Explicitly Listing Geometry and Topology

Models can consist of thousands of vertices and faces – we need some way to list them efficiently

This is called a **Mesh**.
Explicitly Listing Geometry and Topology

```c
static GLfloat CubeVertices[3][3] = {
    {-1., -1., -1.},
    { 1., -1., -1.},
    {-1.,  1., -1.},
    { 1.,  1., -1.},
    {-1., -1.,  1.},
    { 1., -1.,  1.},
    {-1.,  1.,  1.},
    { 1.,  1.,  1.}
};

static GLfloat CubeColors[3][3] = {
    { 0., 0., 0.},
    { 1., 0., 0.},
    { 0., 1., 0.},
    { 1., 1., 0.},
    { 0., 0., 1.},
    { 1., 0., 1.},
    { 0., 1., 1.},
    { 1., 1., 1.}
};

static GLuint CubeQuadIndices[4][4] = {
    { 0, 2, 3, 1 },
    { 4, 5, 7, 6 },
    { 1, 3, 7, 5 },
    { 0, 4, 6, 2 },
    { 2, 6, 7, 3 },
    { 0, 1, 5, 4 }
};
```
The Cube Can Also Be Defined with Triangles

```
GLuint CubeQuadIndices[4] = {
    {0, 2, 3, 1},
    {4, 5, 7, 6},
    {1, 3, 7, 5},
    {0, 4, 6, 2},
    {2, 6, 7, 3},
    {0, 1, 5, 4}
};
```

```
GLuint CubeTriangleIndices[3] = {
    {0, 2, 3},
    {0, 3, 1},
    {4, 5, 7},
    {4, 7, 6},
    {1, 3, 7},
    {1, 7, 5},
    {0, 4, 6},
    {0, 6, 2},
    {2, 6, 7},
    {2, 7, 3},
    {0, 1, 5},
    {0, 5, 4}
};
```

3D Printing uses a Triangular Mesh Data Format

```
```
3D Printing uses a Triangular Mesh Data Format

Dessert at the House of Someone Obsessed with OSU and Computer Graphics 😊
Another way to Model:
Remember Venn Diagrams (2D Boolean Operators) from High School?

Two Overlapping Shapes

Union: \( A \cup B \)

Intersection: \( A \cap B \)

Difference: \( A - B \)

Solid Modeling Using 3D Boolean Operators

Two Overlapping Solids

Union: \( A \cup B \)

Intersection: \( A \cap B \)

Difference: \( A - B \)

This is often called Constructive Solid Geometry, or CSG
Another way to Model:
Curve Sculpting – Bezier Curve Sculpting

\[
P(t) = (1-t)^3 P_0 + 3t(1-t)^2 P_1 + 3t^2(1-t) P_2 + t^3 P_3
\]

\[0 \leq t \leq 1.
\]

where \( P \) represents \( \begin{pmatrix} x \\ y \\ z \end{pmatrix} \)

Curve Sculpting – Bezier Curve Sculpting Example
Moving a single point moves an entire curve

Moving a single point moves an entire surface
Surface Equations can also be used for Analysis

With Contour Lines

Showing Curvature

Another way to Model: Sculpting with a Wireframe Mesh

This is often called a "Lattice"
Modeling → Simulation (Explosion)

Modeling → Simulation (Smoke)
Object Modeling Rules for 3D Printing

The object must be a legal solid. It must have a definite inside and a definite outside. It can't have any missing face pieces.

“Definite inside and outside” is sometimes called “Two-manifold” or “Watertight”

The Simplified Euler’s Formula* for Legal Solids

*sometimes called the Euler-Poincaré formula

\[ F - E + V = 2 \]

\( F \) Faces
\( E \) Edges
\( V \) Vertices

For a cube, \( 6 - 12 + 8 = 2 \)

The full formula is:

\[ F - E + V - L = 2( B - G ) \]

\( F \) Faces
\( E \) Edges
\( V \) Vertices
\( L \) Inner Loops (within faces)
\( B \) Bodies
\( G \) Genus (number of through-holes)
Objects cannot pass through other objects. If you want two shapes together, do a Boolean union on them so that they become one complete object.