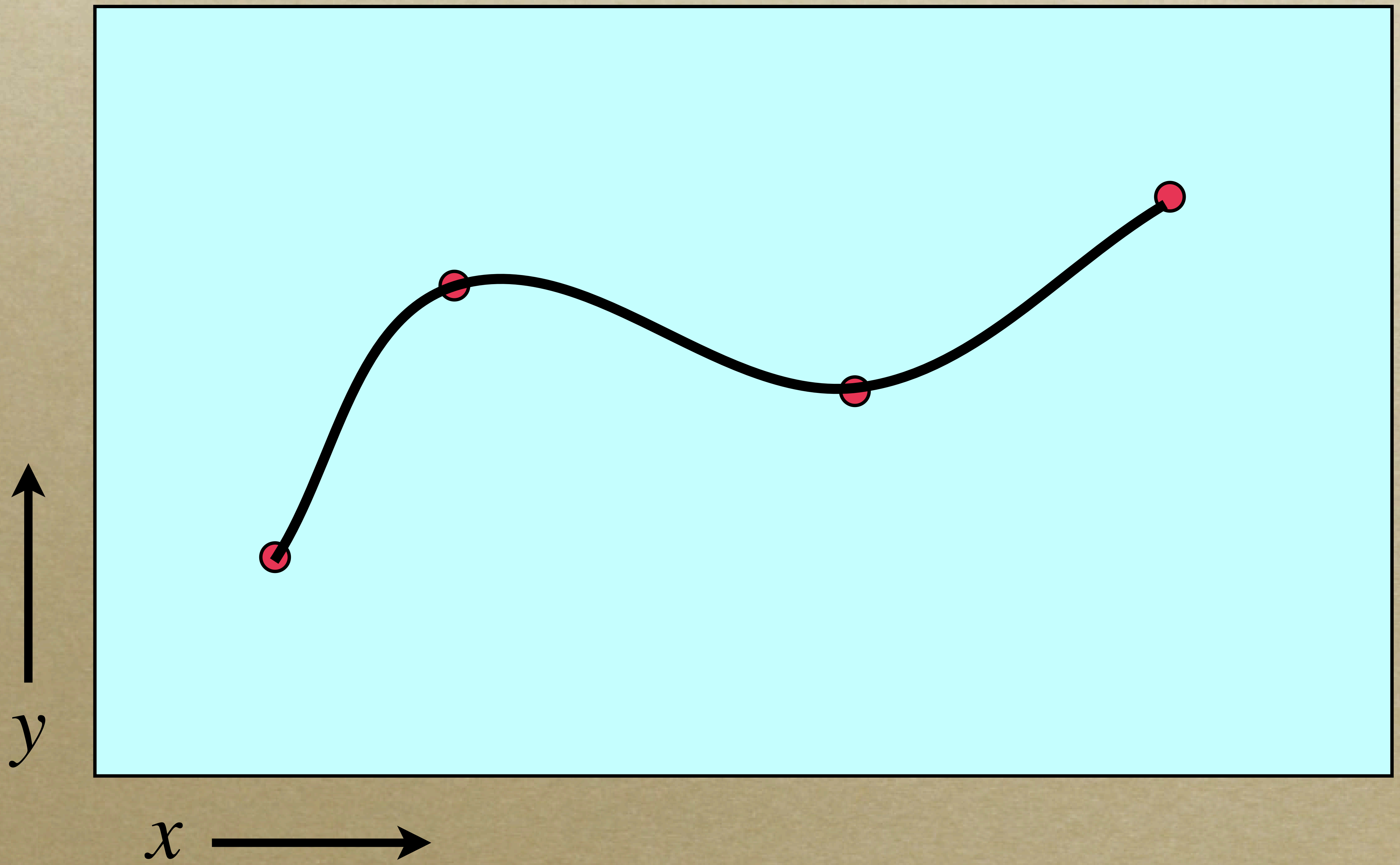
Modelling Techniques

- *Parametric Patches*
- *Constructive Solid Geometry (CSG)*
- *Subdivision Surfaces*
- *Implicit Surfaces*

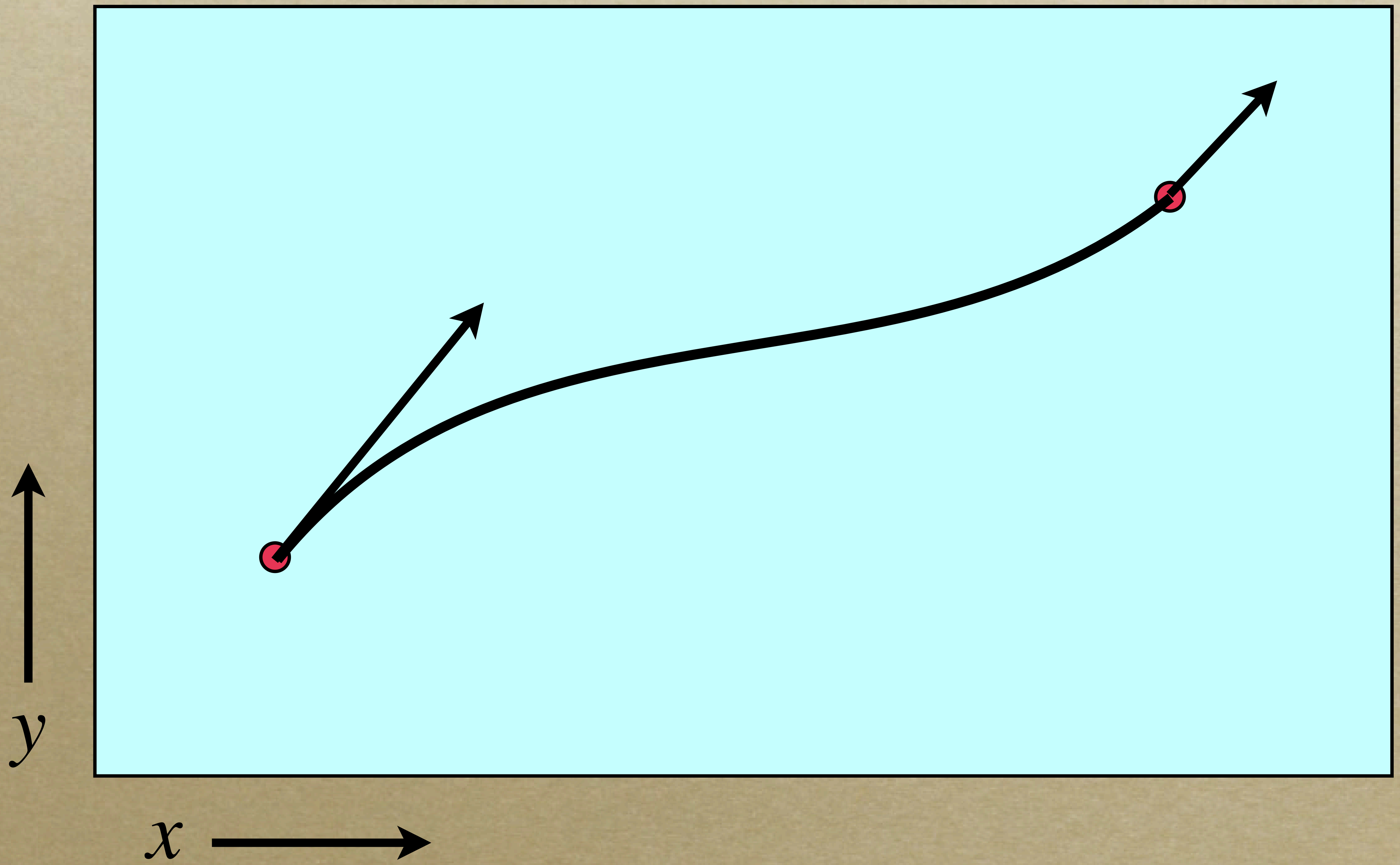
Parametric patches

- *Polygons are flat*
- *Objects have curved faces*
- *Can we fit a curve to points in space?*
- *Can we fit a surface to points in space?*

