

# Computer Graphics 10: 3D Object Representations

In today's lecture we are going to start to look at how objects are modelled in 3D

- Polyhedra
- Quadric surfaces
- Sweep representations
- Constructive solid geometry methods

Objects are simply a set of surface polygons that enclose an object interior

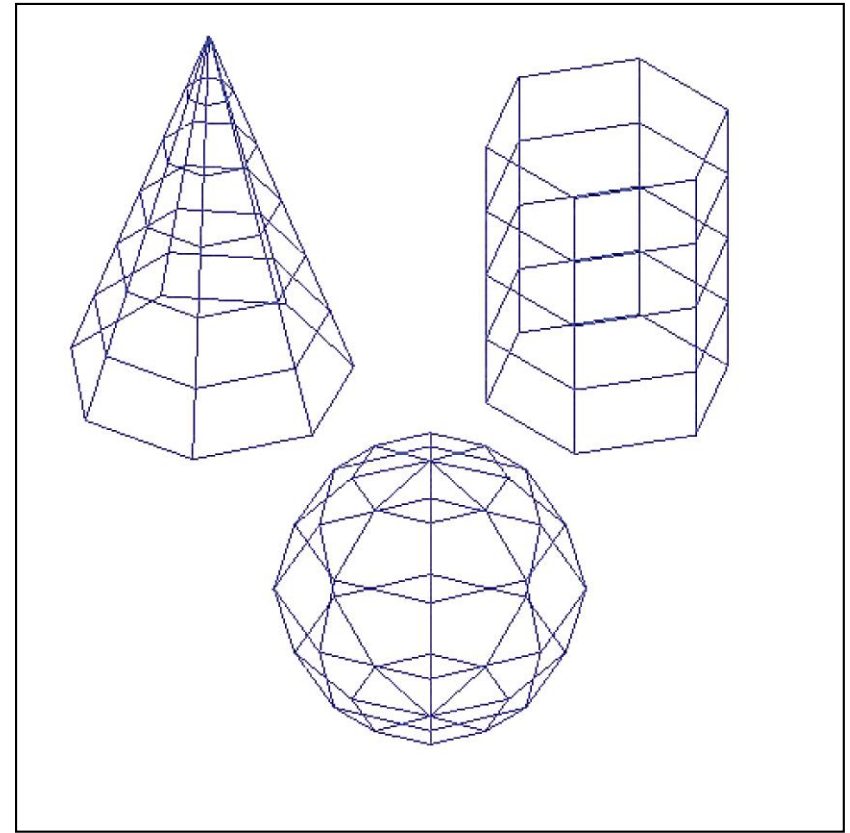
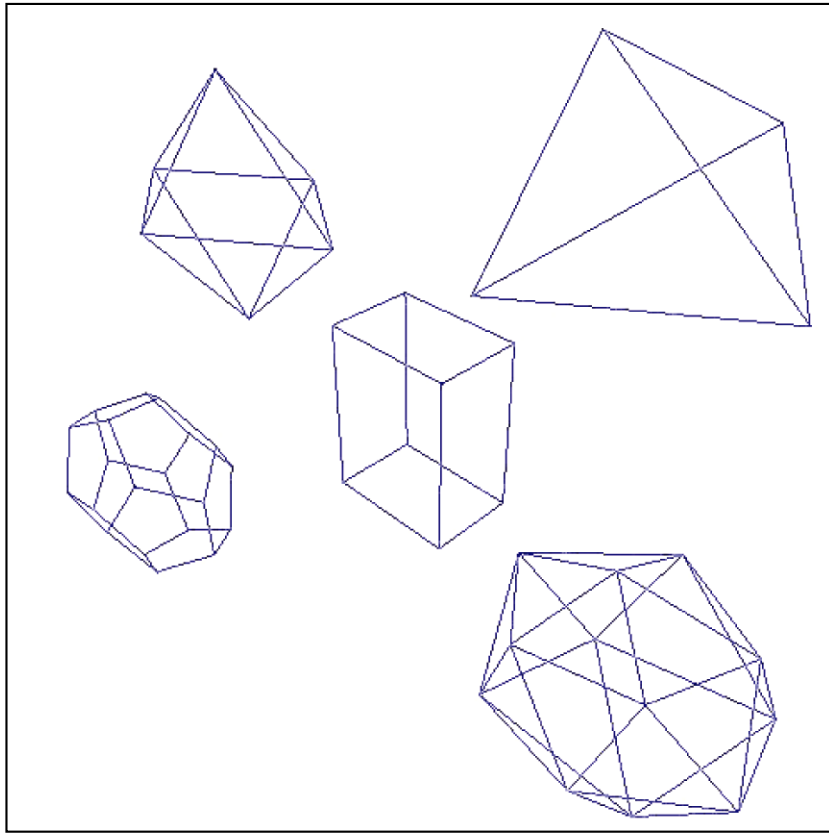
Simplest and fastest way to render objects

