

# Parametric 3D CAD with OpenSCAD

*or...* Drawing 3D objects with code

Graham Klyne, @gklyne

# Install and start OpenSCAD

- Web site:
  - <http://www.openscad.org/>
- Manual:
  - [http://en.wikibooks.org/wiki/OpenSCAD\\_User\\_Manual](http://en.wikibooks.org/wiki/OpenSCAD_User_Manual)

# Key features

- Parametric
  - Users of objects define dimensions and features
  - A single design can be realized for different uses
  - Designs can be adjusted to use available materials
- Coding not drawing
  - Algorithmic specification of complex shapes
    - e.g. teeth on a gear
  - Errors can be corrected by changing the code
  - Build new designs on shared materials
  - Not necessarily for everyone

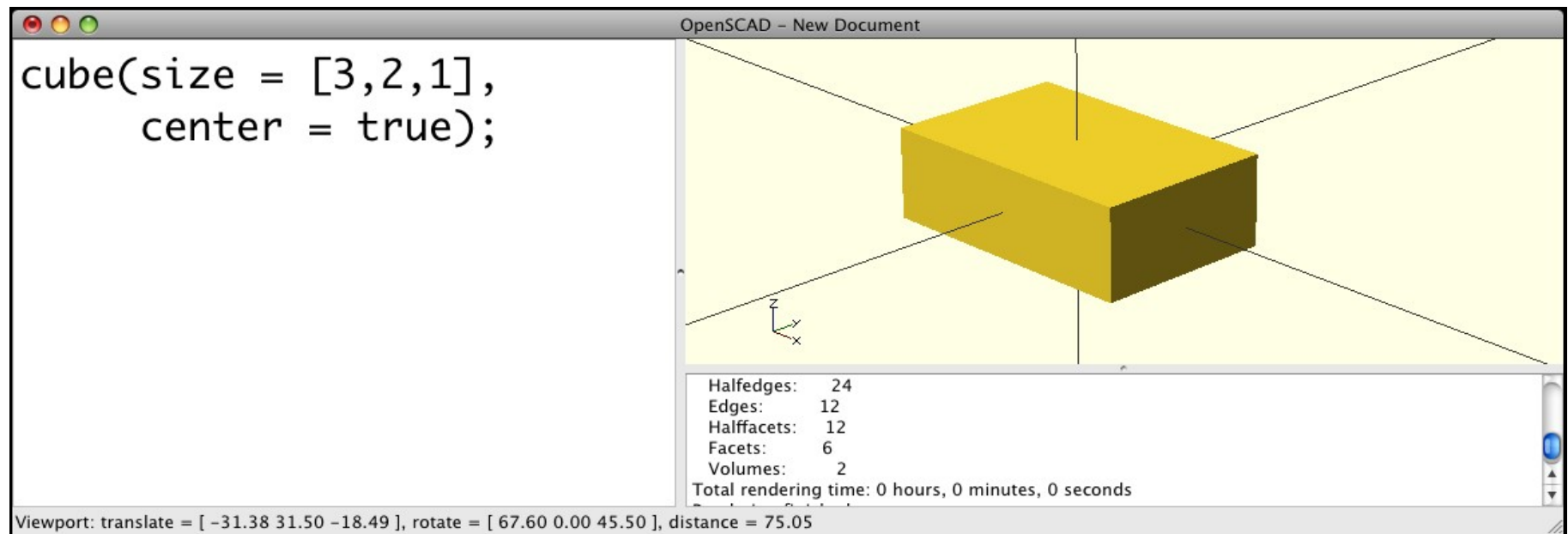
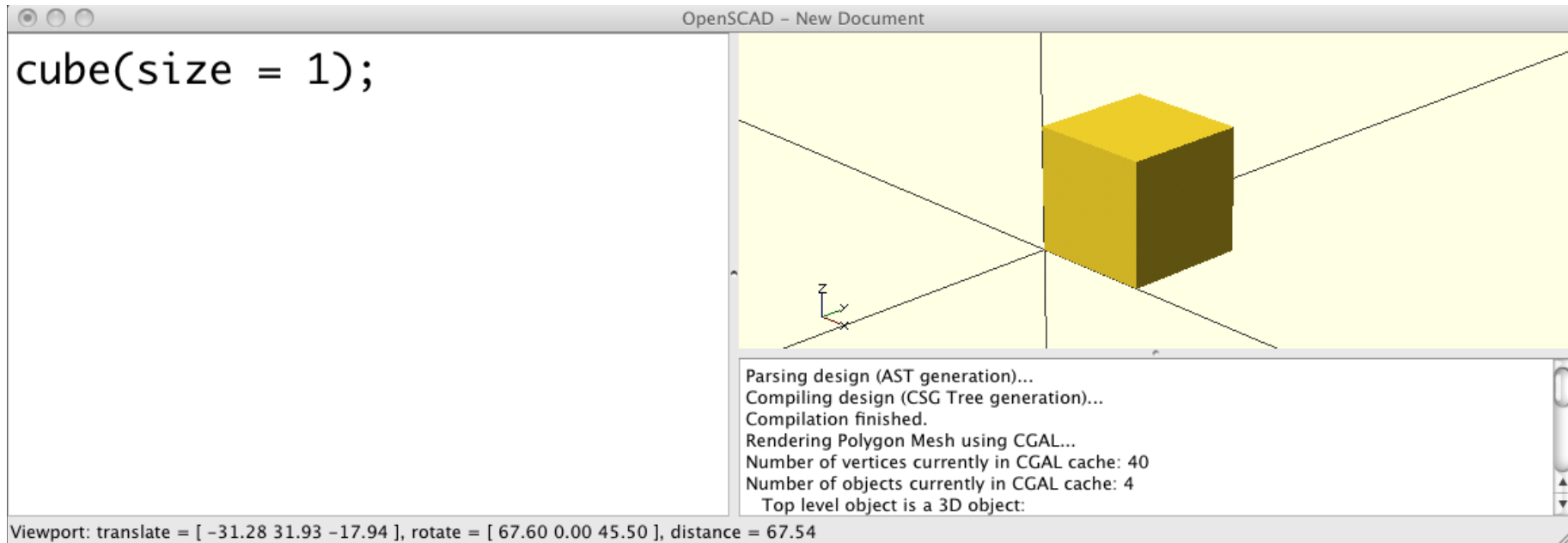
# Viewport survival guide