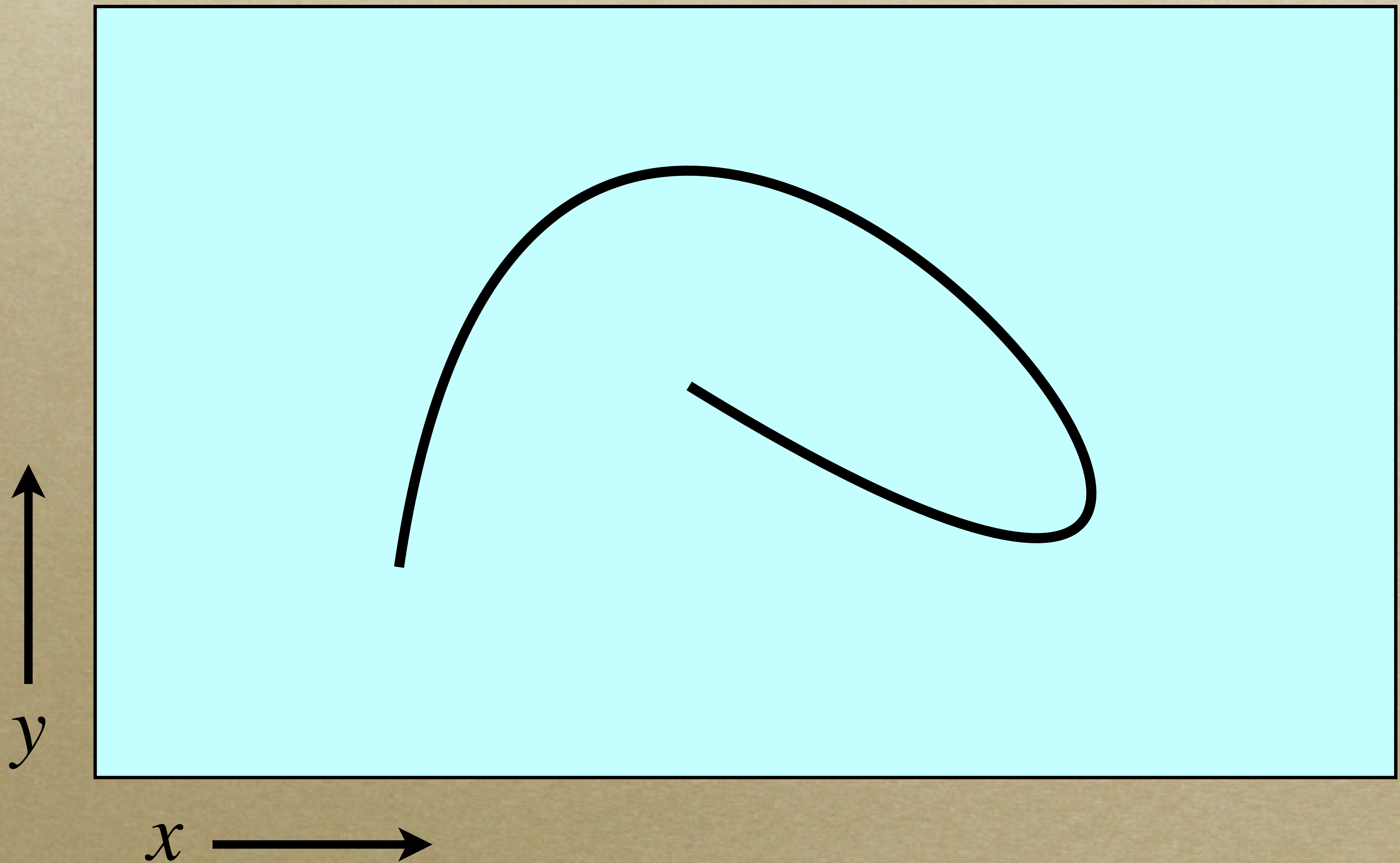
Curve fitting



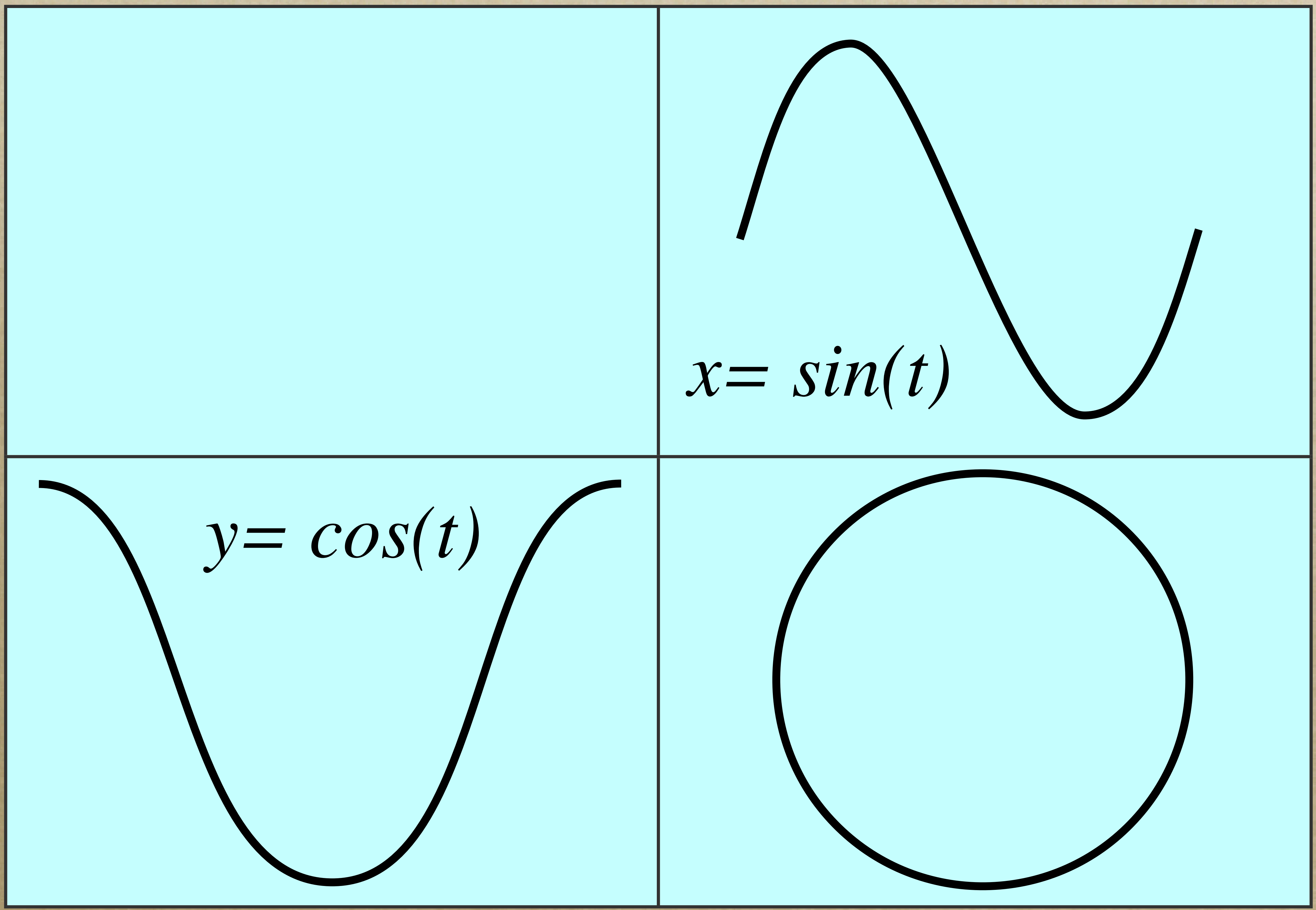
Curve fitting



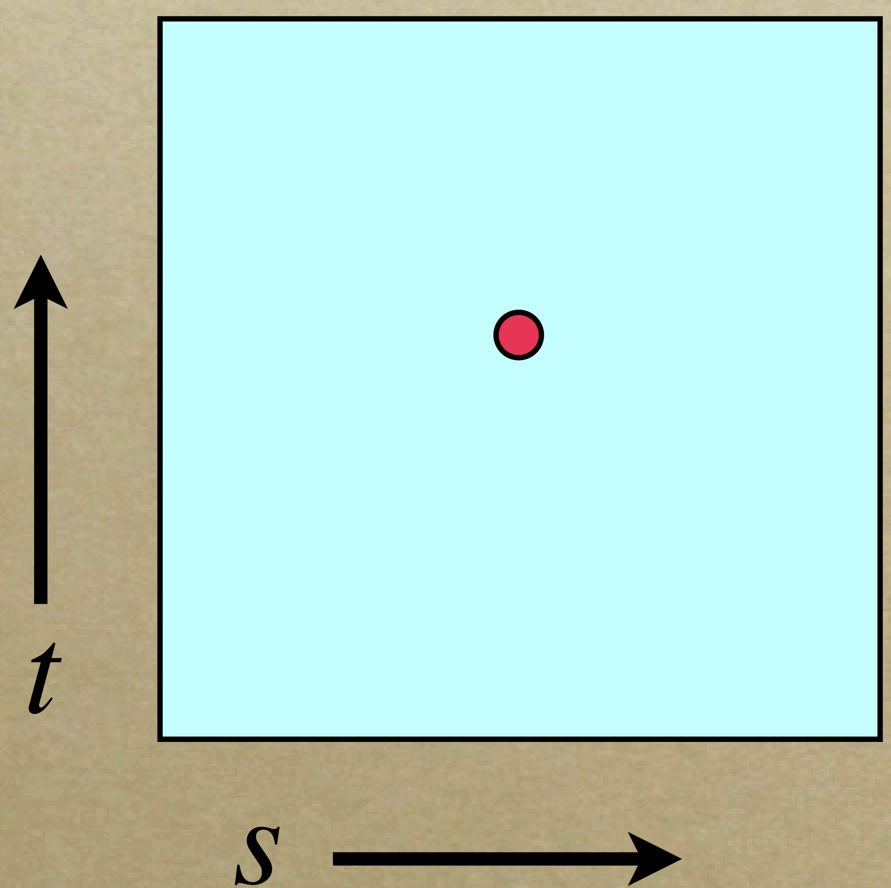
How do we do this one?

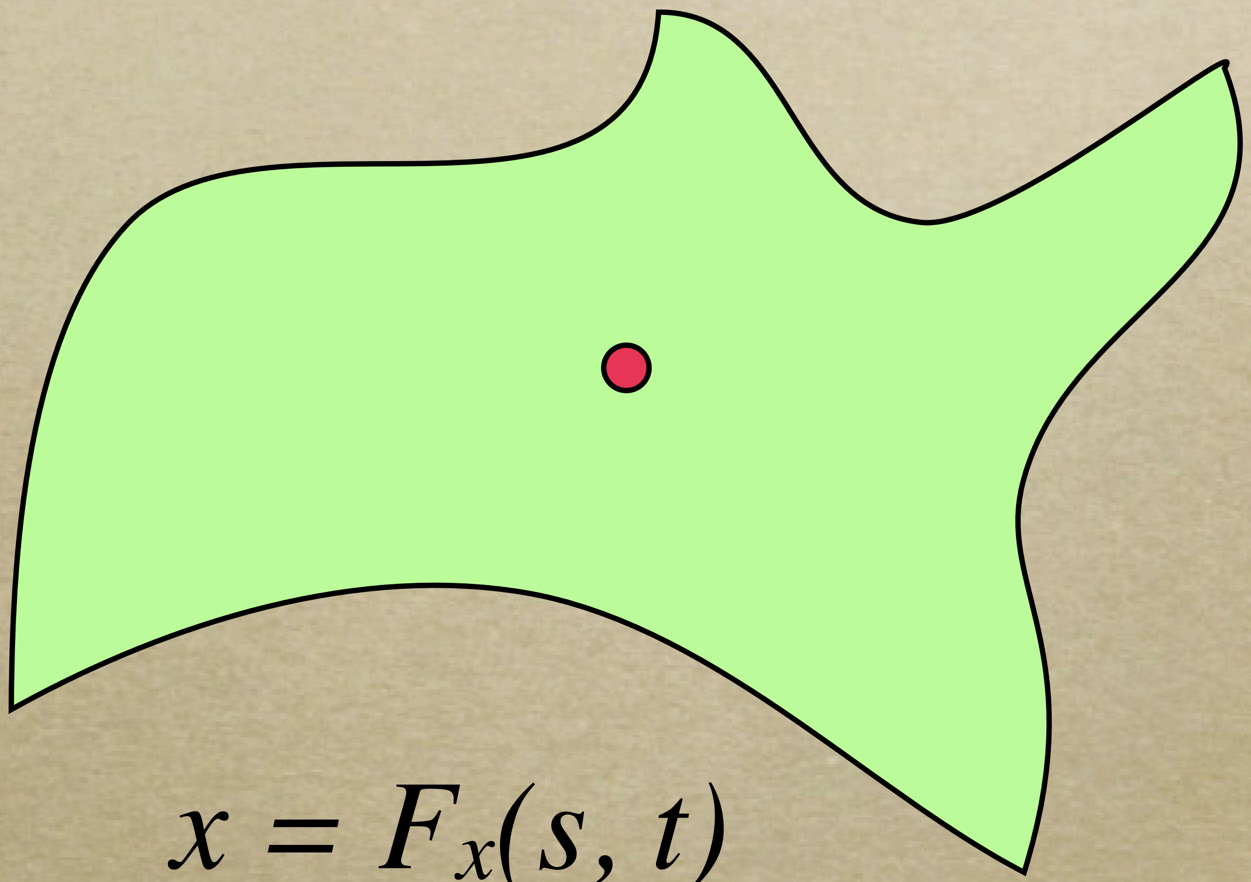


Plot X(t), Y(t)



Patches





$$x = F_x(s, t)$$
$$y = F_y(s, t)$$
$$z = F_z(s, t)$$

What function?