Often referred to as *standard graphics objects*

In many cases packages allow us to define objects as curved surfaces etc but actually convert these to polygon meshes for display

To define polyhedra we simply define the vertices of the polygons required

# Polyhedra (cont...)



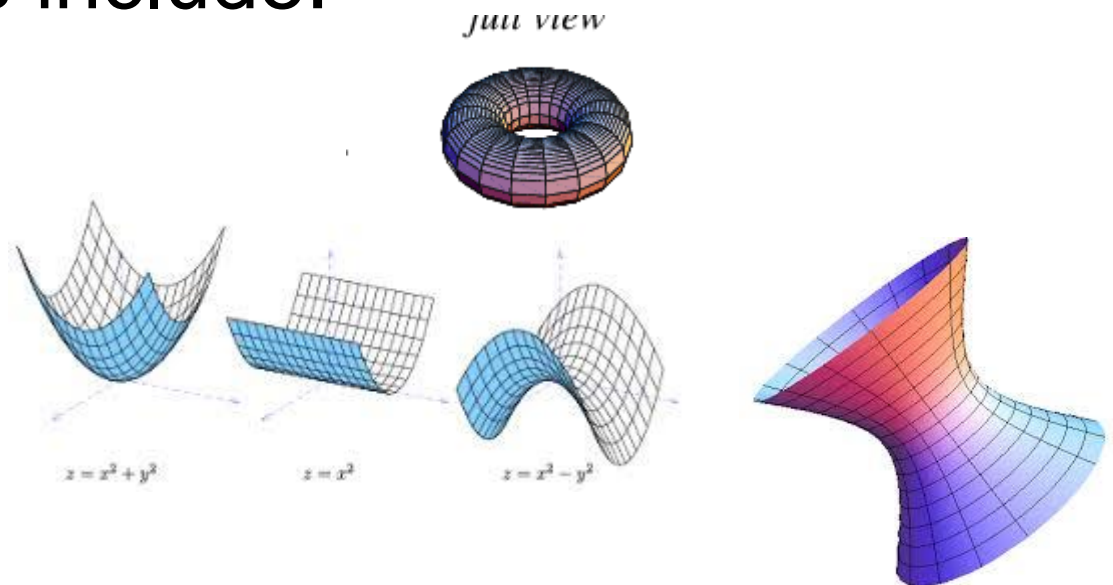
# Quadric Surfaces

A frequently used class of objects are quadric surfaces

These are 3D surfaces described using quadratic equations

Quadric surfaces include:

- Spheres
- Ellipsoids
- Tori
- Paraboloids
- Hyperboloids



# Quadric Surfaces - Spheres

A spherical surface with radius  $r$  centred on the origin is defined as the set of points  $(x, y, z)$  that satisfy the equation