- Quick display update: F5
- Full recompute and display update: F6
- View > Show axes: COMMAND/2
- Pan view:
  - Right-drag
- Zoom view:
  - Scroll-wheel, or “+”, “-”
- Change text size:
  - COMMAND/“+”, COMMAND/“-”

# Primitive solid shapes

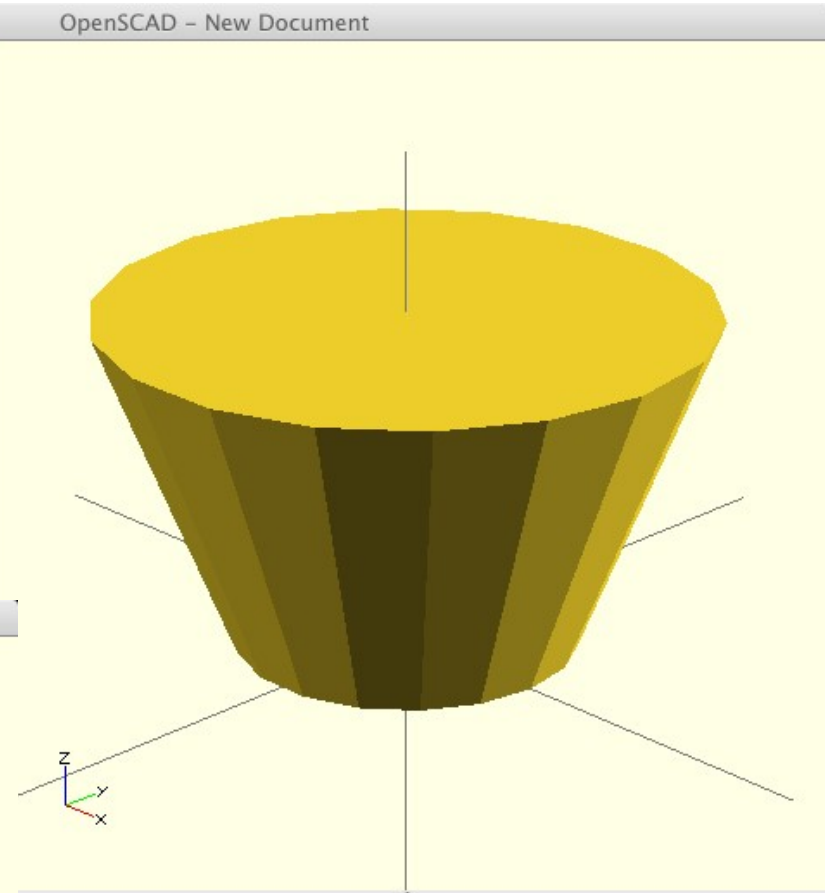
- Cube / cuboid
- Cylinder/cone
- Sphere
- *Also, general polyhedron and extruded -D shapes are possible, but I won't go into that.*

# Cube / cuboid



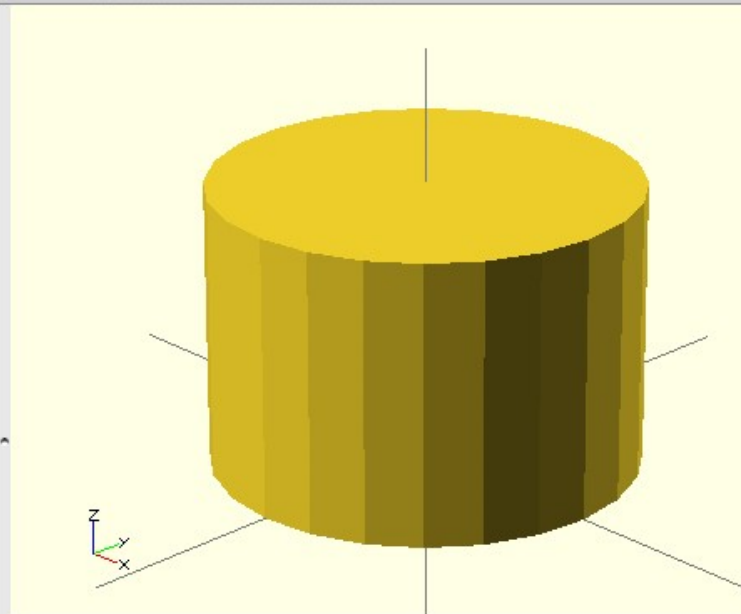
# Cylinder and cone

```
cylinder(  
  h = 20,  
  r1 = 10,  
  r2 = 18,  
  $fa= 20);
```