$X(s, t) =$

$X_{3,3}s^3t^3 +$	$X_{3,2}s^3t^2 +$	$X_{3,1}s^3t +$	$X_{3,0}s^3 +$
$X_{2,3}s^2t^3 +$	$X_{2,2}s^2t^2 +$	$X_{2,1}s^2t +$	$X_{2,0}s^2 +$
$X_{1,3}st^3 +$	$X_{1,2}st^2 +$	$X_{1,1}st +$	$X_{1,0}s +$
$X_{0,3}t^3 +$	$X_{0,2}t^2 +$	$X_{0,1}t +$	$X_{0,0}$

16 term cubic for x, y, z

That means there are 48 coefficients:

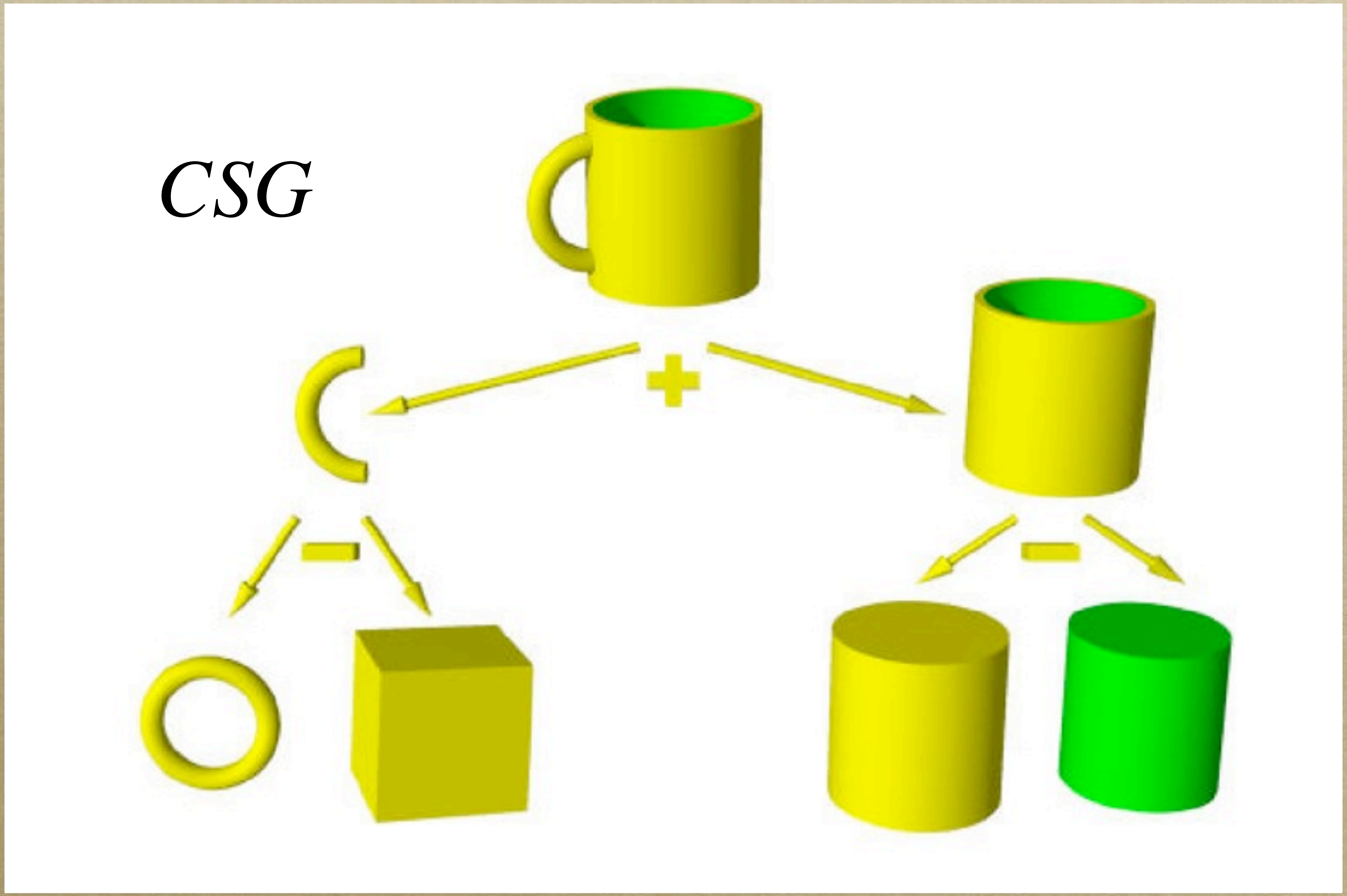
$X_{i,j}$, $Y_{i,j}$, $Z_{i,j}$,

Often we derive the values from 16 points: $\boldsymbol{u}_{i,j}$

Pros and cons

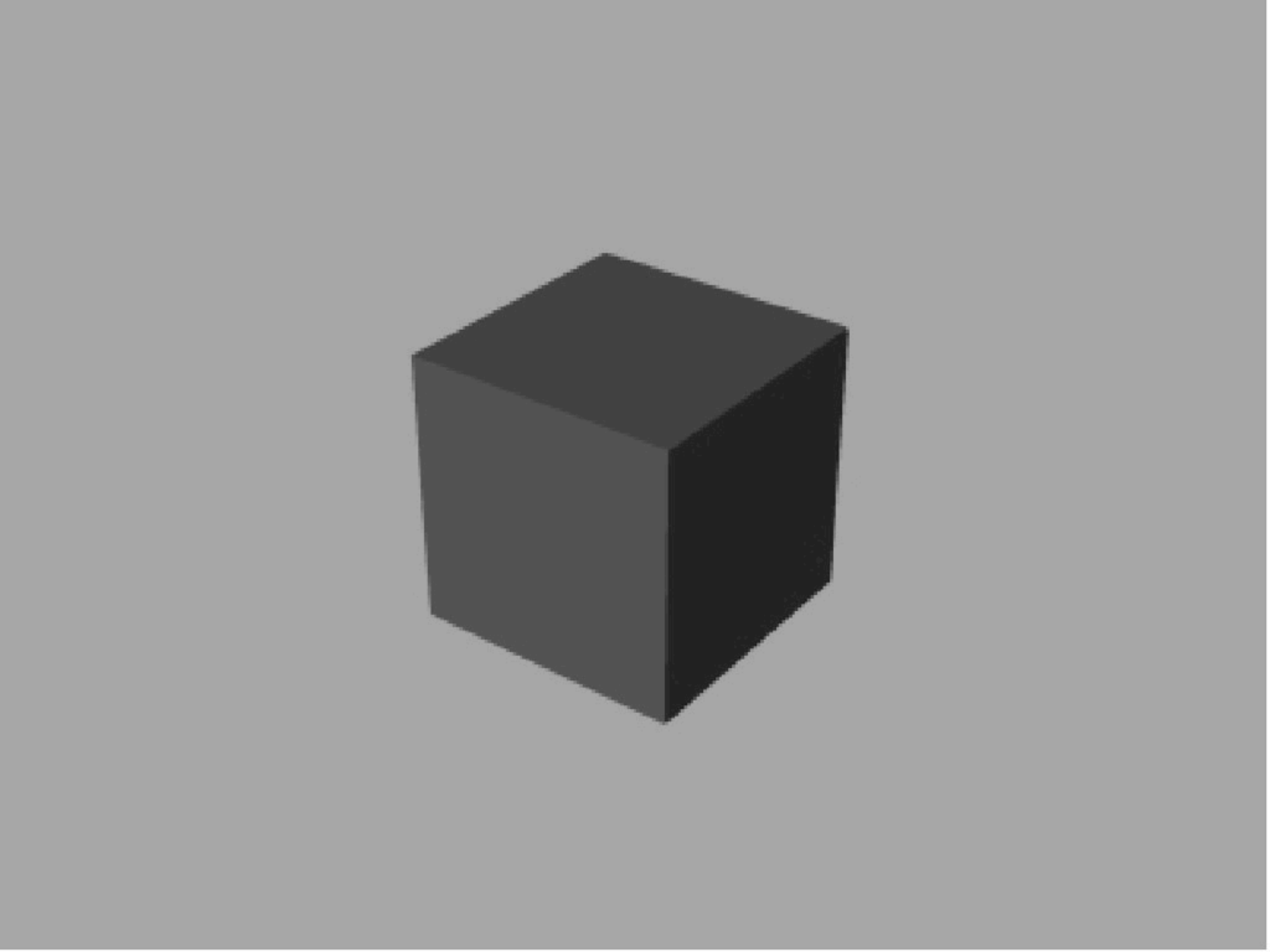
+ *Can make a huge variety of shapes*
+ *Smooth surfaces*
+ *Can represent spheres and cylinders*
- *Difficult boundary conditions*
- *Only defines the surface - no inside*