$$x^2 + y^2 + z^2 = r^2$$

This can also be done in parametric form using latitude and longitude angles

$$x = r \cos \phi \cos \theta$$

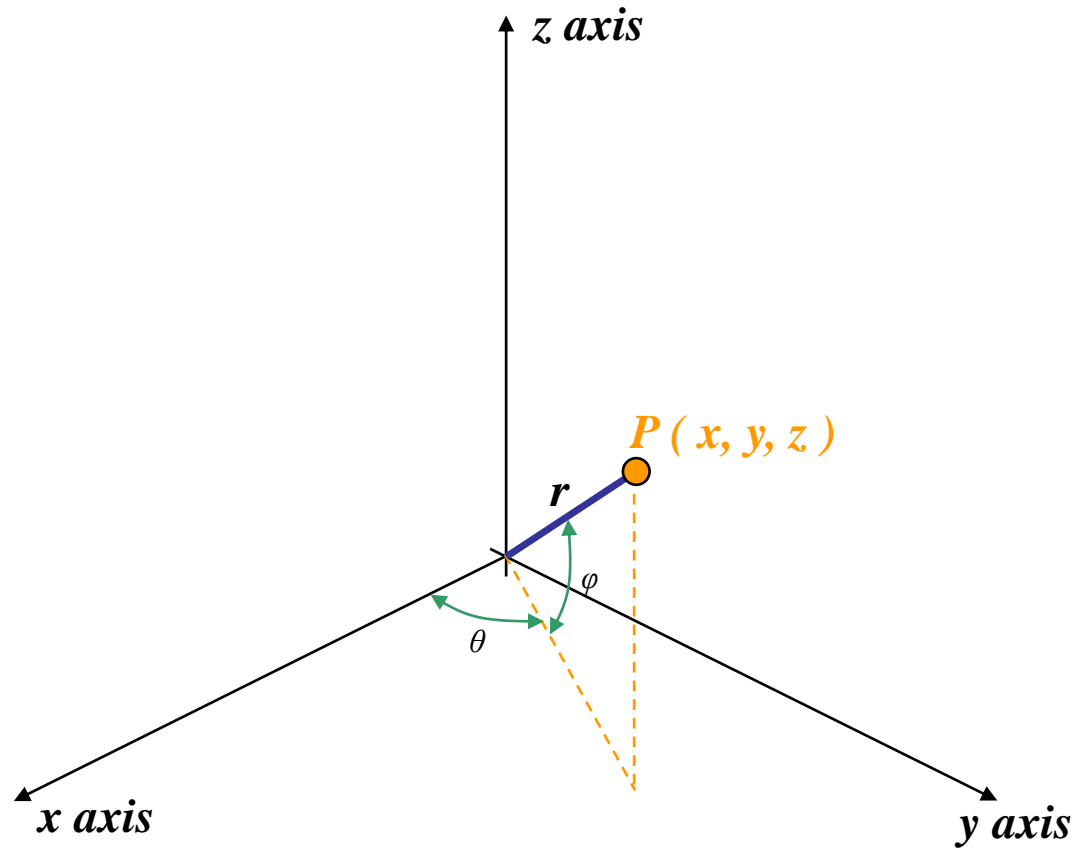
$$y = r \cos \phi \sin \theta$$

$$z = r \sin \phi$$

$$-\pi/2 \leq \phi \leq \pi/2$$

$$-\pi \leq \theta \leq \pi$$

# Quadric Surfaces – Spheres (cont...)



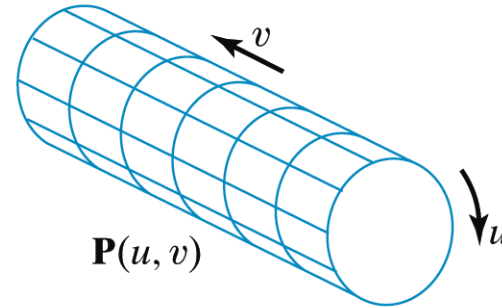
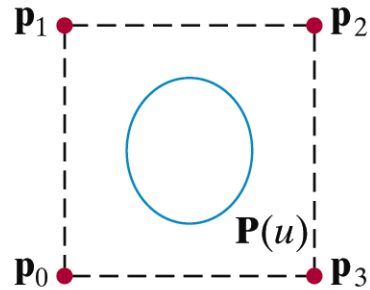
# Sweep Representations

Sweep representations are useful for constructing 3 dimensional objects that possess translational, rotational or other symmetries

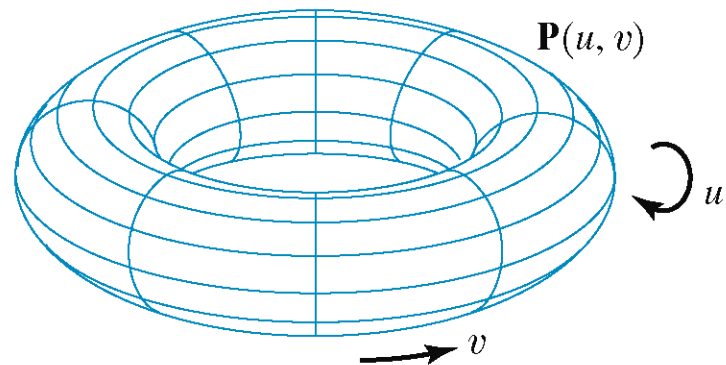
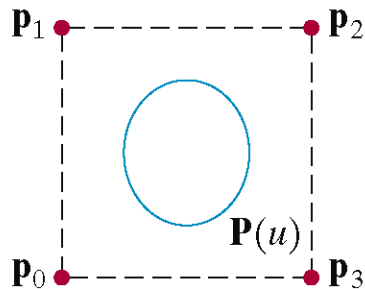
Objects are specified as a 2 dimensional shape and a sweep that moves that shape through a region of space