Number of vertices currently in CGAL cache: 120  
Number of objects currently in CGAL cache: 25  
Top level object is a 3D object:  
Simple: yes  
Valid: yes  
Vertices: 36  
Halfedges: 140  
Edges: 70  
Half facets: 72  
Facets: 36  
Volumes: 2  
Total rendering time: 0 hours, 0 minutes, 0 seconds  
Rendering finished.

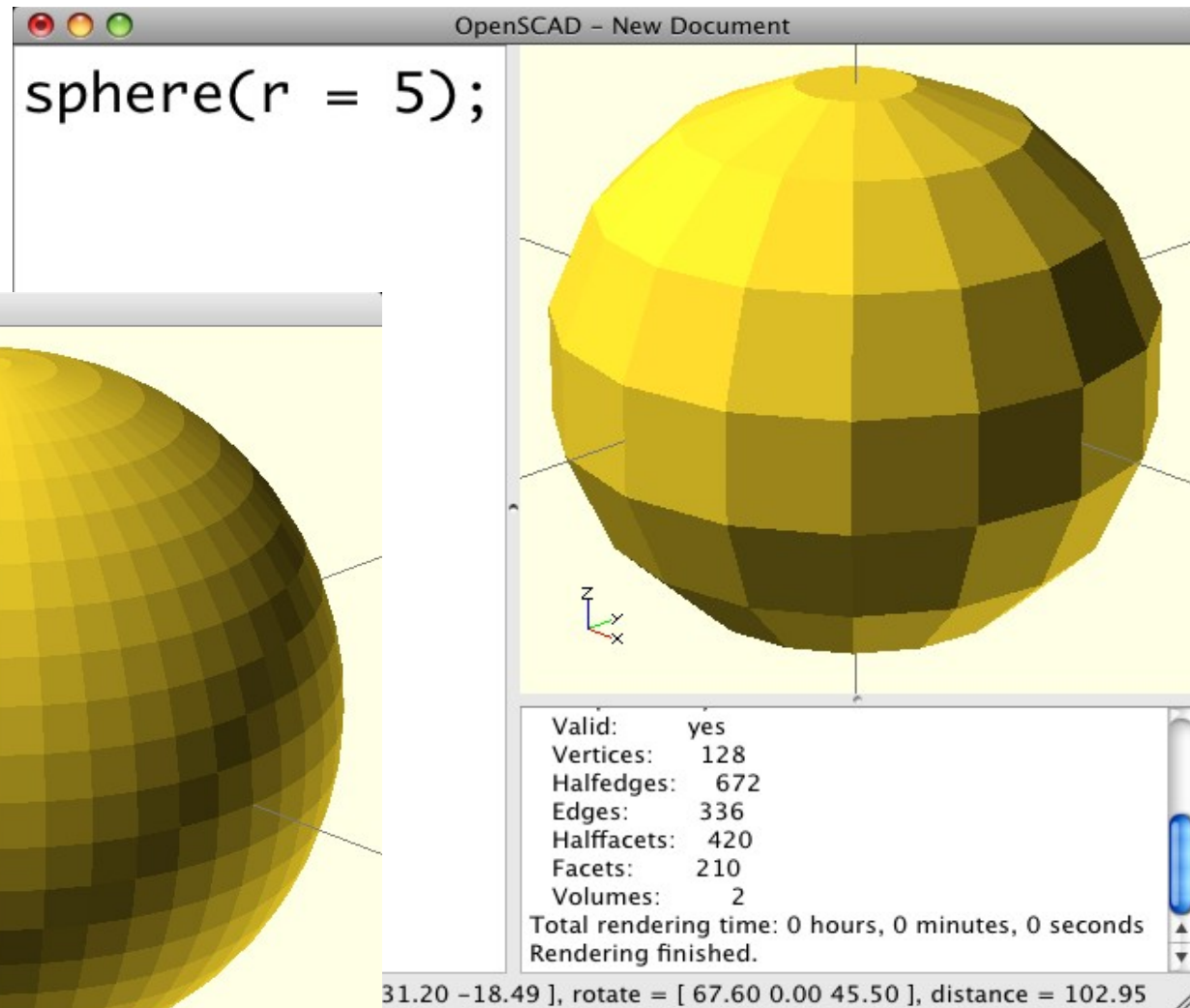
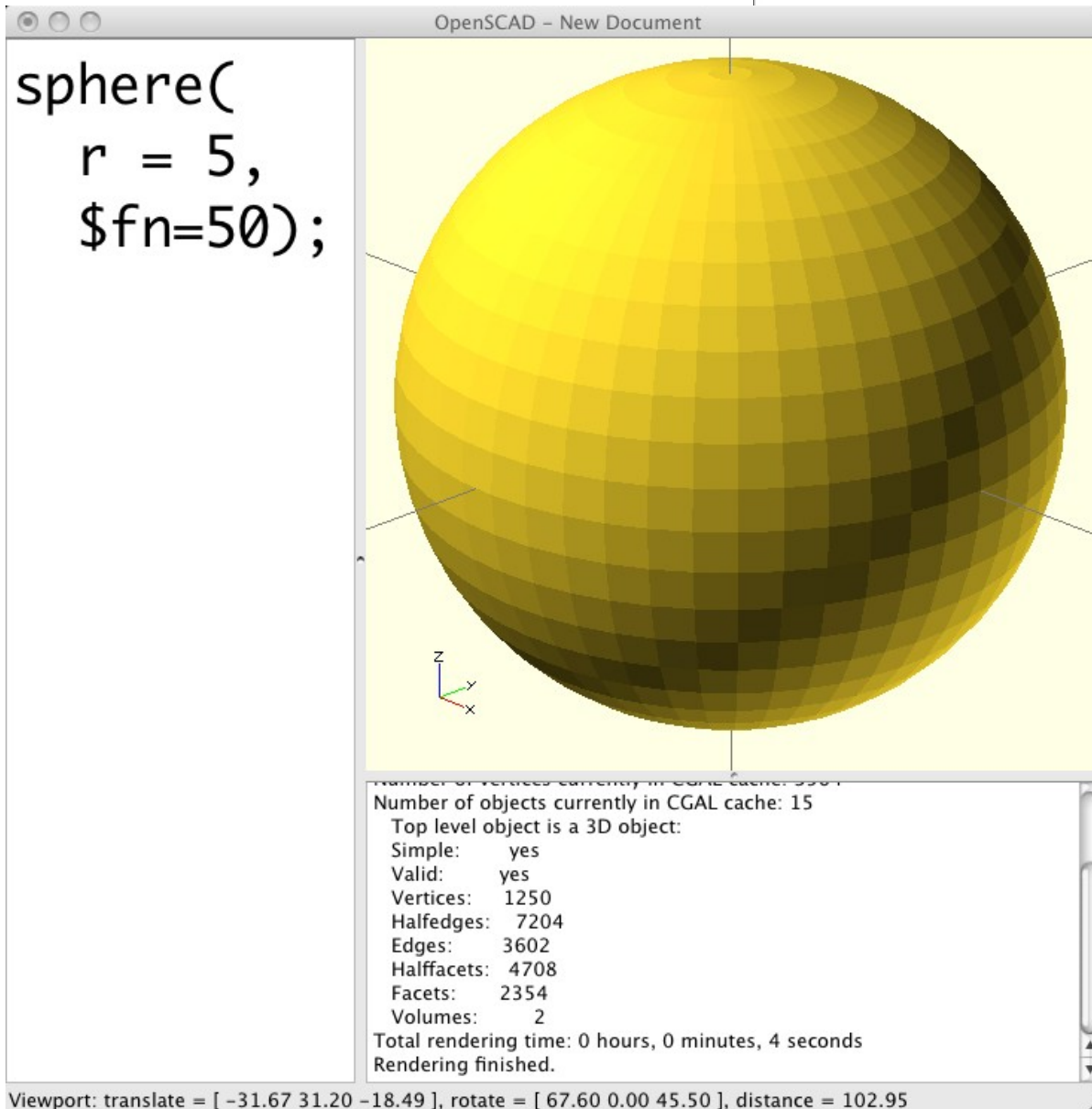
```
cylinder(  
  h = 20,  
  r = 15,  
  $fs= 2);
```