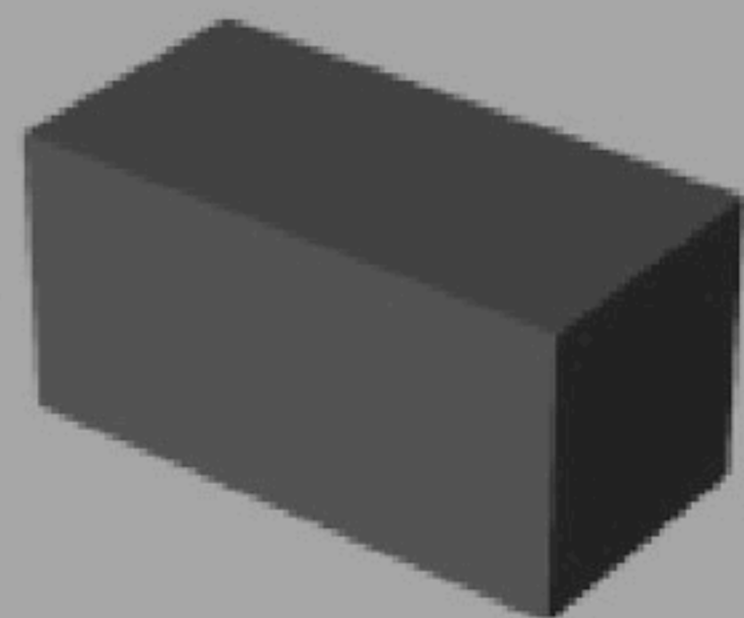
Constructive Solid Geometry

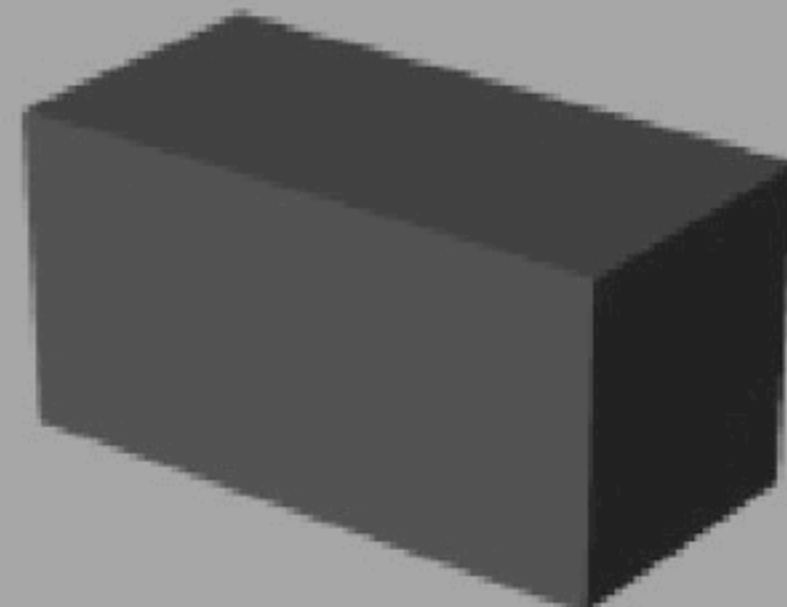


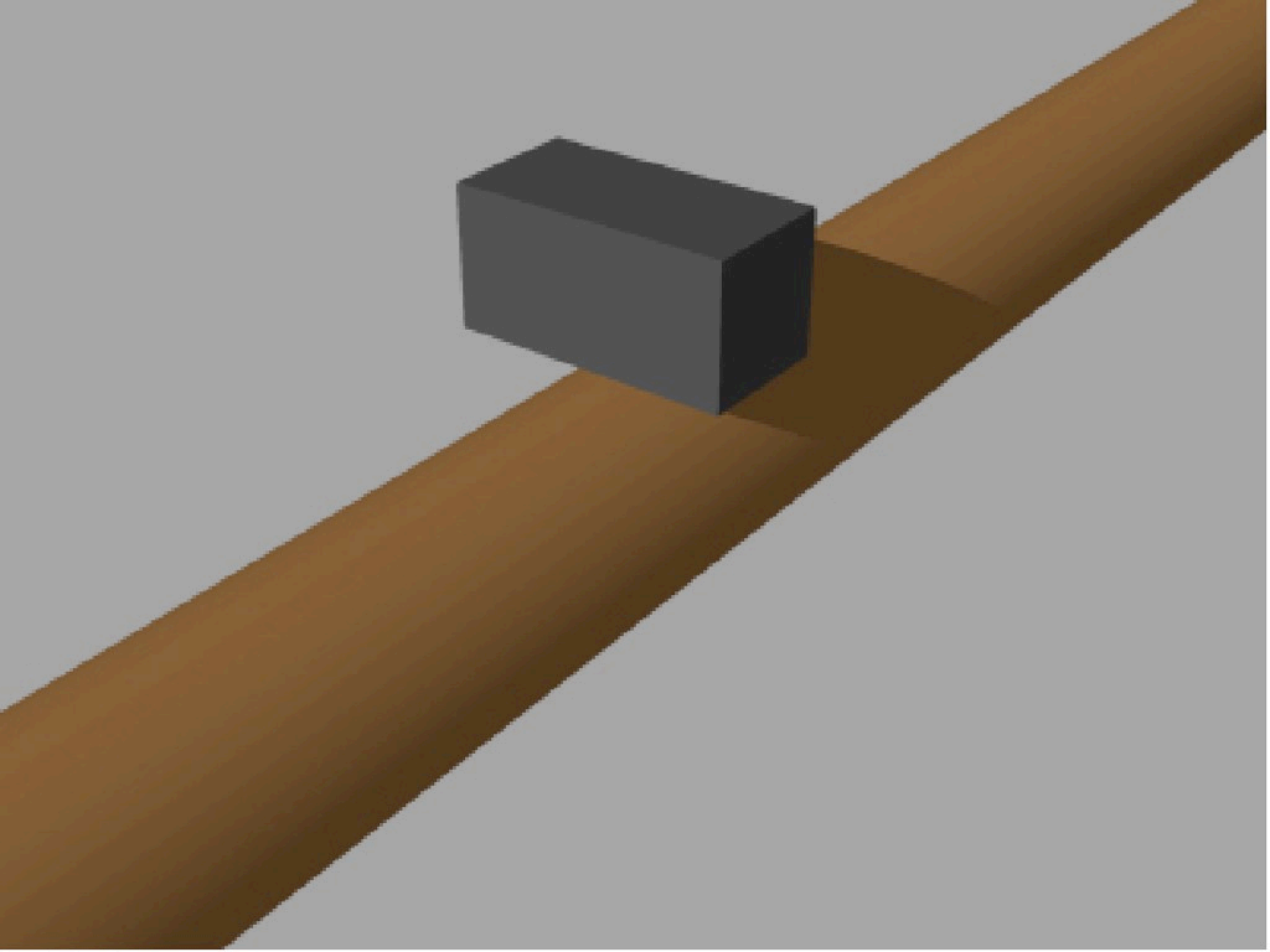
Building a hammer

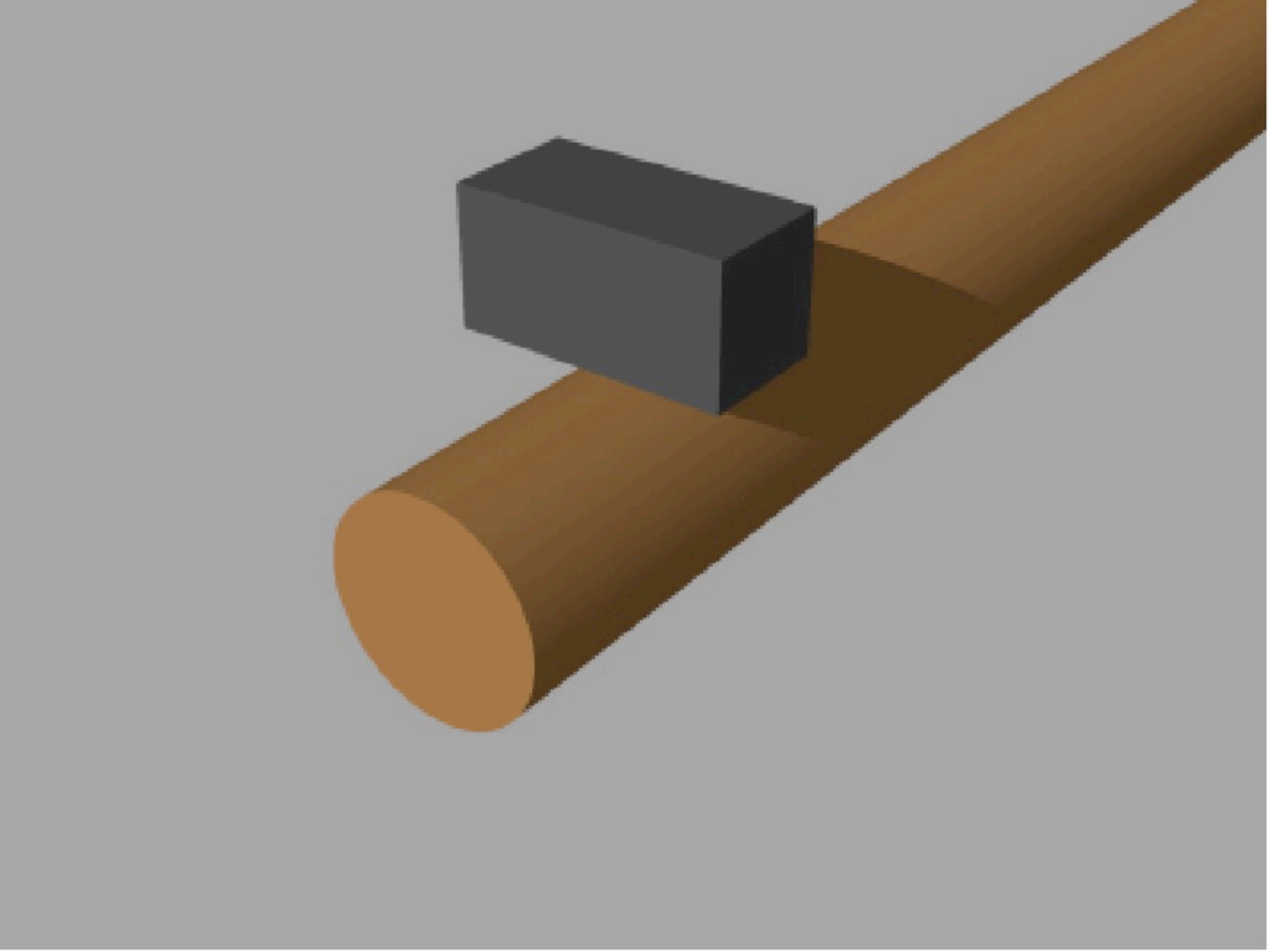
Demonstration of CSG modelling by David Mason (while a stage 4 student).

