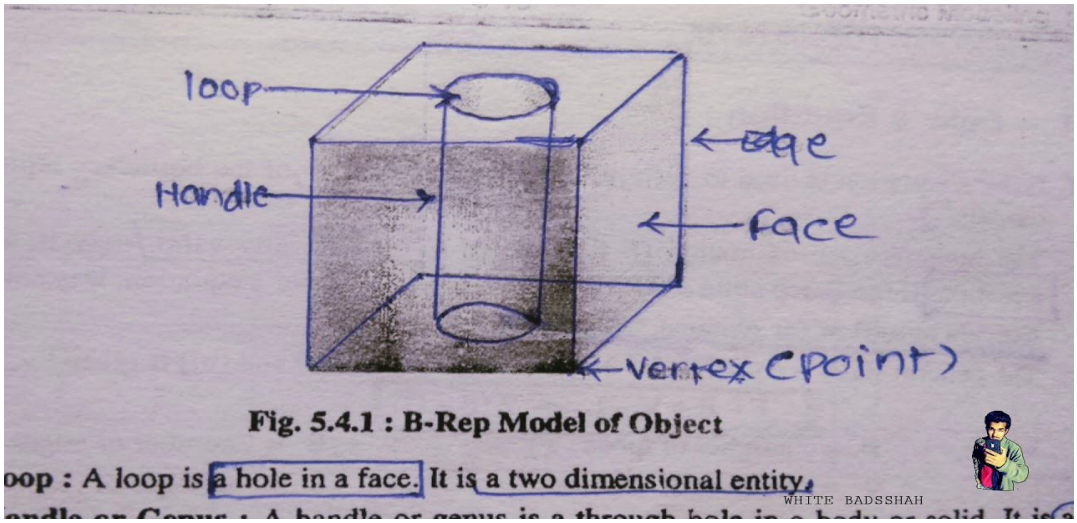
Topology: Combinatorial information like connectivity, associativity and neighbourhood information. Invisible relationship information.

Solid representation- boundary representation, sweep representation & CSG

Boundary representation

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 of models are composed of two parts: topology and geometry (surfaces, curves and points). The main topological items are: *faces*, *edges* and *vertices*. A face is a bounded portion of a surface; an edge is a bounded piece of a curve and a vertex lies at a point



Boundary representation is one of the two most popular and widely used schemes to create solid models of physical objects. A B-rep model or boundary model is based on the topological notion that a physical object is bounded by a set of faces. These faces are regions or subsets of closed and orientable surfaces. A closed surface is one that is continuous without breaks. An orientable surface is one in which it is possible to distinguish two sides by using the direction of the surface normal to point to the inside or outside of the solid model under construction. Each face is bounded by edges and each edge is bounded by vertices. Thus, topologically, a boundary model of an object is comprised of faces, edges, and vertices of the object linked together in such a way as to ensure the topological consistency of the model.

Topological and geometrical information of B-rep

The database of a boundary model contains both its topology and geometry. Topology is created by performing Euler operations and geometry is created by performing Euclidean calculations. Euler operations are used to create, manipulate, and edit the faces, edges, and vertices of a boundary model as the set (Boolean) operations create, manipulate, and edit primitives of CSG models. Euler operators, as Boolean operators, ensure the integrity (closeness, no dangling faces or edges, etc.) of boundary models. They offer a mechanism to check the validity of these models

Advantages and disadvantages of B-rep

The B-rep scheme is very popular and has a strong history in computer graphics because it is closely related to traditional drafting. Its main advantage is that it is very appropriate to construct solid models of unusual shapes that are difficult to build using primitives.

Another major advantage is that it is relatively simple to convert a B-rep model into a wireframe model because the model's boundary definition is similar to the wireframe definition.

One of the major disadvantages of the boundary model is that it requires large amounts of storage because it stores the explicit definition of the model boundaries. It is also a verbose scheme—more verbose than CSG

If B-rep systems do not have a CSG-compatible user interface, then it becomes slow and inconvenient to use Euler operators in a design and production environment.

Sweep representation

Sweeping is based on the notion of moving a point, curve, or a surface along a given path. There are three types of sweep: **linear, nonlinear, and hybrid sweeps**. In linear sweep, the path is a linear or circular vector described by a linear, most often parametric, equation while in nonlinear sweep, the path is a curve described by a higher-order equation (quadratic, cubic, or

higher). Hybrid sweep combines linear and/or nonlinear sweep via set operations and is, therefore, a means of increasing the modeling domain of sweep representations.

Linear sweep can be divided further into **translational and rotational sweep**. In translational sweep, a planar two-dimensional point set described by its boundary (or contour) can be moved a given distance in space in a perpendicular direction (called the directrix) to the plane of the set. Nonlinear sweep is similar to linear sweep but with the directrix being a curve instead of a vector. Hybrid sweep tends to utilize some form of set operations. Figure shows various types of sweep.