# Sweep Representations - Examples



Axis of  
Rotation



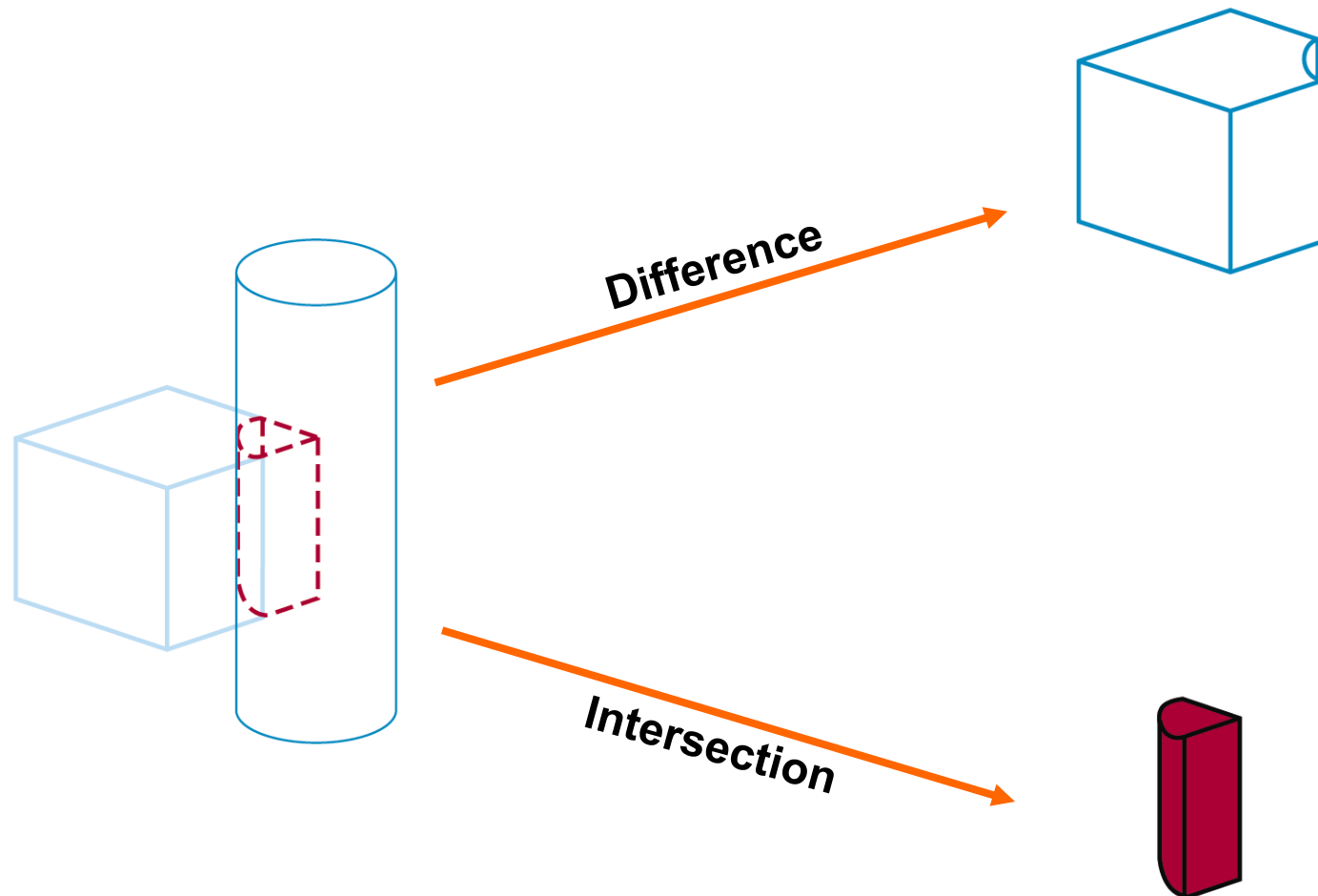
# Constructive Solid Geometry Methods

Constructive Solid Geometry (CSG)  
performs solid modelling by generating a  
new object from two three dimensional  
objects using a set operation