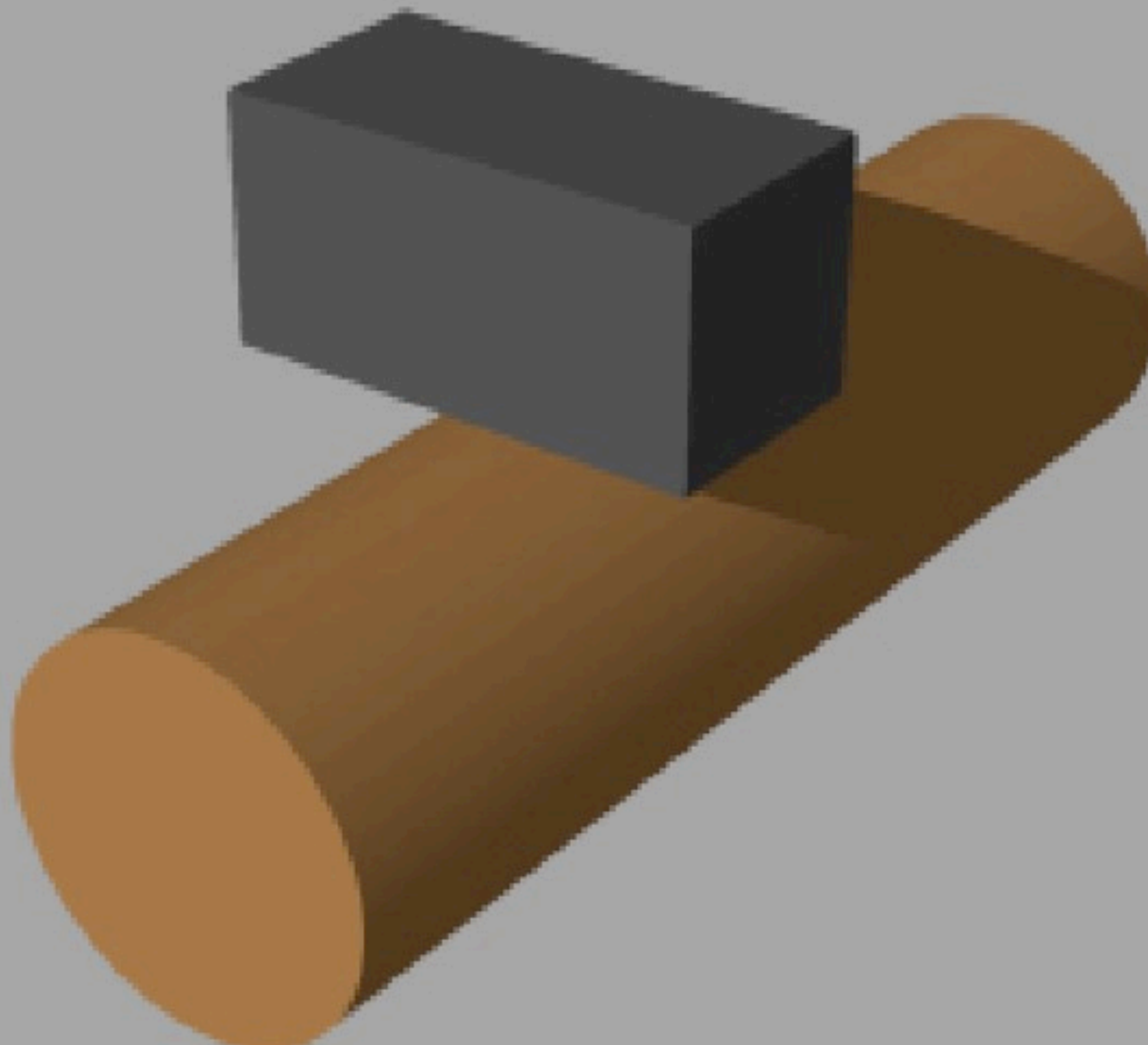


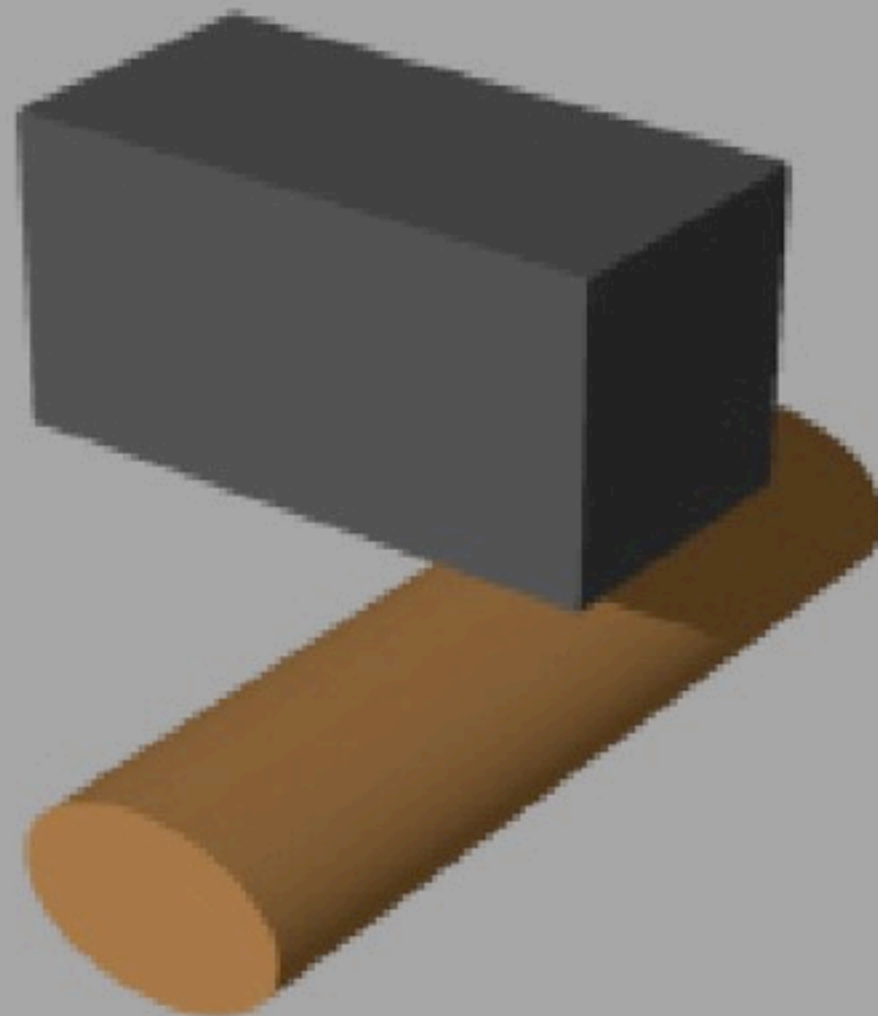


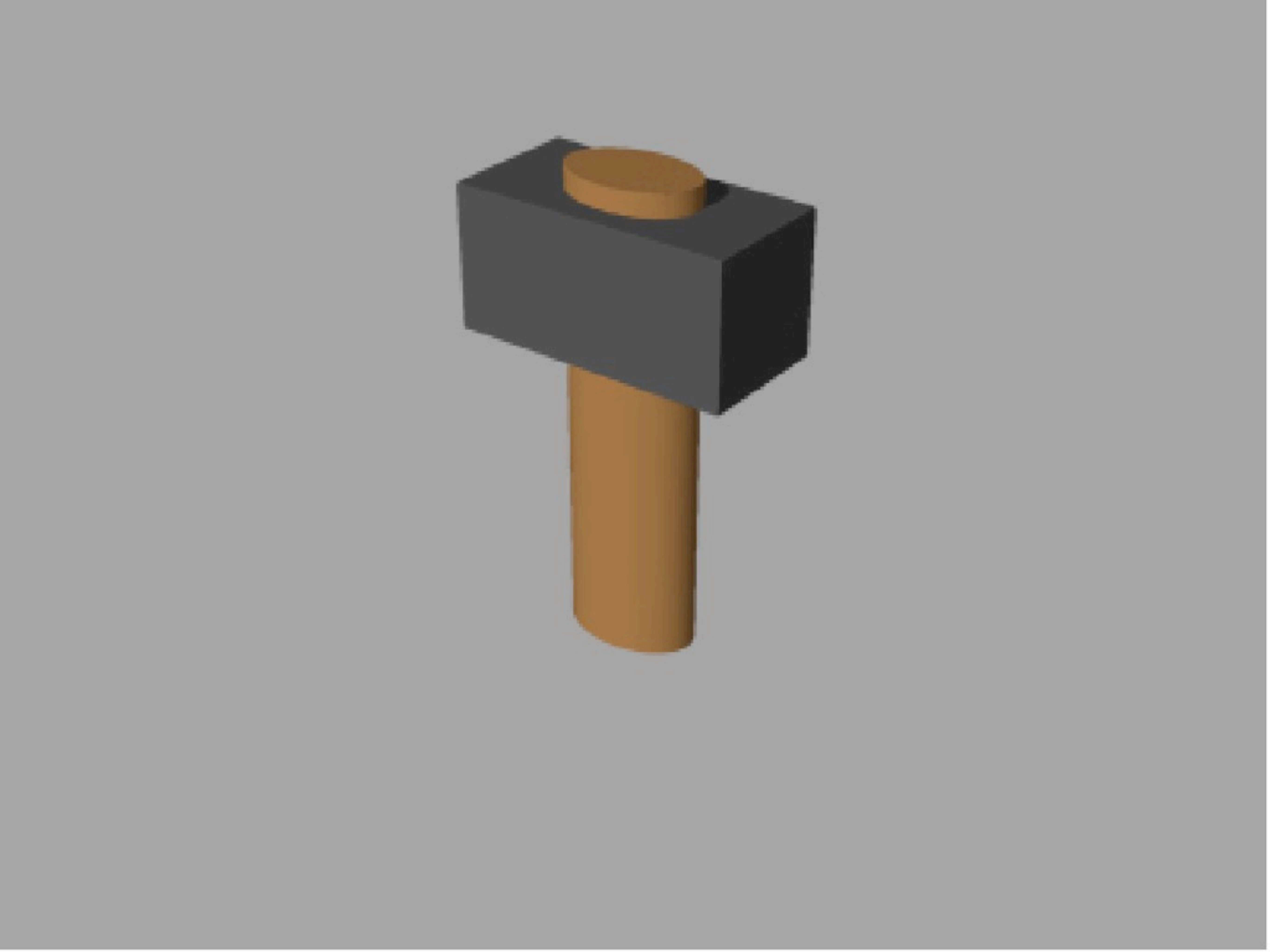




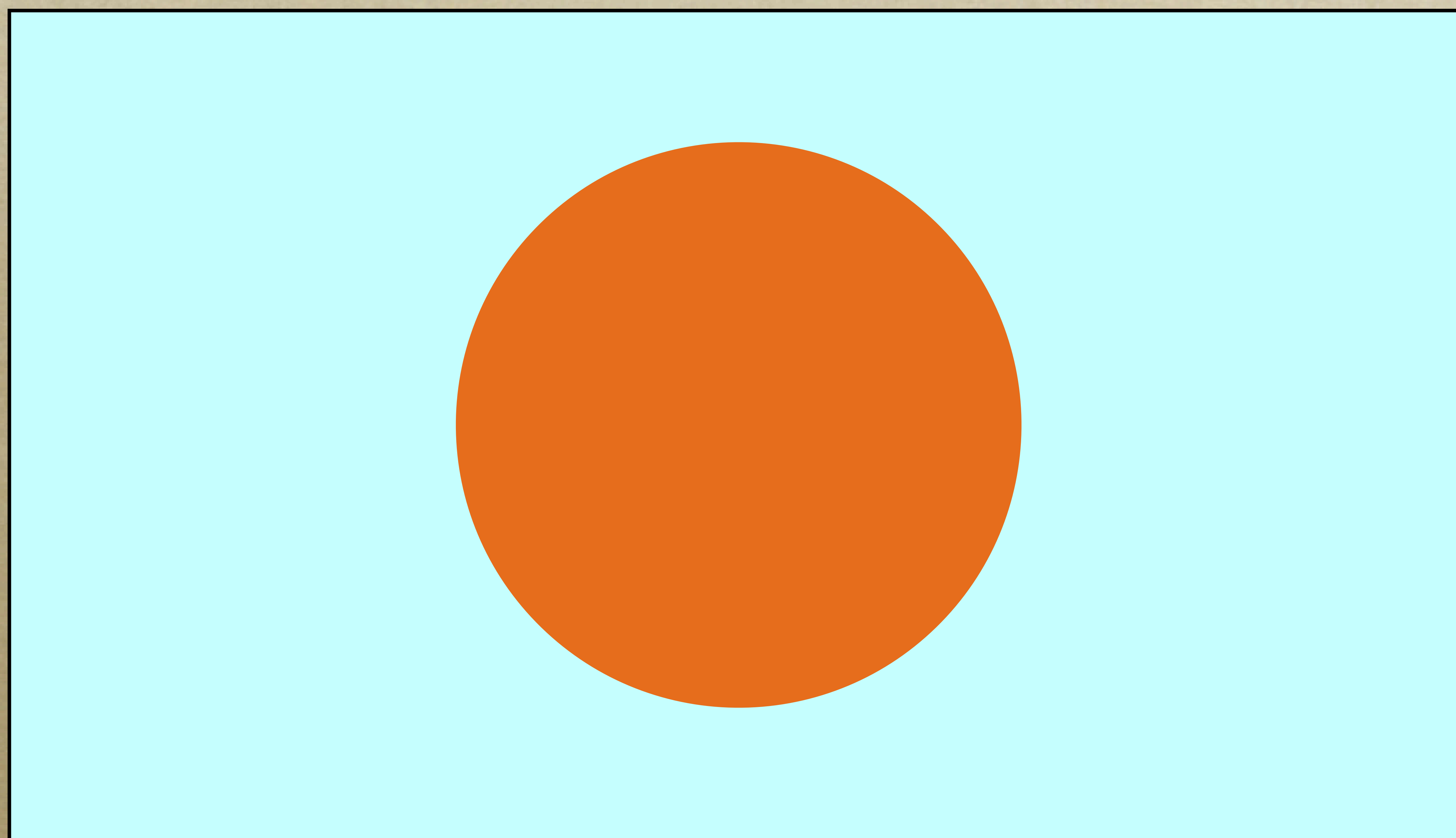




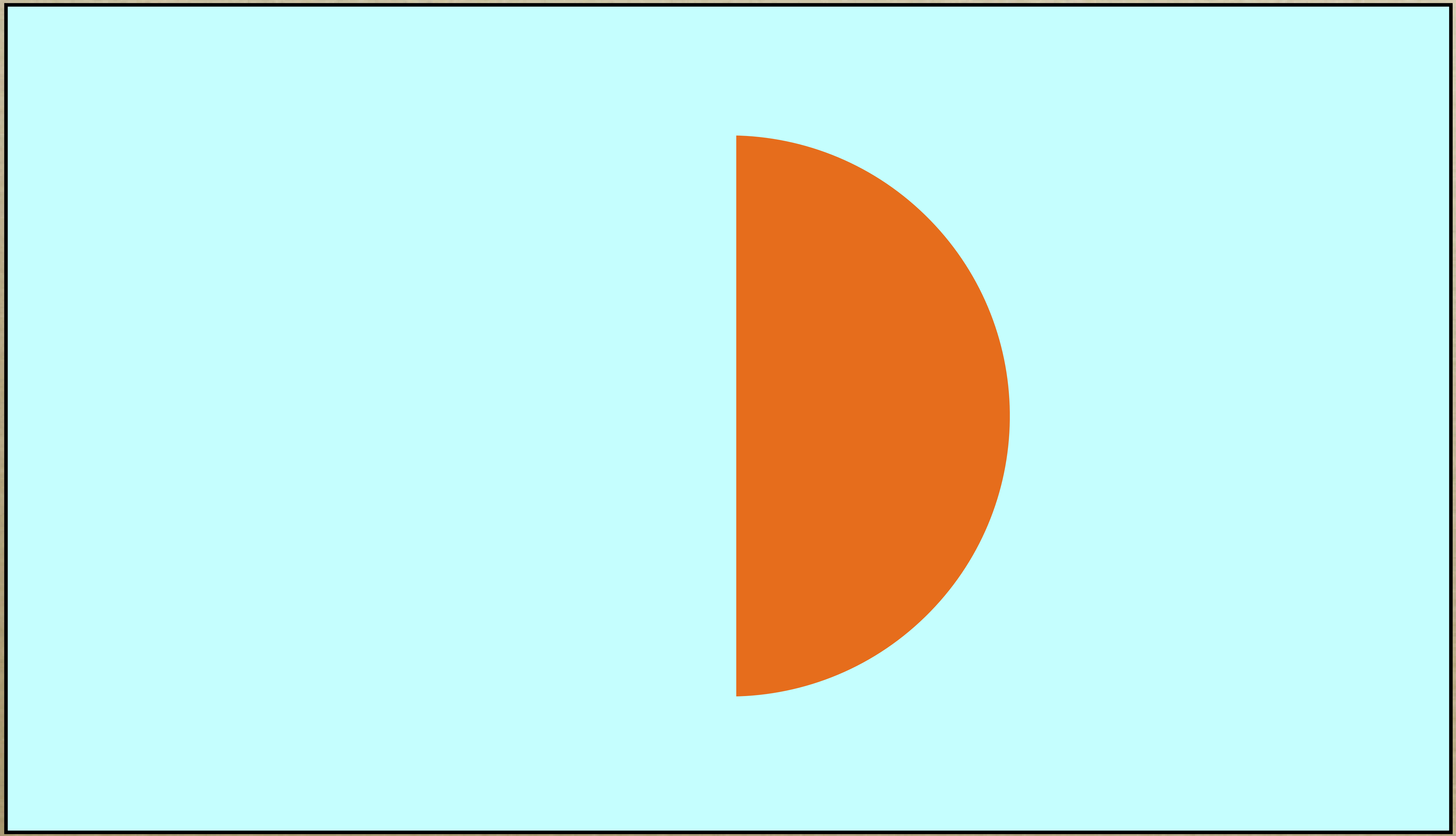




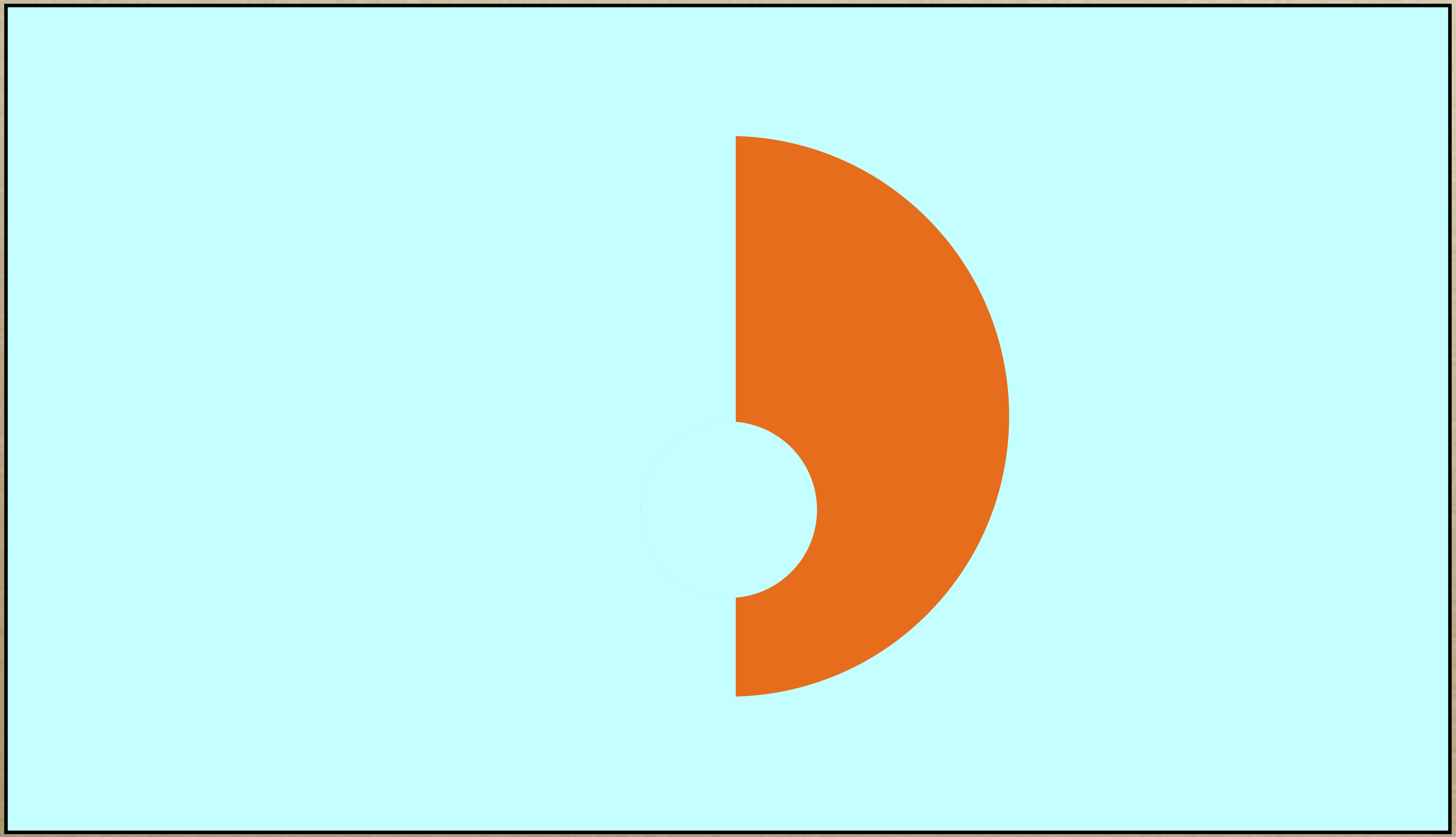
Direct ray tracing example



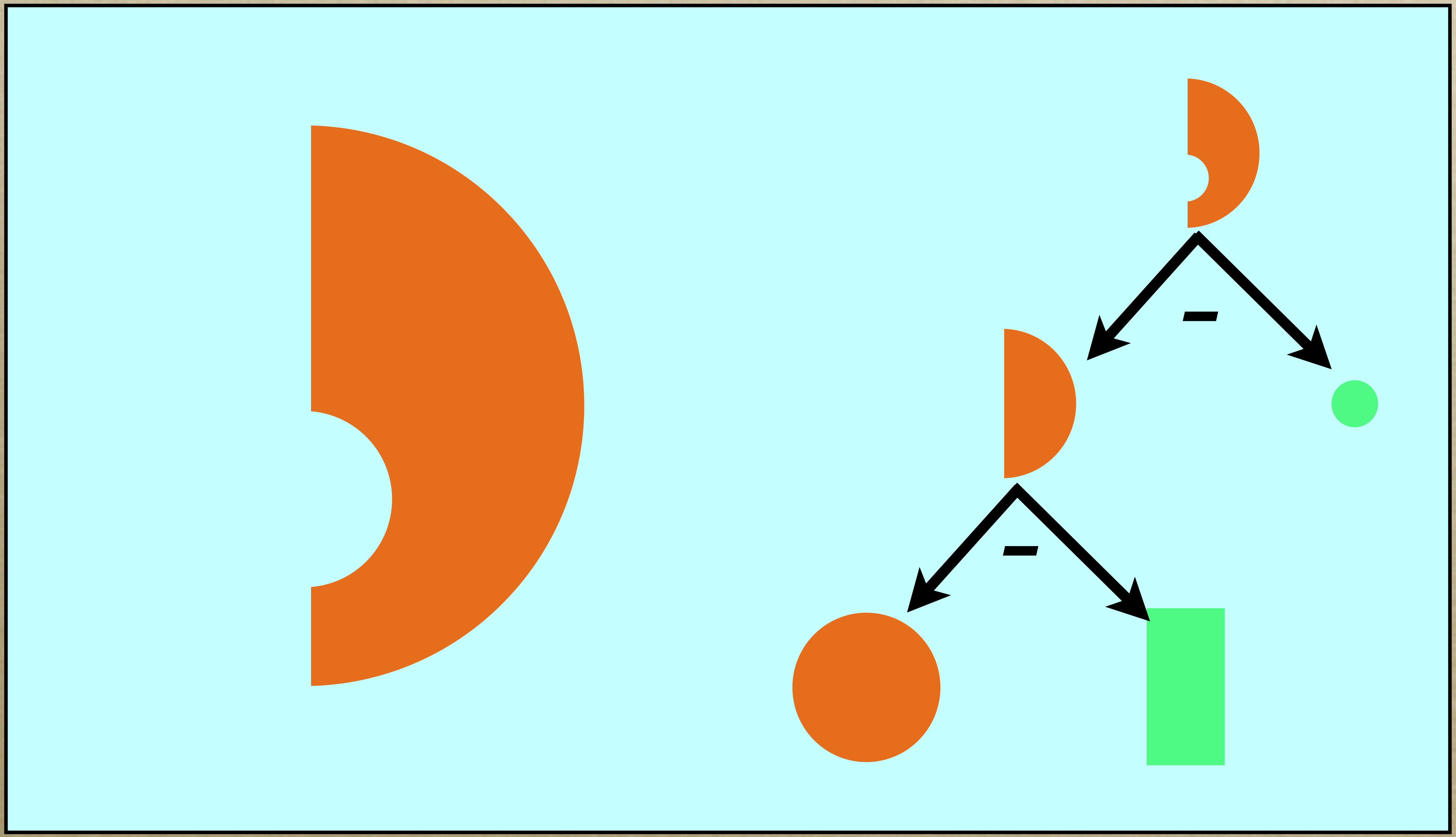
Direct ray tracing example



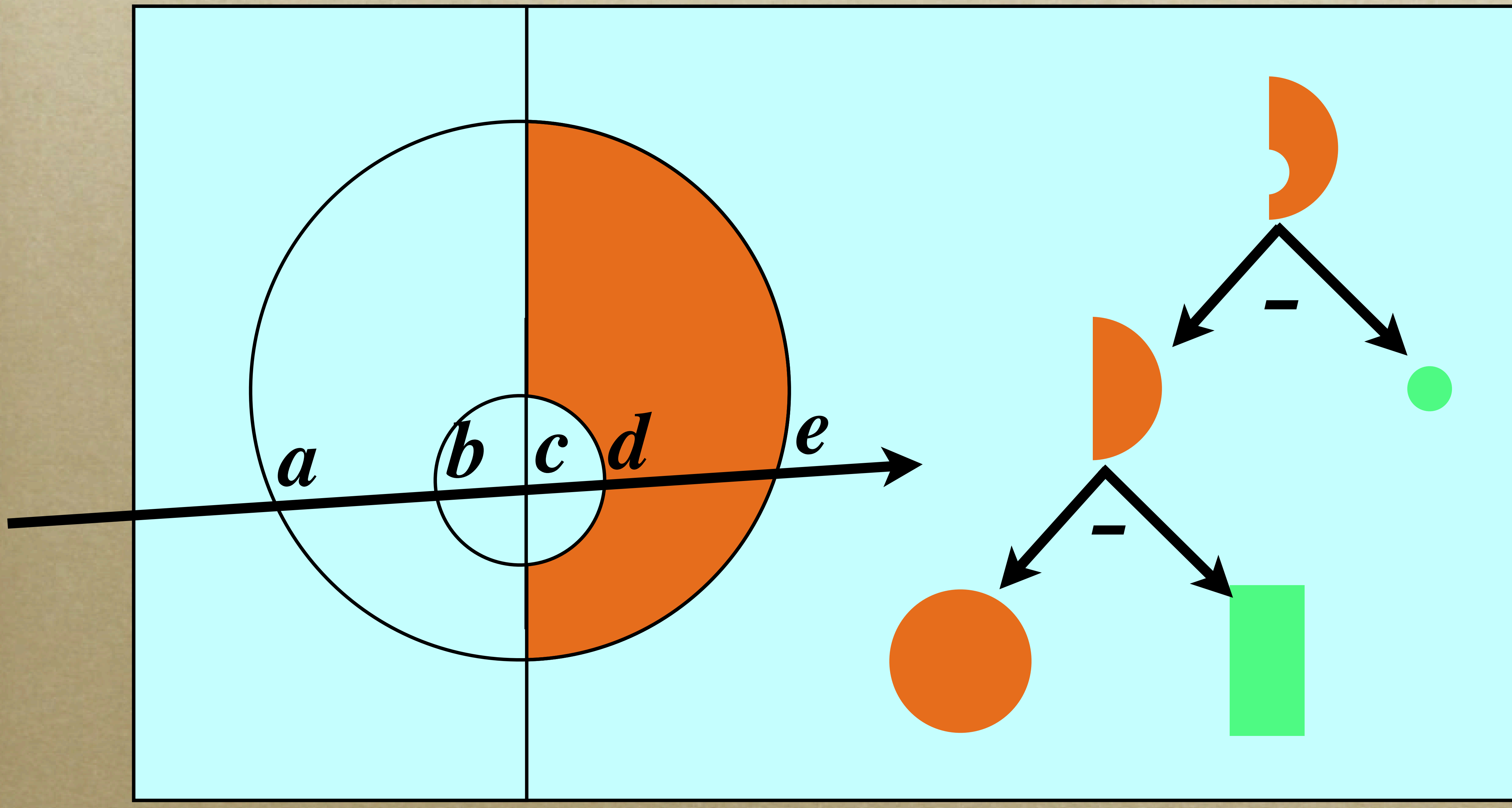
Direct ray tracing example



