

3D Graphics and OpenGL

First Steps

Rendering of 3D Graphics

Objects defined in (virtual/mathematical) 3D space.

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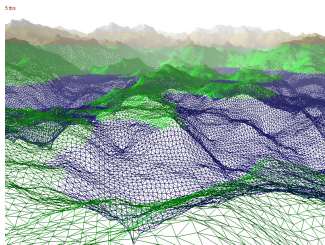
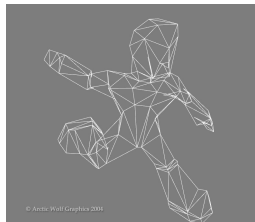
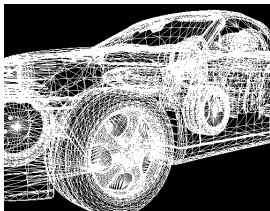
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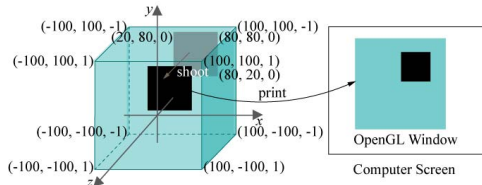


Rendering of 3D Graphics

Main objective: transfer (models built of) triangles from 3D space to 2D screen space. Add colors to the screen pixels covered by triangle (shading).

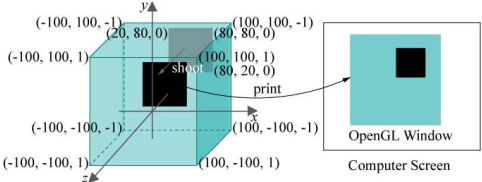
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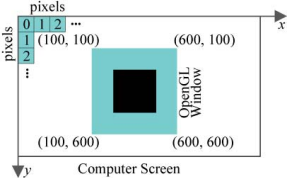
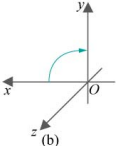
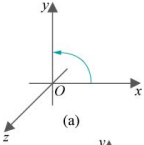


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Coordinate systems:

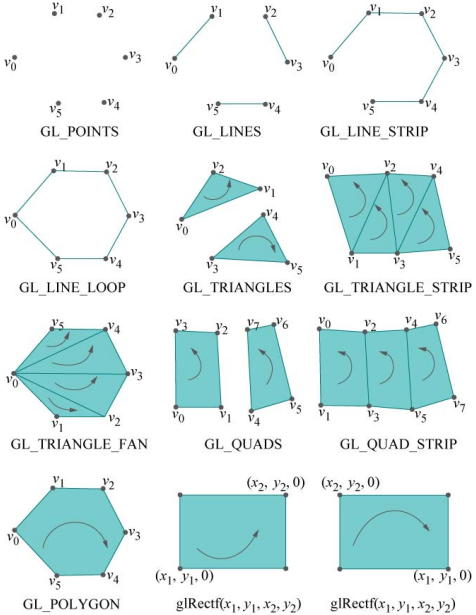


Vertices

Core data: vertices of triangles.

```
glBegin(GL_TRIANGLES);  
    glVertex3f(20.0, 20.0, 0.0);  
    glVertex3f(80.0, 20.0, 0.0);  
    glVertex3f(80.0, 80.0, 0.0);  
    .  
    .  
glEnd();
```

Other OpenGL Primitives

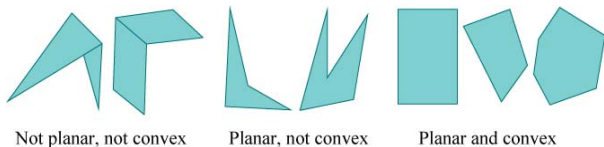


OpenGL Primitives

Polygons and quads are divided into triangles by OpenGL before rendering. Must be **plane** and **convex**

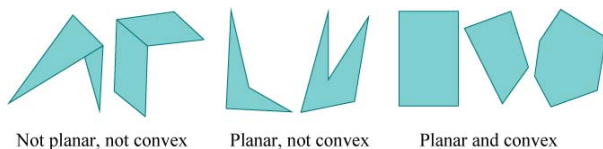
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For efficiency, use **array lists** (single rendering call accessing array of many points) and **display lists** (precompiled and stored groups of OpenGL commands, including declarations of geometry/primitives). See sections 3.1 and 3.2.