Valid set operations include

- Union
- Intersection
- Difference

# Constructive Solid Geometry Methods (cont...)



CSG usually starts with a small set of primitives such as blocks, pyramids, spheres and cones

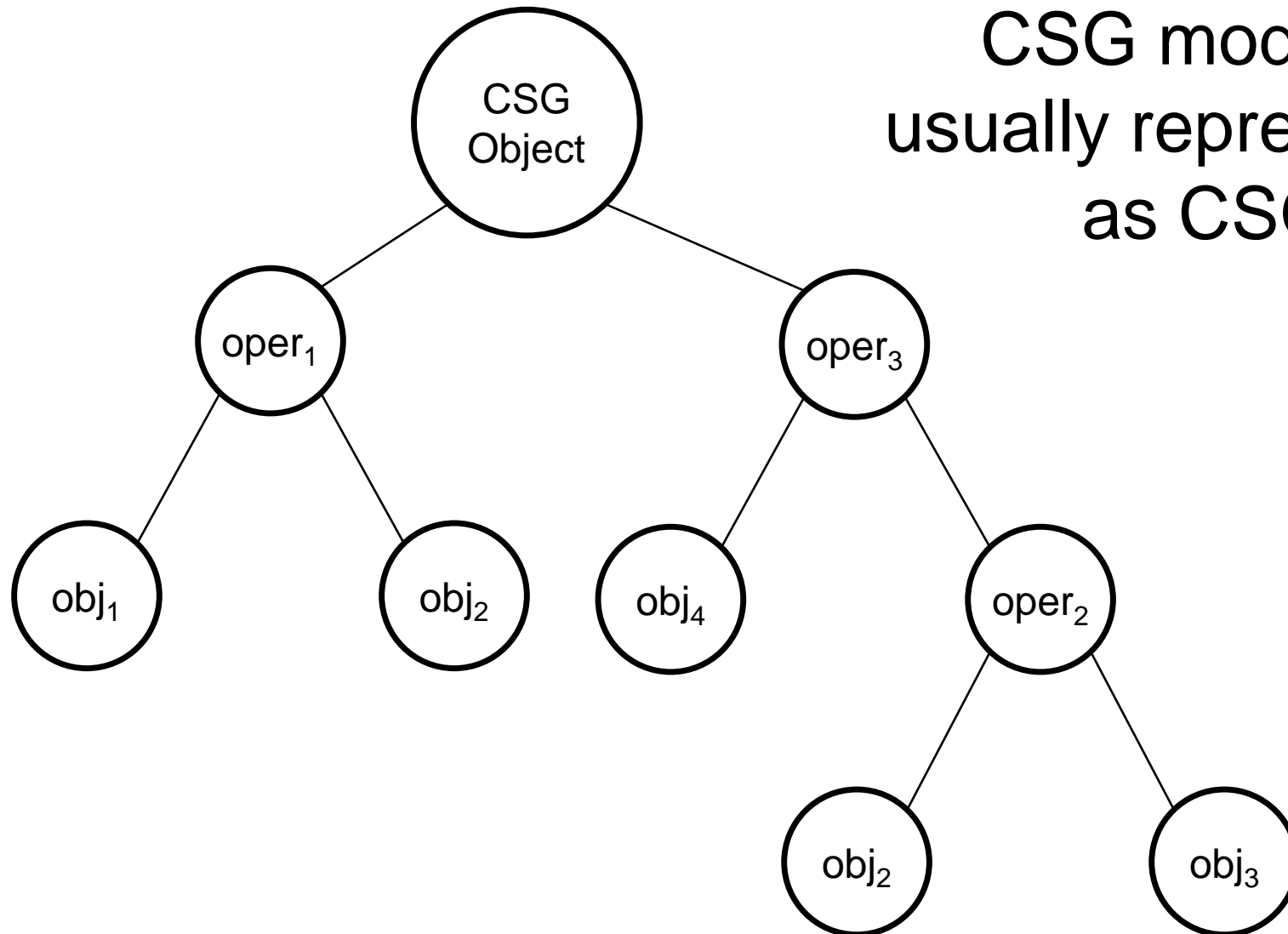
Two objects are initially created and combined using some set operation to create a new object