Object and CSG 'tree'



Classifying the ray



Classification at *subtract* node

Right / *Left*	*In*	*Out*	*Border*
In	*Out*	*In*	*Border*
Out	*Out*	*Out*	*Out*
Border	*Out*	*Border*	

Classification at *add* node

Left \ *Right*	*In*	*Out*	*Border*
In	*In*	*In*	*In*
Out	*In*	*Out*	*Border*
Border	*In*	*Border*	

Pros and cons

\+ *Create engineering objects easily*

\+ *Directly ray traceable*

\+ *Can be used for volume properties*

\- *Difficult to make free form shapes*

Subdivision surfaces

- *A recursive approach to adding detail*
- *E.g. Catmull-Clark mesh subdivison: (steps are only sketched out here)*
  - *Add a point at centroid of each face*
  - *Add new 'average' edge points*
  - *'Smooth out' original vertices*
- *In the limit, a cube becomes a sphere*

Implicit surfaces

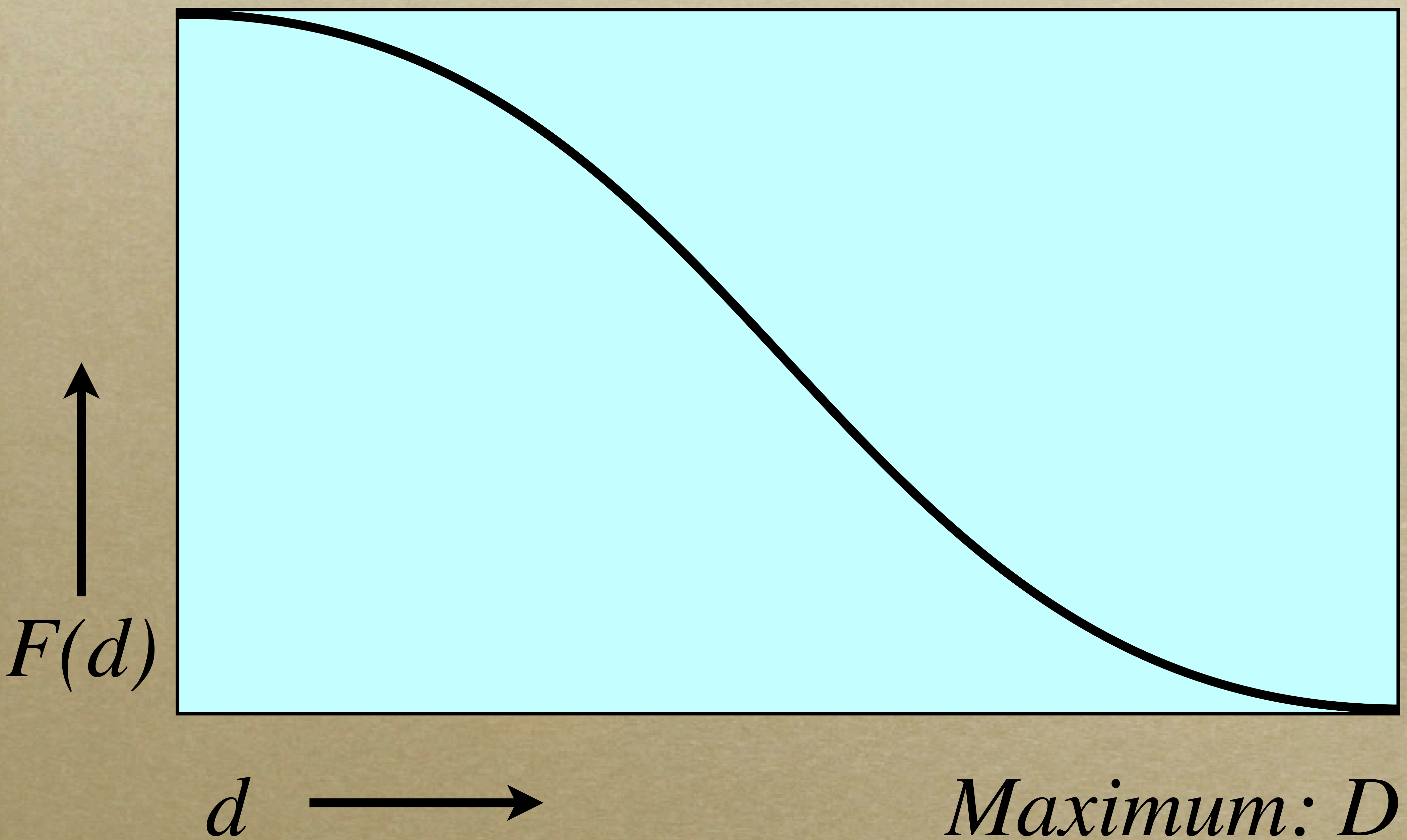
Instead of $\mathbf{p} = (F_x(s, t), F_y(s, t), F_z(s, t))$