Number of vertices currently in CGAL cache: 31  
Top level object is a 3D object:  
Simple: yes  
Valid: yes  
Vertices: 48  
Halfedges: 144  
Edges: 72  
Half facets: 52  
Facets: 26

Viewport: translate = [ -34.40 33.89 -9.21 ], rotate = [ 67.60 0.00 45.50 ], distance = 295.25

# Sphere

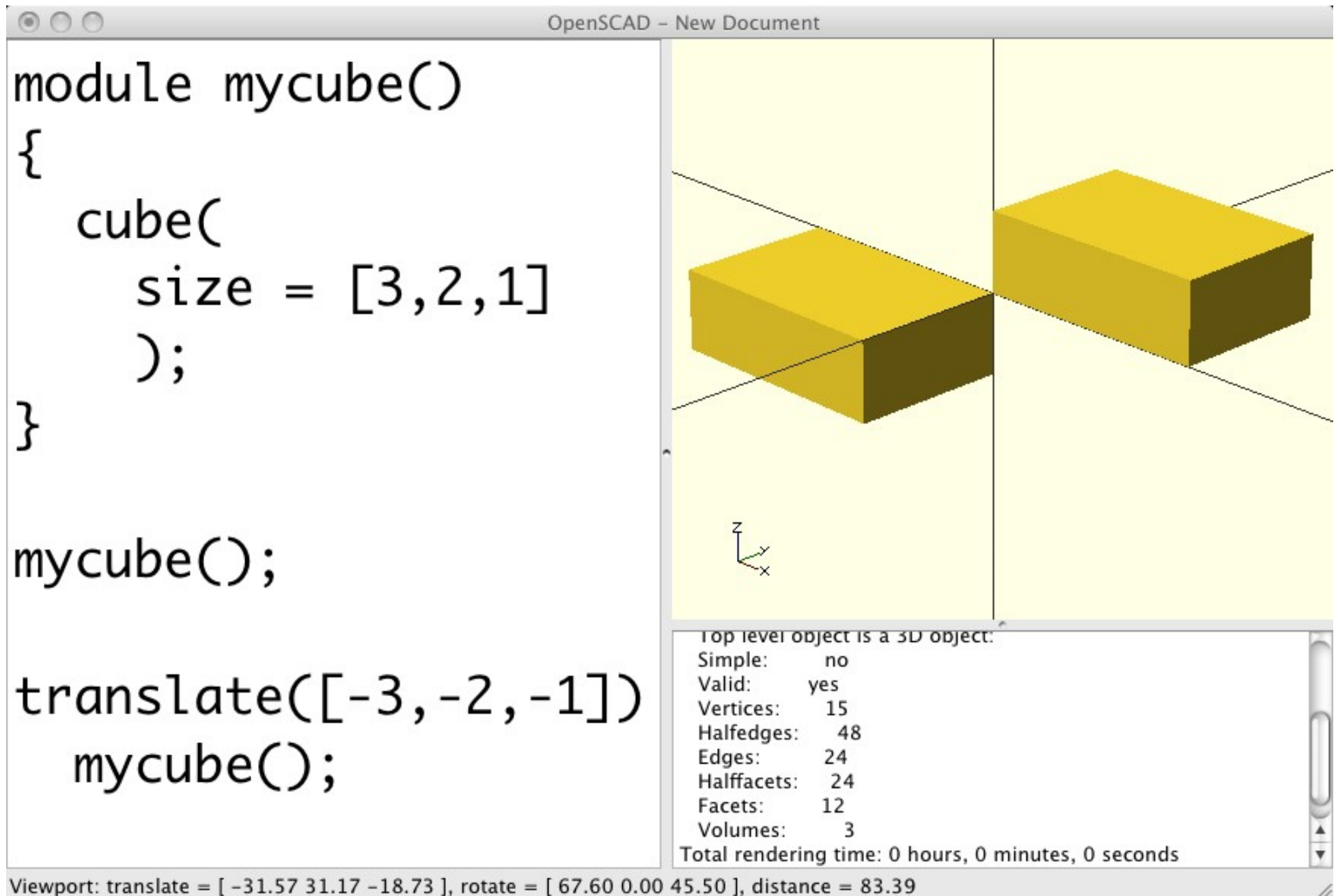




# Transformations

- Translate (move)
- Rotate

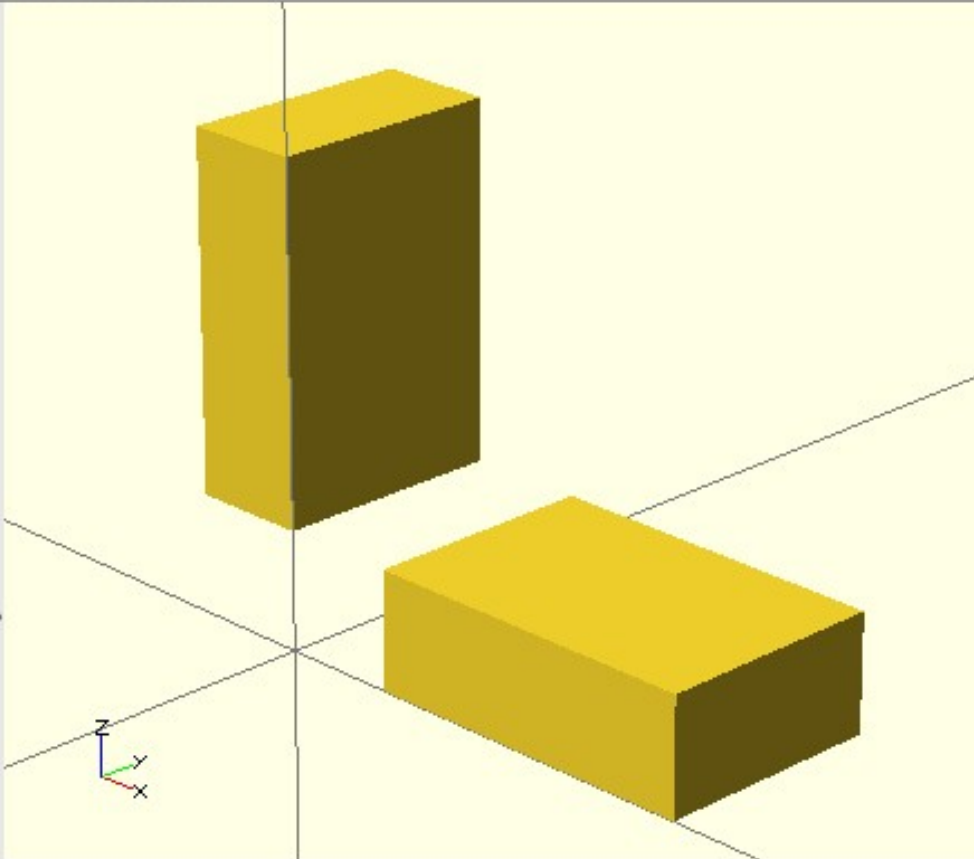
# Translate



# Rotate

OpenSCAD - New Document

```
module mycube()  
{  
  translate([1,0,0])  
  cube(  