This object can then be combined with another primitive to make another new object

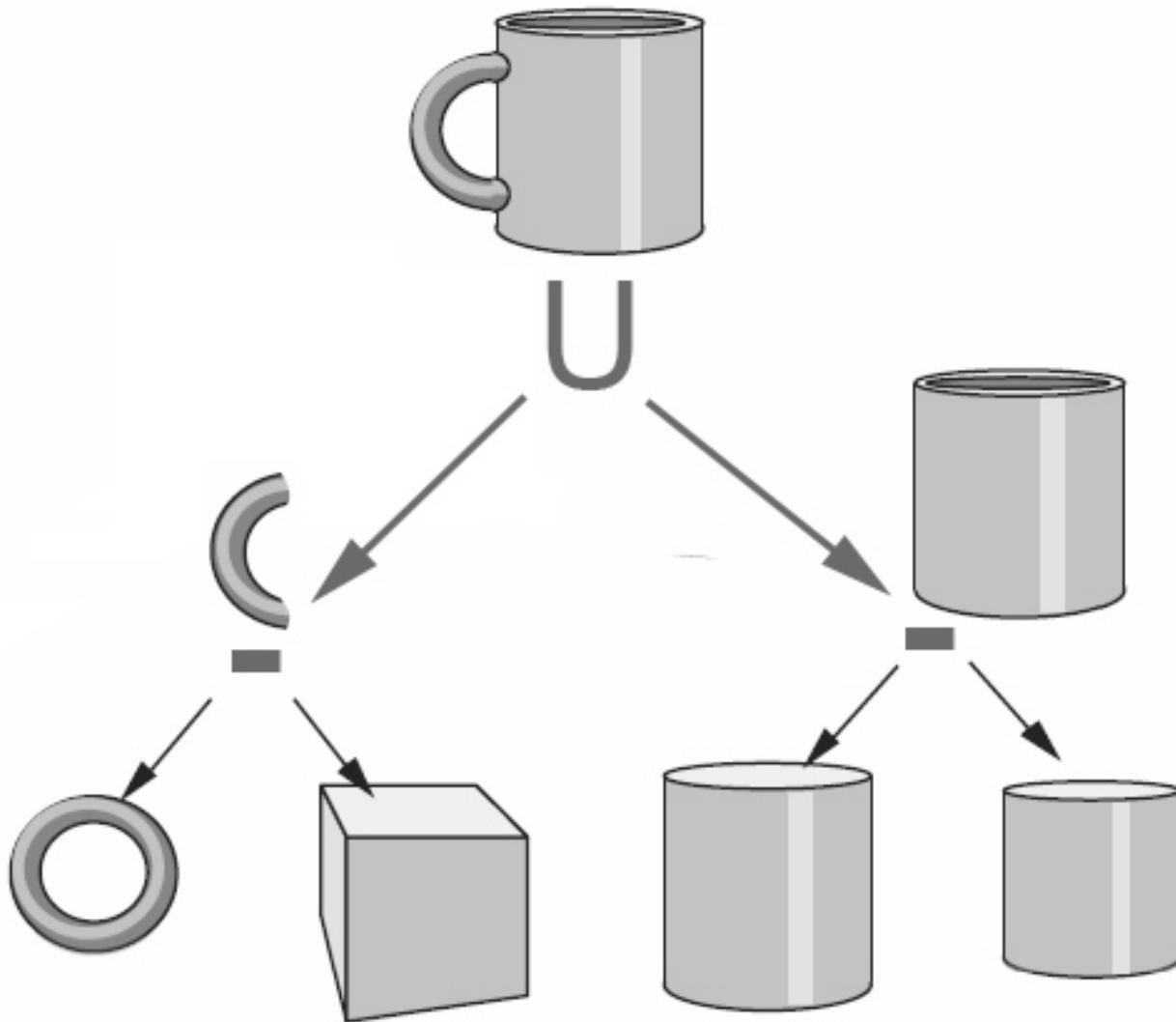
This process continues until modelling complete

