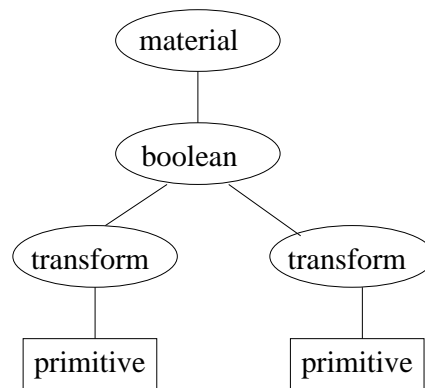


## 18.6 Modeling and CSG

**Modeling:** Constructive Solid Geometry

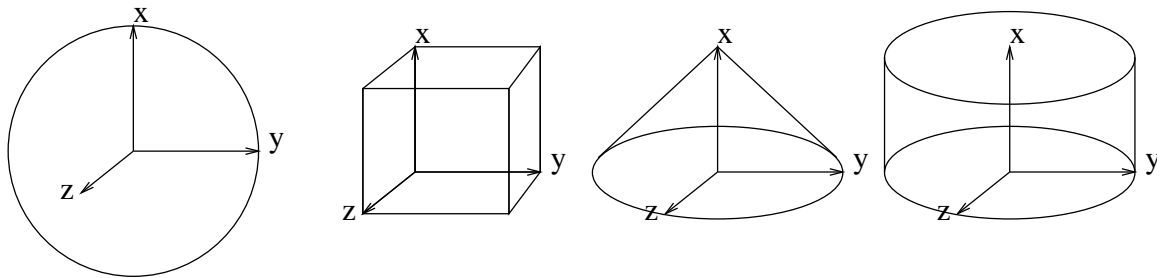
- How do we model for a Ray Tracer?
- Hierarchical modeling works well, but we easily can do more.
- In *Constructive Solid Geometry* all primitives are solids.
- New type of internal node: Boolean operation.  
Intersection, Union, Difference
- Thus, our model is a DAG with
  - Leaf nodes representing primitives
  - Internal nodes are transformations, materials, or boolean operations.



**CSG:** The primitives

We will want a rich set of primitives. How do we specify them?

- As a “canonical” primitive

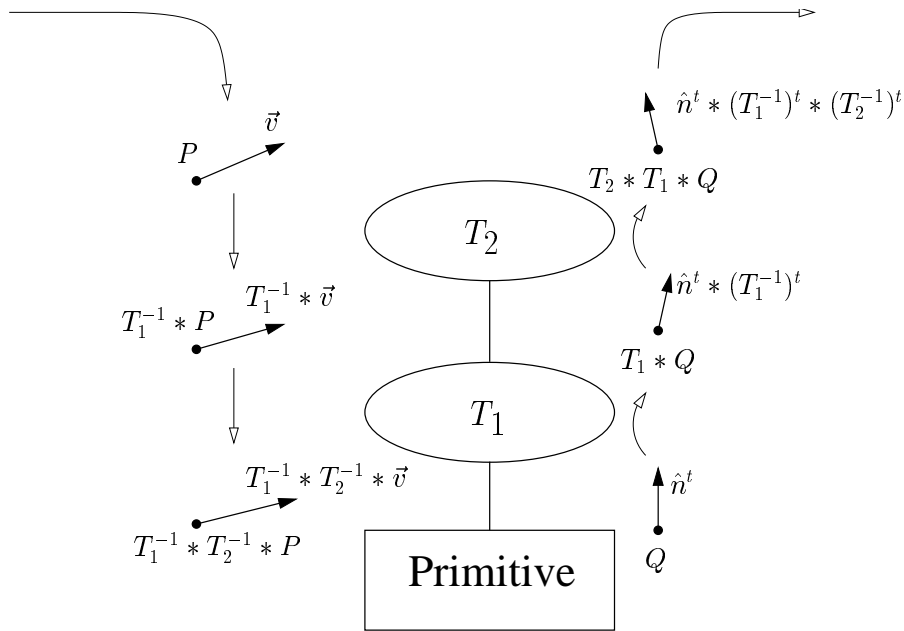


`Sphere()*Scale(2,2,2)*Translate(x,y,z)`

- As a transformed canonical primitive
  - `Sphere(r,x,y,z);`
  - `Cube(x,y,z,dx,dy,dz);`
  - `Cone(width,height,x,y,z,dx,dy,dz);`

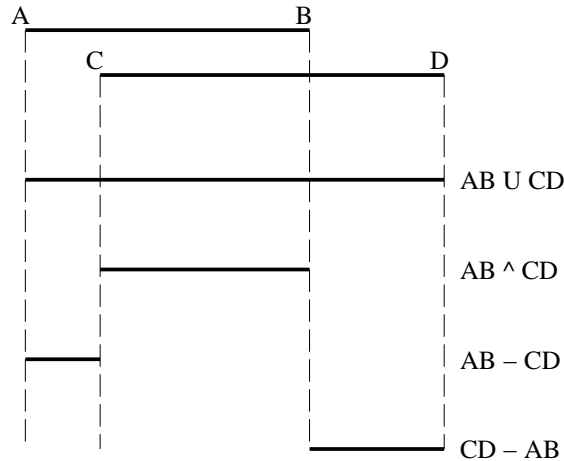
**CSG:** Traversing the transformation tree

- After transformation are applied, our primitives will be warped.
  - Rather than intersect ray with warped primitive (which is worse once we add boolean operations), we will transform the ray.
  - On the way down, apply *inverse transformation* to ray.
  - On the way back, apply the transformation to the point and to the normal
- Caution:** see notes on transforming normals



### CSG: Boolean operations

- Could apply boolean operations to transformed primitives and construct a surface for that object.  
Problem: representation too complex
- Idea: perform a complete ray intersect object with each primitive. This gives us a (set of) line segment(s).  
Next, perform boolean operations on line segments.



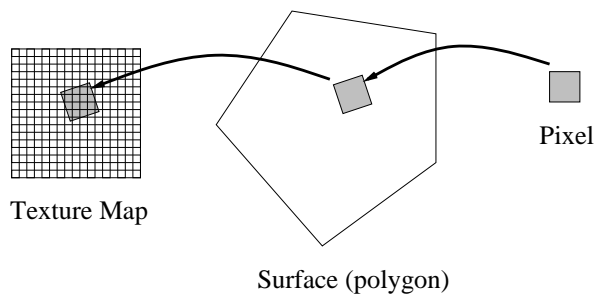
- Note that if we transform the ray on the way down, then we must transform the entire segment on the way back
- Also, we must be careful with normals: they flip for difference.

♠ Readings: Watt: 2.2.

## 18.7 Texture Mapping

### Texture Mapping:

- If we add detail by increasing model complexity, then computation cost increases.
- If detail is surface detail, then we can use texture mapping.
- Idea: scan a photo of the detail and paste it on objects.
  - Associate texture with polygon
  - Map pixel onto polygon and then into texture map
  - Use weighted average of covered texture to compute colour.



- Tile polygon with texture if needed
  - For some textures, tiling introduces unwanted pattern
  - See SIGGRAPH 97 for method to extend textures (expensive)
- Greatly improves images!
- Not just ray traced image