# BOUNDARY REPRESENTATION

# (B-REP)

- ✓ B-Rep stands for Boundary Representation.
- ✓ It is an extension to the wireframe model.
- ✓ B-Rep describes the solid in terms of its surface boundaries: Vertices, edges and faces as shown in figure 35

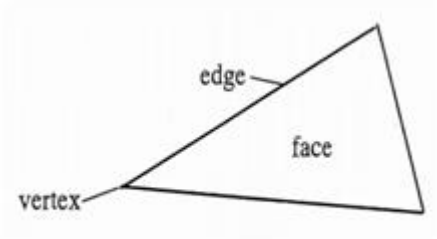



**Figure 35**

- ✓ It 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.
- ✓ There are 2 types of information in a B – rep topological and geometric.
- ✓ Topological information provides the relationships among vertices, edges and faces similar to that used in a wireframe model.
- ✓ In addition to connectivity, topological information also includes orientation of edges and faces.
- ✓ Geometric information is usually equations of the edges and faces.
- ✓ The B-rep of 2 manifolds that have faces with holes satisfies the generalized Euler's formula:

$$V-E+F-H=2(C-G)$$

Where, V = Number of vertices.

E = Number of edges.

F = Number of faces.

H = Number of holes in the faces.

C is the number of separate components (parts).

G is the genus (for a torus G = 1)

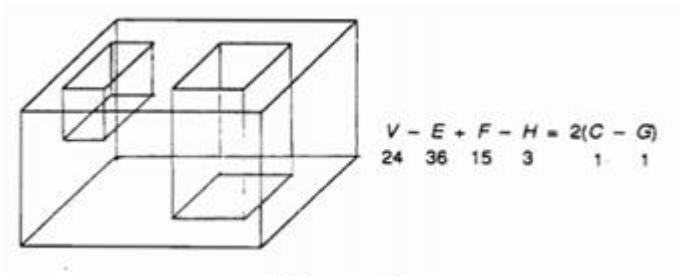



Figure 36

# Sweep Representations:

Sweep representations are used to construct 3D object from 2D shape that have some kind of symmetry.

For example, a prism can be generated using a translational sweep and rotational sweeps can be used to create curved surfaces like an ellipsoid or a torus.

In both cases, you start with a cross-section and generate more vertices by applying the appropriate transformation.

More complex objects can be formed by using more complex transformations. Also, we can define a path for a sweep that allows you to create more interesting shapes.

# Constructive solid geometry

- ✓ CSG stands for Constructive Solid Geometry.
- ✓ It is based on set of 3D solid primitives and regularized set theoretic operations.
- ✓ Traditional primitives are: Block, cones, sphere, cylinder and torus.
- ✓ Operations: union, intersection, difference + translation and rotation.
- ✓ A complex solid is represented using with a binary tree usually called as CSG tree.
- ✓ CSG tree is shown below in figure 37.

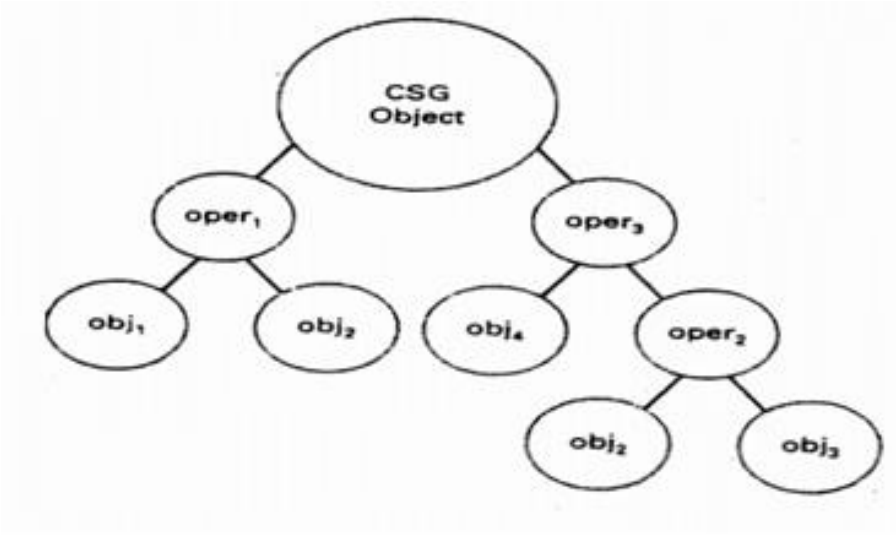



Figure 37

- ✓ Ray casting is a method used for determining boundaries of the resulting object if you start with a boundary representation.
- ✓ Octree representations are designed to make this process easier.

Example:

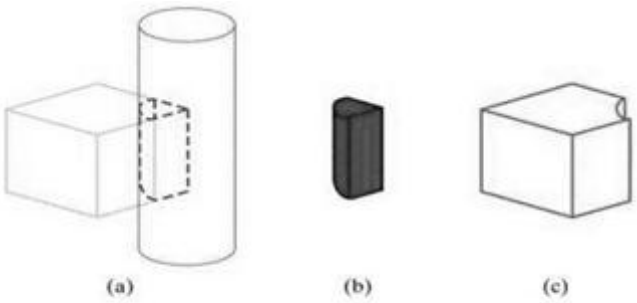


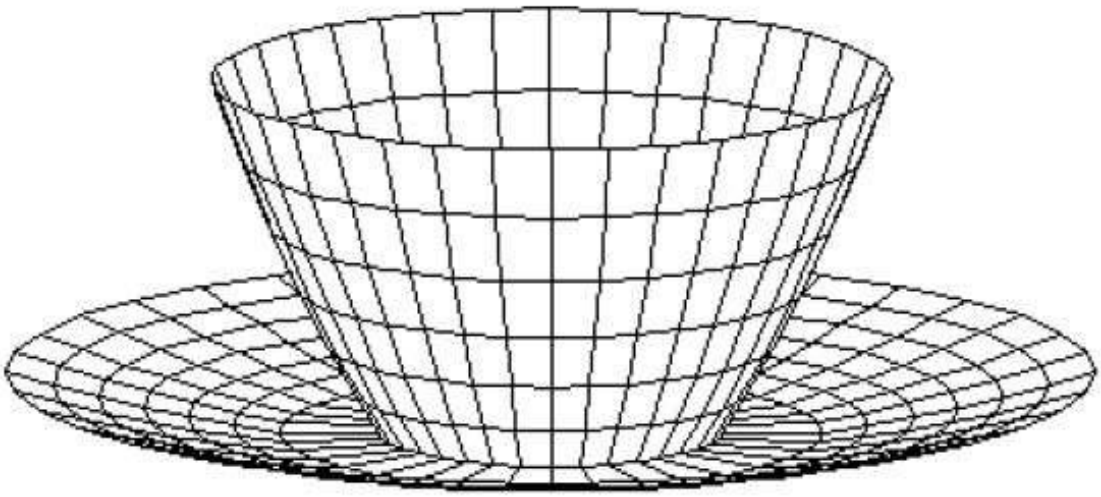

Figure 38

# Polygon Meshes

**Definition :-** A polygon mesh is a collection of edges, faces and connecting points that is used to provide a polygon model for 3-D modeling and computer animation. Its geometric makeup can be stored in order to facilitate various kinds of simulation of three-dimensional renderings.

# Polygon Meshes

3D surfaces and solids can be approximated by a set of polygonal and line elements. Such surfaces are called **polygonal meshes**. In polygon mesh, each edge is shared by at most two polygons. The set of polygons or faces, together form the "skin" of the object.



This method can be used to represent a broad class of solids/surfaces in graphics. A polygonal mesh can be rendered using hidden surface removal algorithms. The polygon mesh can be represented by three ways −

- Explicit representation
- Pointers to a vertex list
- Pointers to an edge list

## Advantages

- It can be used to model almost any object.
- They are easy to represent as a collection of vertices.
- They are easy to transform.
- They are easy to draw on computer screen.

## Disadvantages

- Curved surfaces can only be approximately described.

- It is difficult to simulate some type of objects like hair or liquid.

# REGULARISED BOOLEAN SET

---

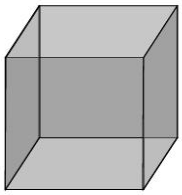
**Solid is bound by surfaces. So need to also define the polygons of vertices, which form the solid. It must also be a valid representation.**

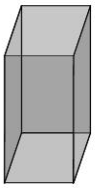
**Regularized Boolean Set Operations**

**Operators (*op*):**
**Union:** ∪
**Intersection:** ∩
**Difference:** -

**Boolean intersections of, say cubes, may produce solids, planes, lines, points and null object. Two examples:**

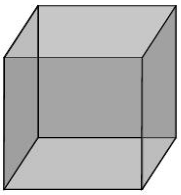
**A**

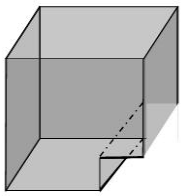




$A \cap B$

**B**





**A - B**

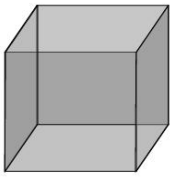
**Solid is bound by surfaces. So need to also define the polygons of vertices, which form the solid. It must also be a valid representation.**

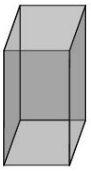
**Regularized Boolean Set Operations**

**Operators (*op*):**
**Union:** ∪
**Intersection:** ∩
**Difference:** -

**Boolean intersections of, say cubes, may produce solids, planes, lines, points and null object. Two examples:**

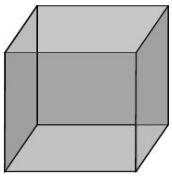
**A**

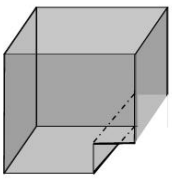




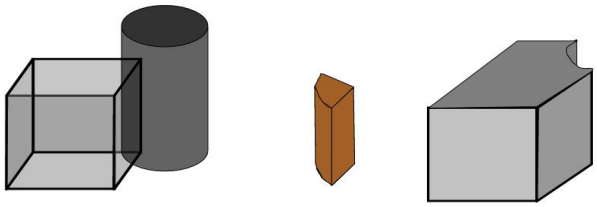
$A \cap B$

**B**





**A - B**



## COMPARISON OF REPRESENTATION

| **Parameters** | **Sweep representation** | **Boundary representation** | **CSG** |
|---|---|---|---|
| Accuracy | High | Sometimes requires High approximations | High |
| Domain | Limited | Can represent wide class of objects | Limited to some extend |
| Uniqueness | Unique | Unique | Not Unique |
| Validity | Easy to validate | Most difficult to validate | Easy to validate |
| Closure | Not closed under boolean operations | May suffer from closure problems under boolean operations | Closed |
| Compactness and Efficiency | More compact and efficient | compact and evaluation is not necessary | More compact needs necessary evaluation of boolean operations and transformation |