Geometry

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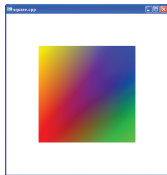
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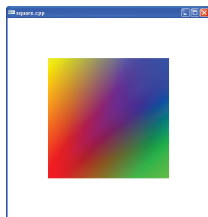
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E.g., setting (foreground/vertex) color using glColor:

```
glBegin(GL_QUADS);
  glColor3f(1.0, 0.0, 0.0);
  glVertex3f(20.0, 20.0, 0.0);
  glColor3f(0.0, 1.0, 0.0);
  glVertex3f(80.0, 20.0, 0.0);
  glColor3f(0.0, 0.0, 1.0);
  glVertex3f(80.0, 80.0, 0.0);
  glColor3f(1.0, 1.0, 0.0);
  glVertex3f(20.0, 80.0, 0.0);
glEnd()
```



Projections

Transfer (models built of triangles built of vertex) points from 3D space to 2D screen space.

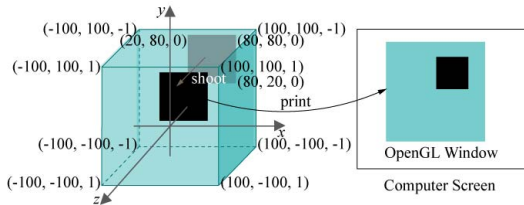
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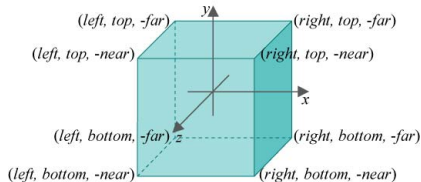
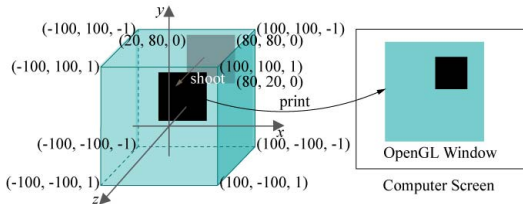
Two types:

- ▶ Orthographic
- ▶ Perspective

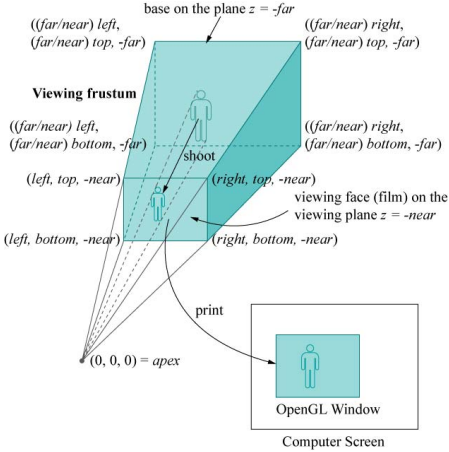
Orthographic Projection



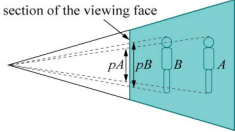
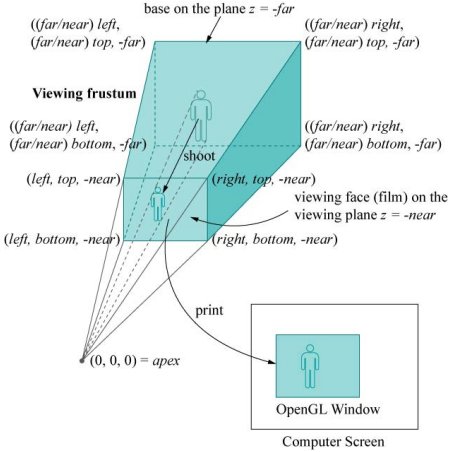
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Perspective Projection



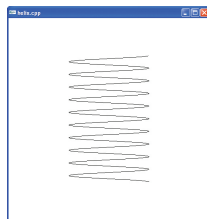
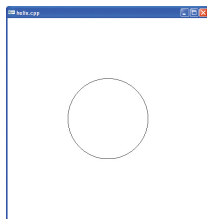
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Perspective