use $\mathbf{p}$ *such that* $F(\mathbf{p}) = k$

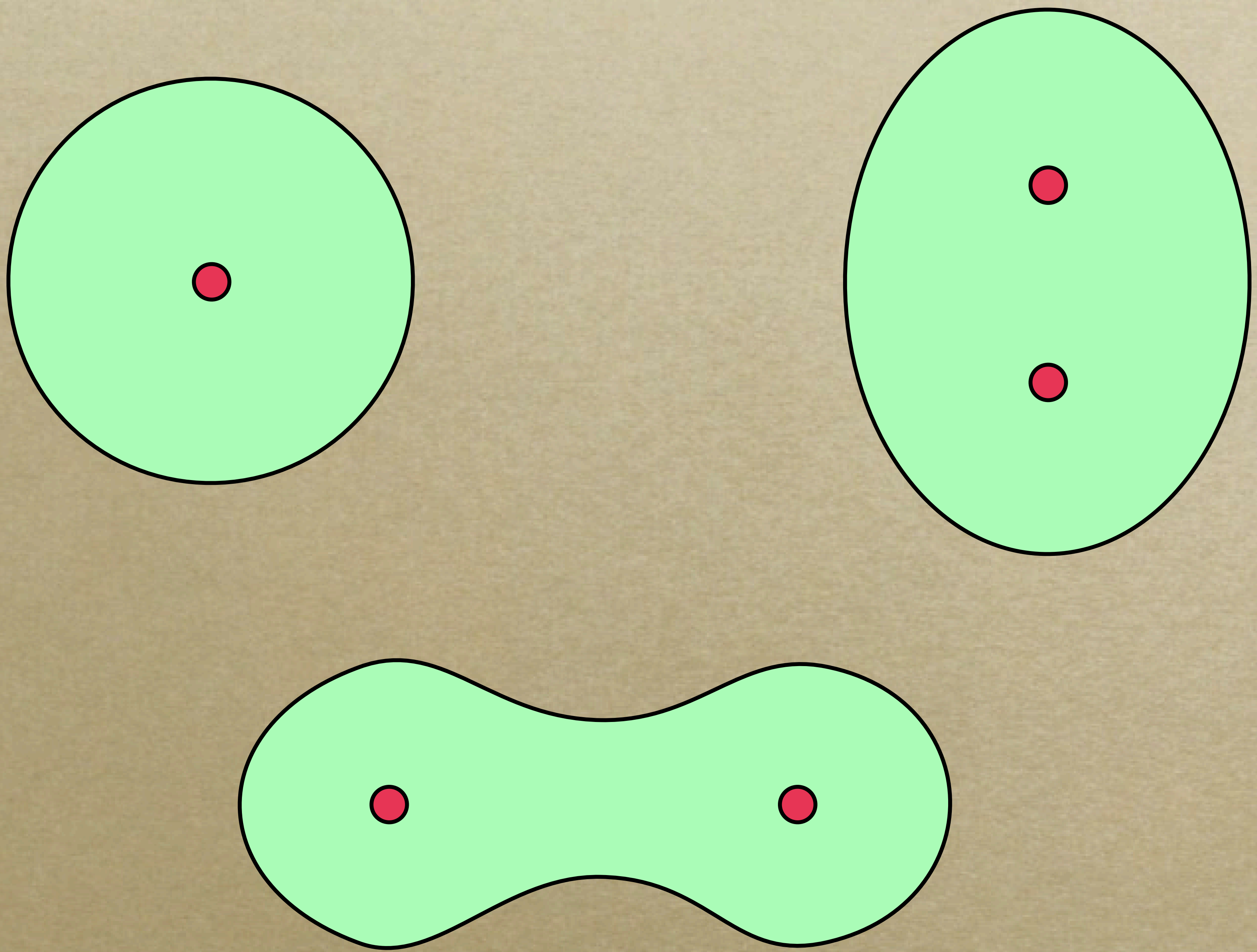
E.g: $\mathbf{p}^2 = 1$ *is a sphere*

Typically make F a function of distance

Field function

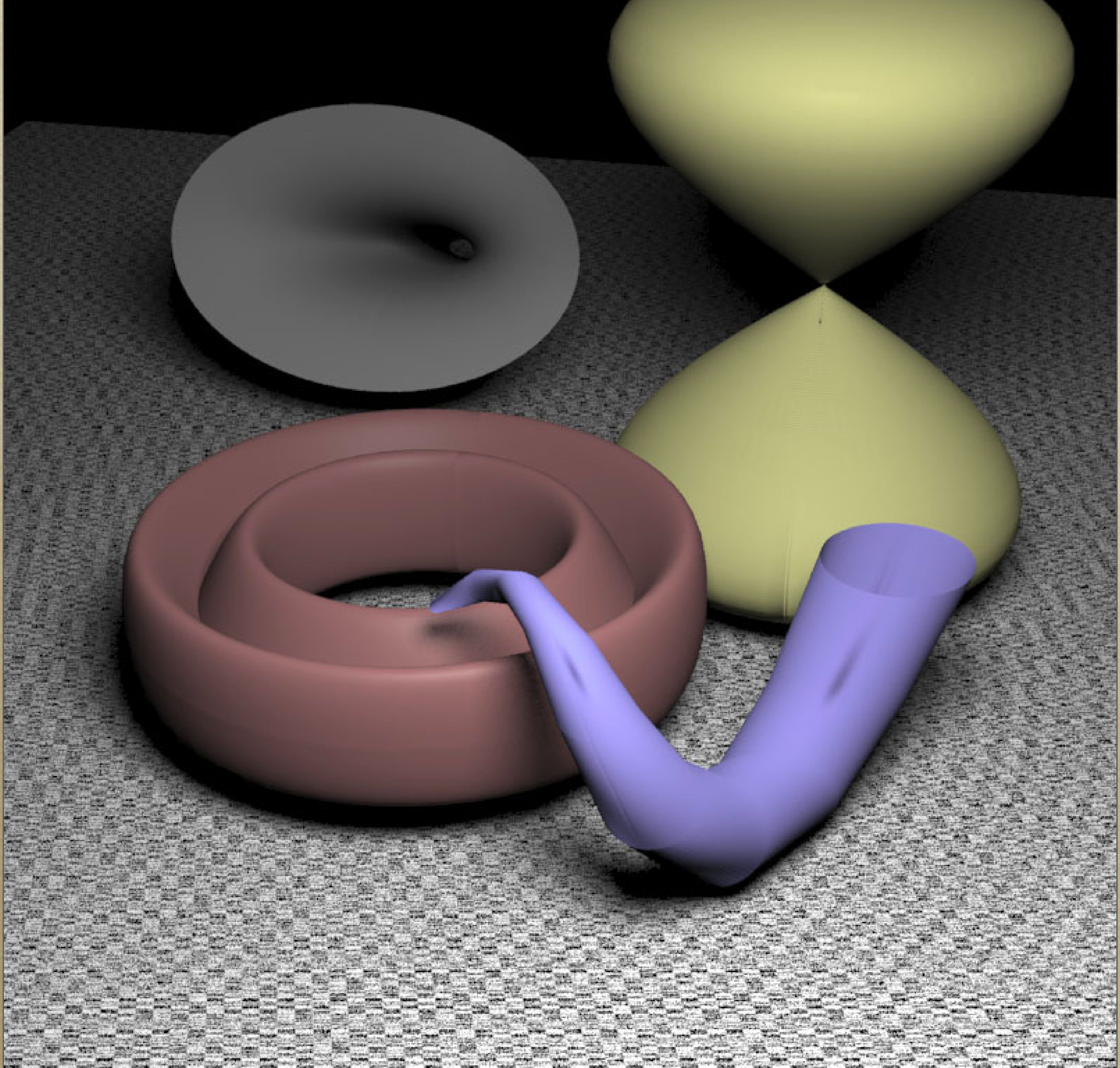


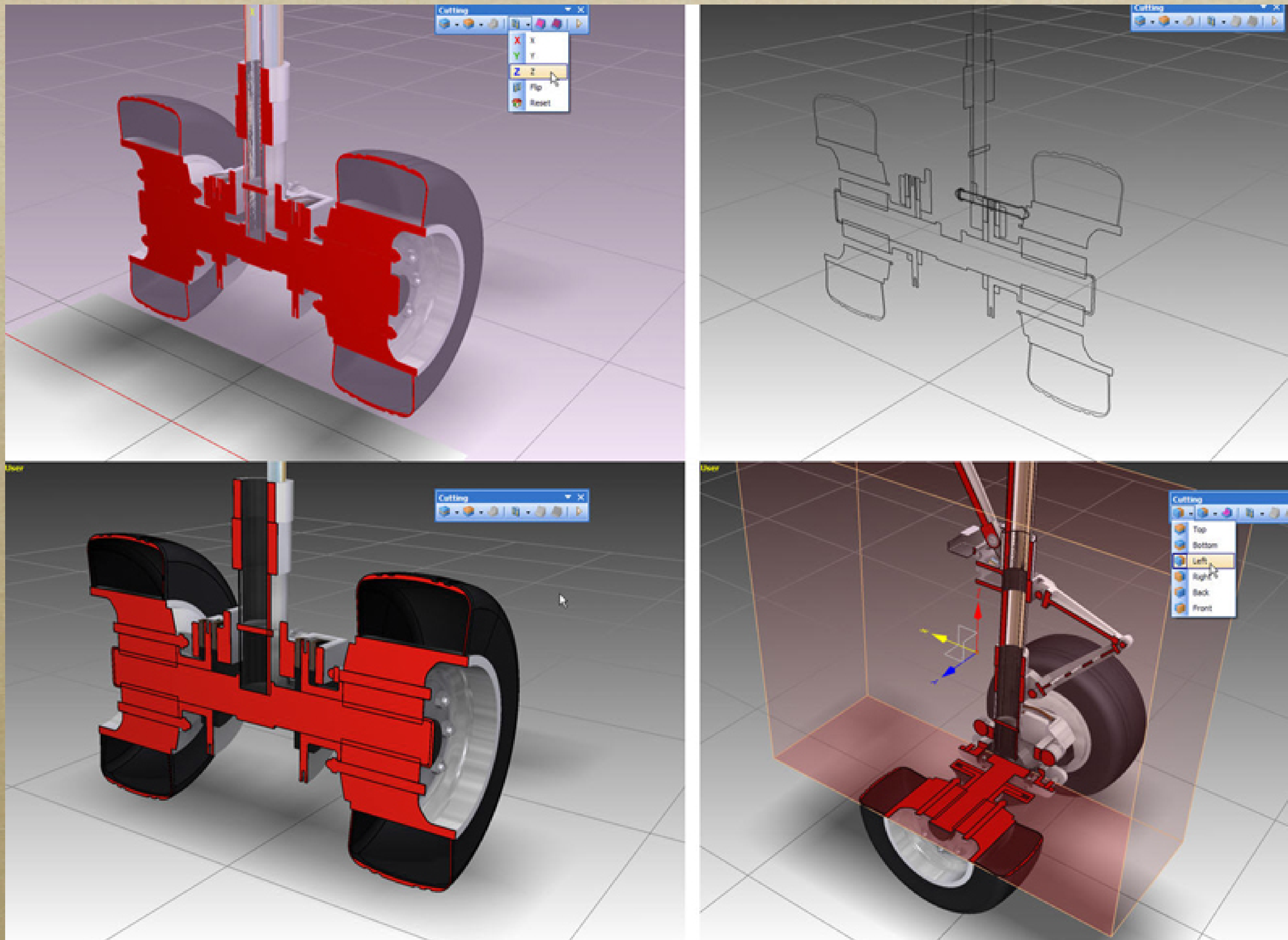
Skeleton of points

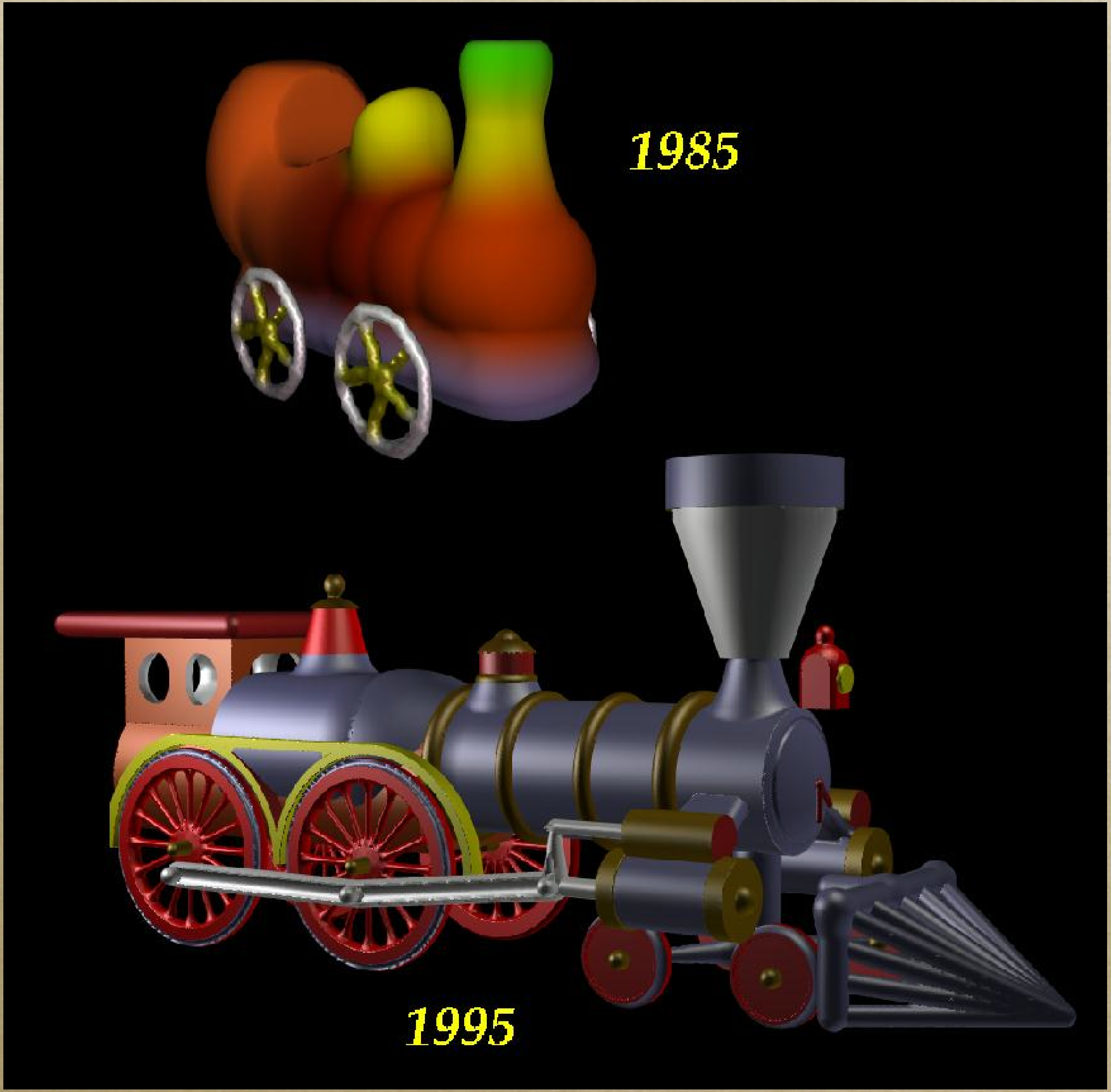


Pros and cons

+ *Intuitive construction*
+ *guaranteed inside/outside - no holes*
+ *ray traceable*
+ *change topology*
- *no obvious way to draw surface*
- *design seems to be by black art*




Cutting
Flip
Reset
Top
Bottom
Left
Right
Back
Front


1985
1995