    size = [3,2,1]  
  );  
}  
  
mycube();  
  
rotate([0,-90,0])  
  mycube();
```



Simple: yes  
Valid: yes  
Vertices: 16  
Halfedges: 48  
Edges: 24  
Halfacets: 24  
Facets: 12  
Volumes: 3  
Total rendering time: 0 hours, 0 minutes, 0 seconds  
Rendering finished.

Viewport: translate = [ -31.14 32.74 -16.80 ], rotate = [ 67.60 0.00 45.50 ], distance = 83.39

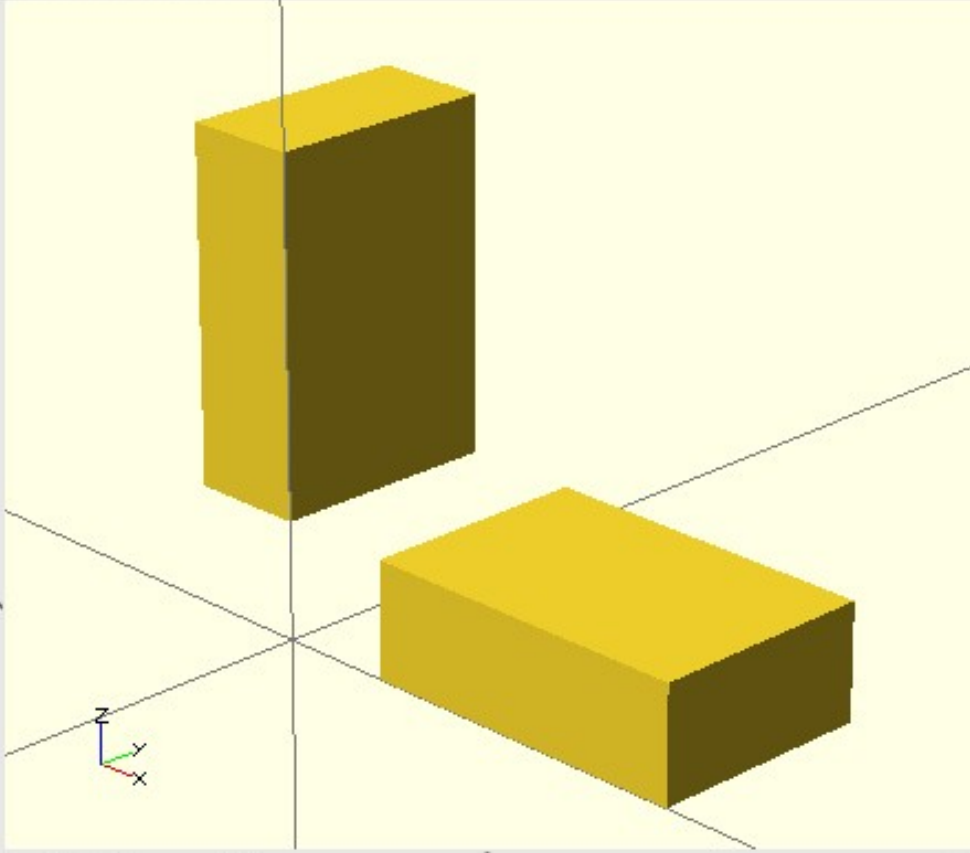
# Constructive Solid Geometry (CSG)

- Like 3D Venn Diagrams
- Boolean combinations of 3D objects
- Union
- Intersection
- Difference