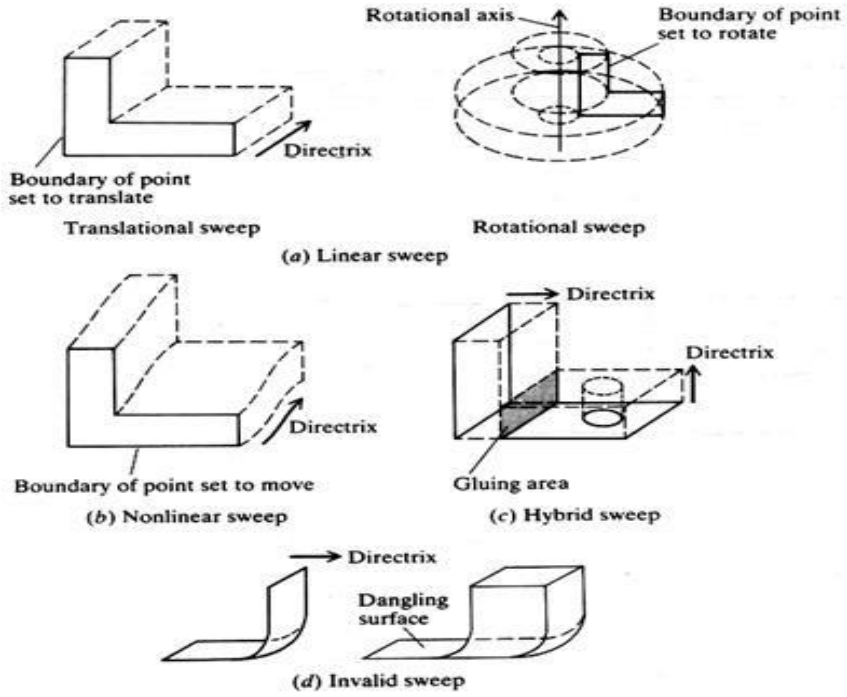
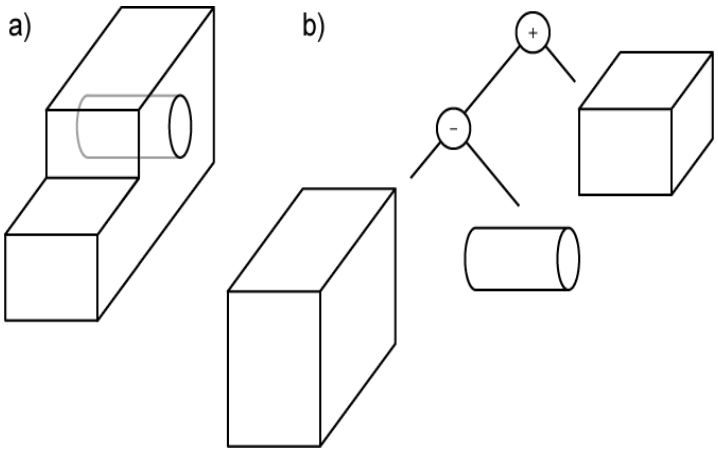


Figure. Types of sweep.

The building operations of linear and nonlinear sweep models are simple: generate the boundary and sweep it. Sweep representation is often called "**constraint-based solid modeling**" because the shape of the initial 2-D sketch provides the constraint to the added dimension. **This modeling technique is considered more intuitive than CSG and is popular in CAD software**. If hybrid sweep is available, these operations extend to include Boolean operations.

Constructive solid geometry (**CSG**)

CSG is a technique used in solid modeling. Constructive solid geometry allows a modeler to create a complex surface or object by using Boolean operatorsto combine simpler objects.[1] potentially generating visually complex objects by combining a few primitive ones

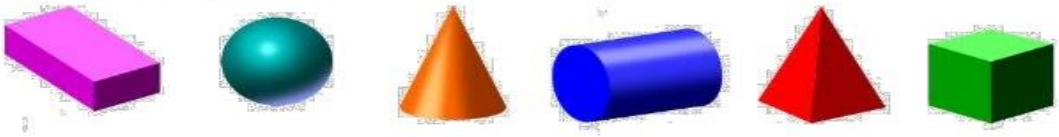


A CSG model is based on the topological notion that a physical object can be divided into a set of primitives (basic elements or shapes) that can be combined in a certain order following a set of rules (Boolean operations) to form the object. Each primitive is bounded by a set of surfaces; usually closed and orientable. A CSG model is fundamentally and topologically different from a B-rep model in that the former does not store explicitly the faces, edges, and vertices

There is a wide variety of primitives available commercially to users. However, the four most commonly used are the **block, cylinder, cone and sphere**. **These are based on the four natural quadrics: planes, cylinders, cones, and spheres**

Constructive solid geometry (CSG)

- **Primitives**: cuboids, cylinders, prisms, pyramids, spheres, cones.



- **Operations**: union, intersection and difference.