# Constructive Solid Geometry Methods (cont...)

CSG models are  
usually represented  
as CSG trees



# Constructive Solid Geometry Methods (cont...)

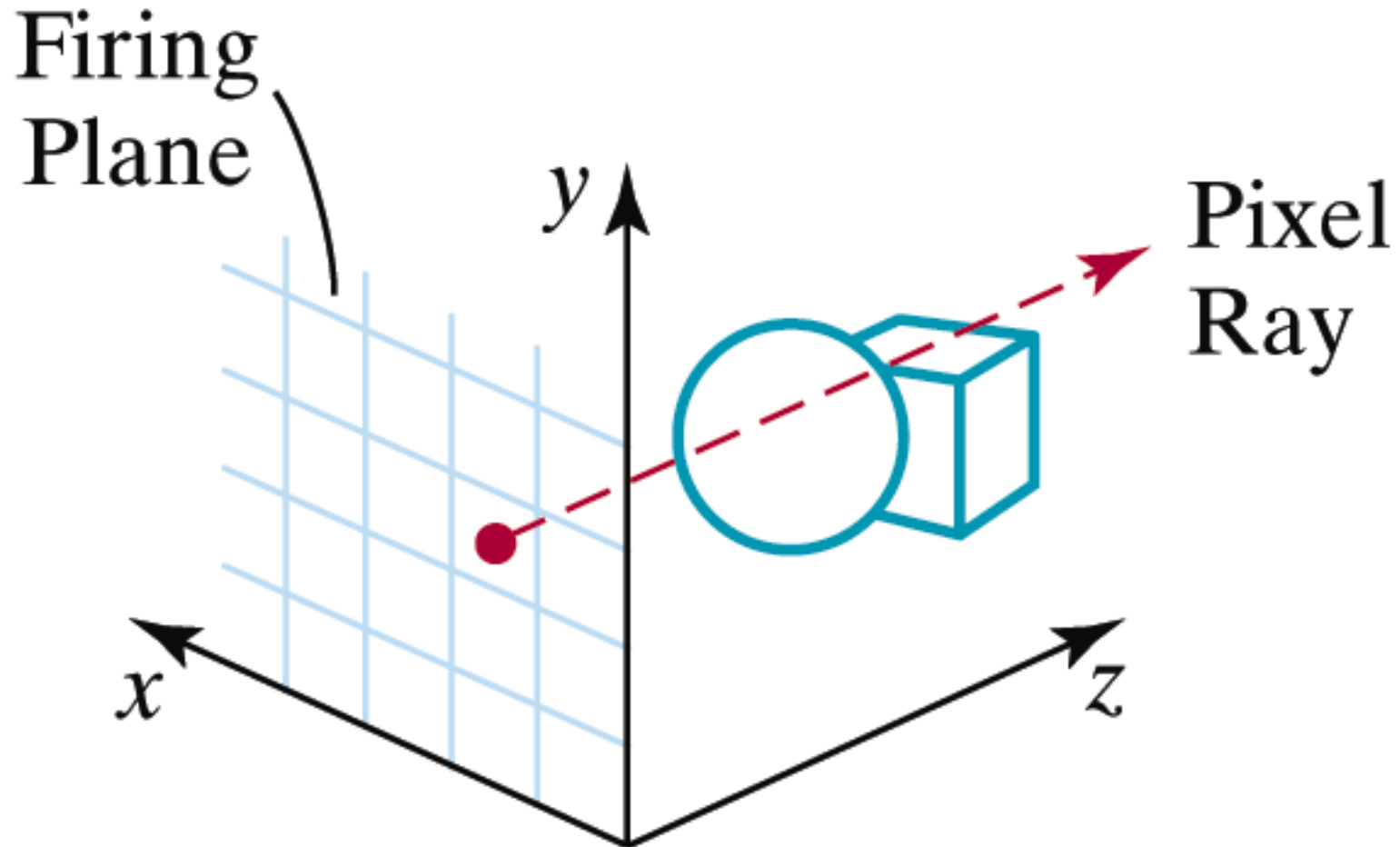


✓ **Ray-casting** is typically used to implement CSG operators when objects are described with boundary representations

✓ Ray casting is applied by determining the objects that are intersected by a set of parallel lines emanating from the  $xy$  plane along the  $z$  axis