# Union

OpenSCAD - New Document

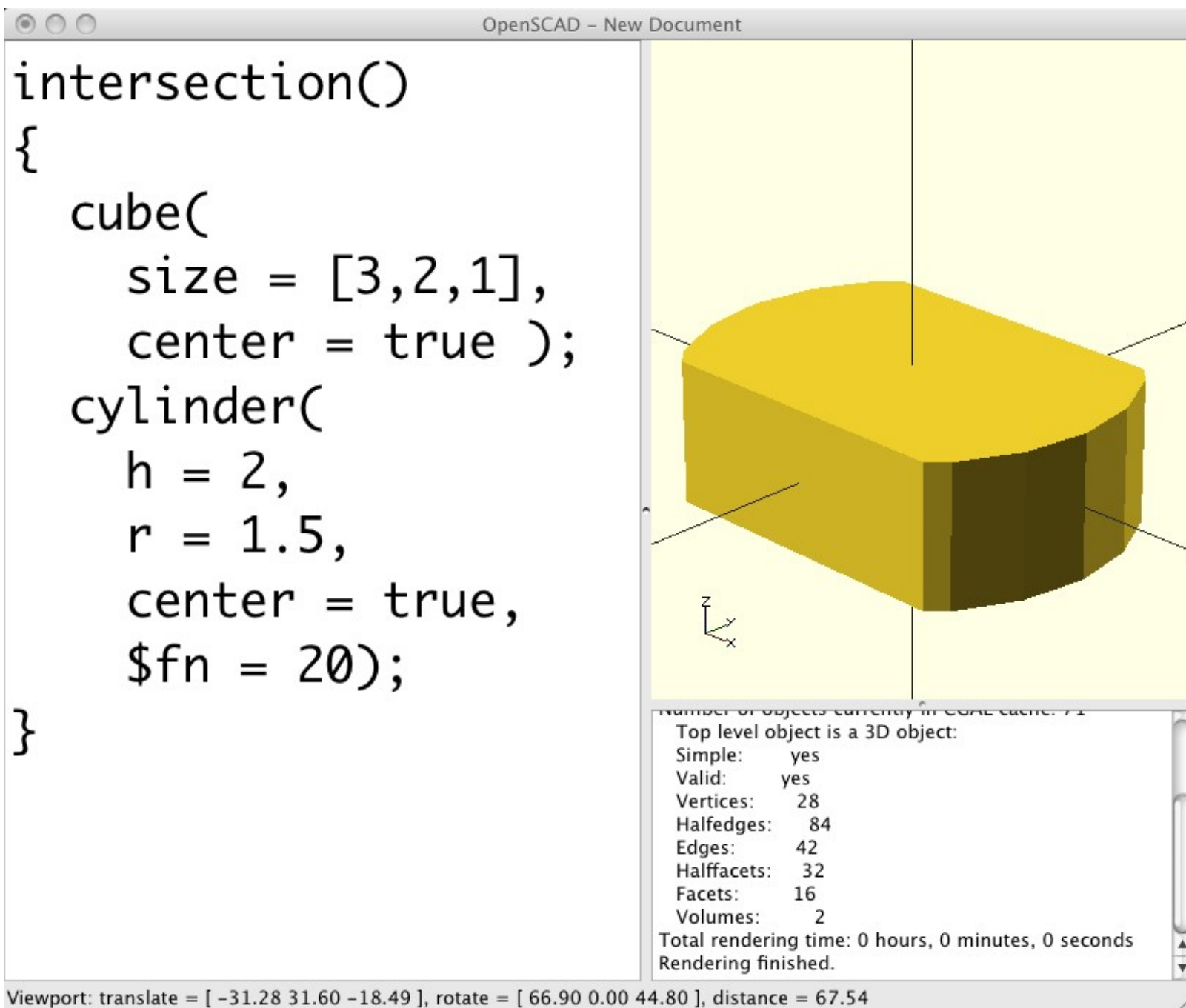
```
module mycube()  
{  
  translate([1,0,0])  
  cube(  
    size = [3,2,1]  
  );  
}  
  
mycube();  
  
rotate([0,-90,0])  
  mycube();
```



Simple: yes  
Valid: yes  
Vertices: 16  
Halfedges: 48  
Edges: 24  
Halfacets: 24  
Facets: 12  
Volumes: 3  
Total rendering time: 0 hours, 0 minutes, 0 seconds  
Rendering finished.

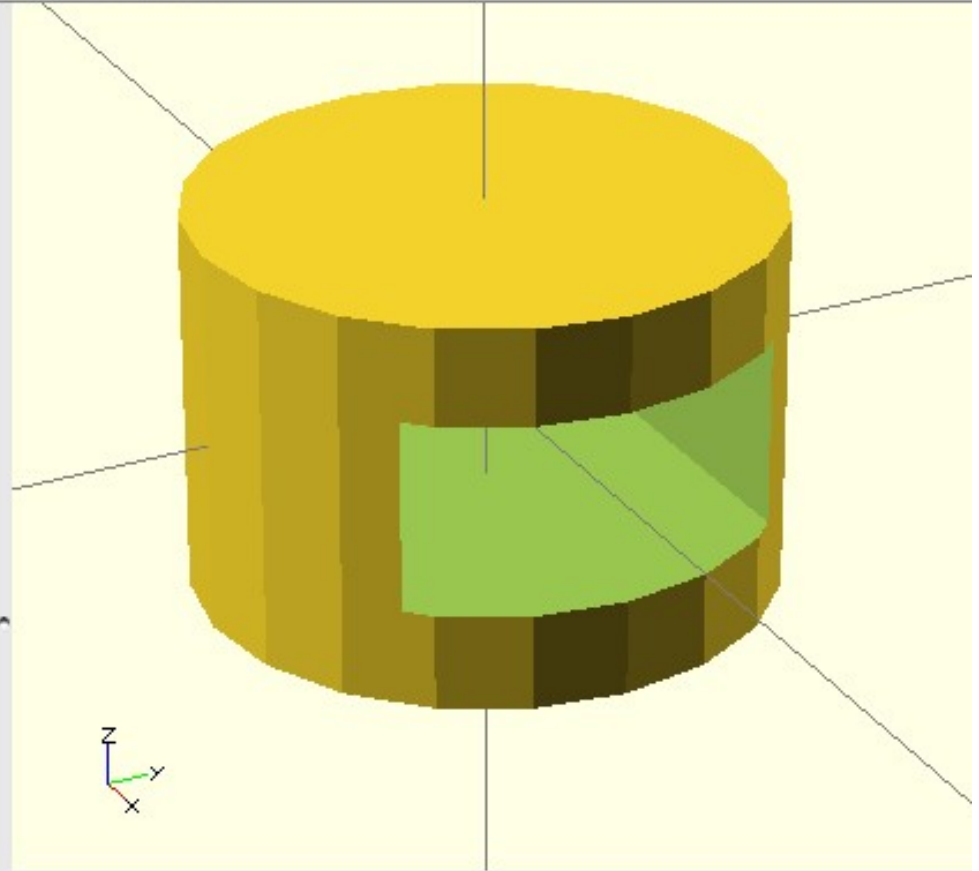
Viewport: translate = [ -31.14 32.74 -16.80 ], rotate = [ 67.60 0.00 45.50 ], distance = 83.39