Helix curve:

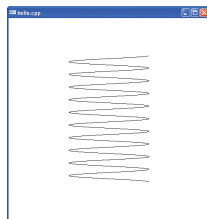
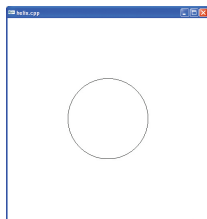
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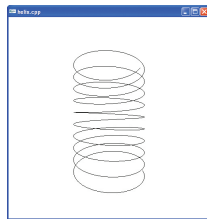
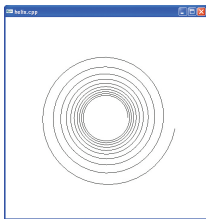
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Projective:

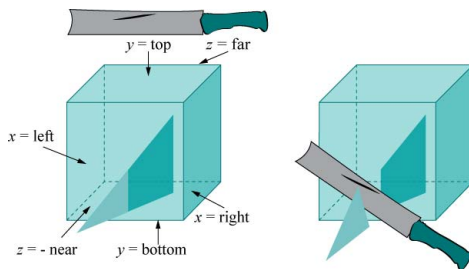


Clipping before Projection

The geometry is clipped against the viewing area planes before projection. Further clipping planes can be specified manually.

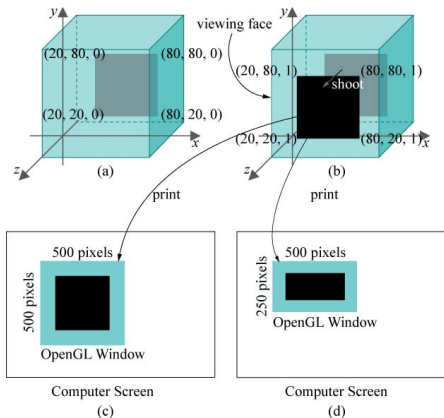
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Stretch after Projection

The projected image is stretched to the screen/window size after projection.



OpenGL Buffers

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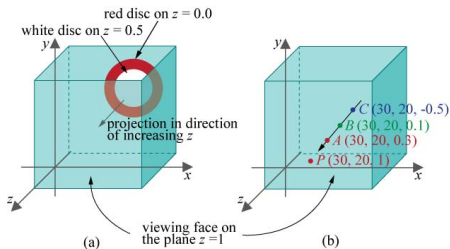
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- ▶ Depth buffer. Resolves hidden surface removal.

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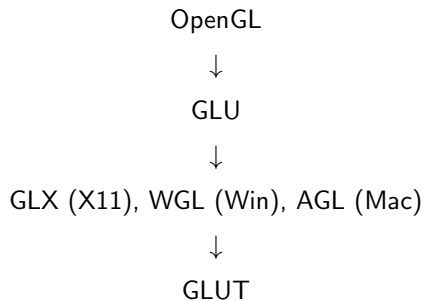
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OpenGL and Assisting Libraries



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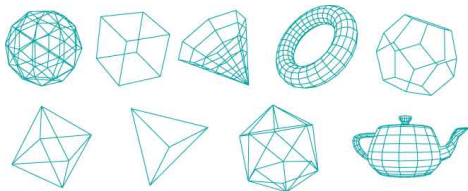
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- ▶ Animation through timed callbacks (`glutTimerFunc()`) or idle time callback (`glutIdleFunc()`).
- ▶ Commands for triangles for basic models (cube, cone, sphere, torus, teapot, ...).



OpenGL Command Naming

Example:

```
glVertex3f(20.0, 5.0, 10.0);
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Suffix	Data Type	C-Language Type	OpenGL Type
b	8-bit integer	signed char	GLbyte
s	16-bit integer	short	GLshort
i	32-bit integer	int	GLint, GLsizei
f	32-bit floating-point	float	GLfloat, GLclampf
d	64-bit floating-point	double	GLdouble, GLclampd
ub	8-bit unsigned integer	unsigned char	GLubyte, GLboolean
us	16-bit unsigned integer	unsigned short	GLushort
ui	32-bit unsigned integer	unsigned int	GLuint, GLenum, GLbitfield