✓ The  $xy$  plane is referred to as the **firing plane**

# Ray-Casting (cont...)

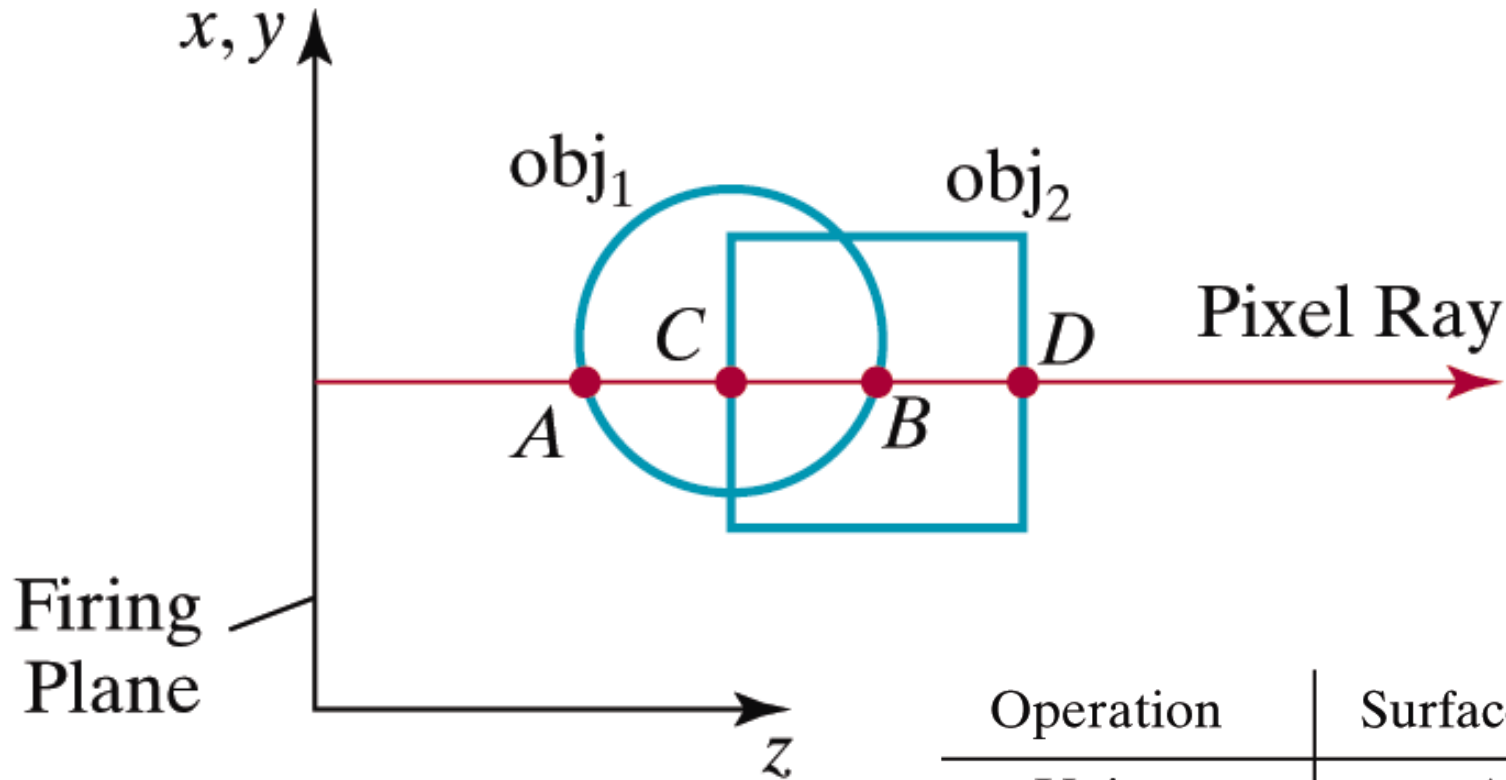




Surface intersections along each ray are calculated and these are sorted according to distance from the firing plane

The surface limits for the composite object are then determined by the specified set operation

# Ray Casting Example



Operation	Surface Limits
Union	$A, D$
Intersection	$C, B$
Difference ( $obj_2 - obj_1$ )	$B, D$

In today's lecture we began to look at how objects are modelled in 3D

Polyhedra are by far the most common modelling technique, but there are many others

Often more exotic modelling techniques are used in a modelling phase, but the resultant models are converted to polyhedra before rendering

Next time we will look at more modelling techniques