# Intersection



# Difference

```
difference()  
{  
  cylinder(  
    h = 2,  
    r = 1.5,  
    center = true,  
    $fn = 20);  
  cube(  
    size = [3,2,1],  
    center = true );  
}
```



Number of objects currently in cone cache: 75

Top level object is a 3D object:

Simple:	yes
Valid:	yes
Vertices:	68
Halfedges:	204
Edges:	102
Halffacets:	68
Facets:	34
Volumes:	2

Viewport: translate = [ -35.64 18.20 -20.33 ], rotate = [ 63.40 0.00 63.00 ], distance = 67.54

# The gotcha: non-manifold shapes

- Avoid Boolean combinations with co-incident surfaces
- These result in zero-thickness boundaries between objects, which computers cannot reliably represent
- UNION/DIFFERENCE objects should overlap
- See also: <http://reprap.org/wiki/AoI>



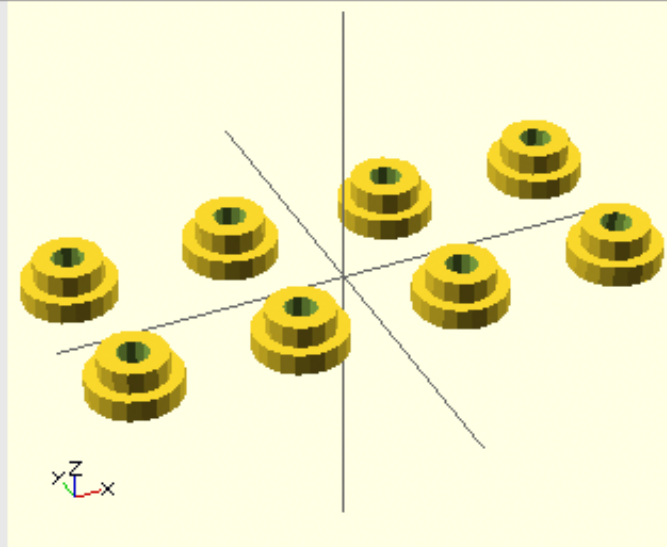
# A very simple design

```
OpenSCAD - springseat.scad

// Single object
module springseat(od, id, boltd, totalh, flangeh)
{
    or = od/2;
    ir = id/2;
    br = boltd/2;
    difference()
    {
        union() {
            cylinder(r=ir, h=totalh);
            cylinder(r=or, h=flangeh);
        }
        translate([0,0,-6]) {
            cylinder(r=br, h=totalh+10, $fn=12);
        }
    }
}

// Main object array:
outerd = 13;
innerd = 9.5;
holed = 4.5; // +0.5 for M4 bolt
totalh = 6;
endh = 3;

// Implicit union of all objects
pitch = outerd+10;
for (x = [-1.5*pitch, -0.5*pitch, 0.5*pitch, 1.5*pitch]) {
    for (y = [-0.5*pitch, 0.5*pitch]) {
        translate([x,y,0]) {
            springseat(outerd, innerd, holed, totalh, endh);
        }
    }
}
```



```
Parsing design (AST generation)...
Compiling design (CSG Tree generation)...
Compilation finished.
Rendering Polygon Mesh using CGAL...
Number of vertices currently in CGAL cache: 8669
Number of objects currently in CGAL cache: 94
Top level object is a 3D object:
Simple:    yes
Valid:     yes
Vertices:  768
Halfedges: 2304
Edges:     1152
Half facets: 816
Facets:    408
Volumes:   9
Total rendering time: 0 hours, 0 minutes, 9 seconds
Rendering finished.
```

Viewport: translate = [ 0.00 0.00 0.00 ], rotate = [ 55.00 0.00 335.00 ], distance = 405.00

# Materials

- Slides:
  - ...
- Spring seat design:
  - ...