CS130 : Computer Graphics

Lecture 6: Graphics Pipeline (cont.)

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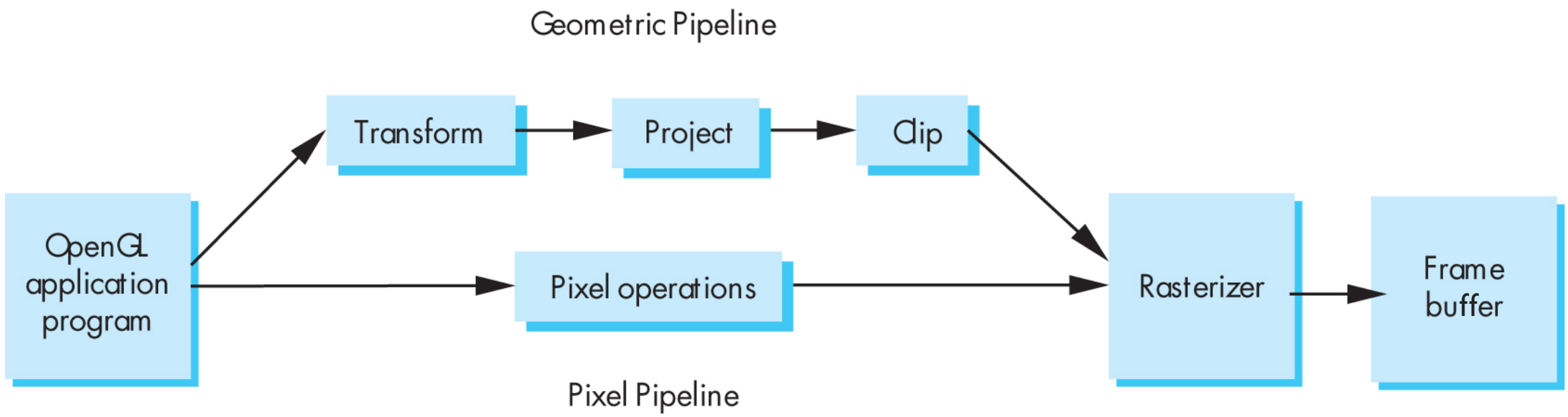
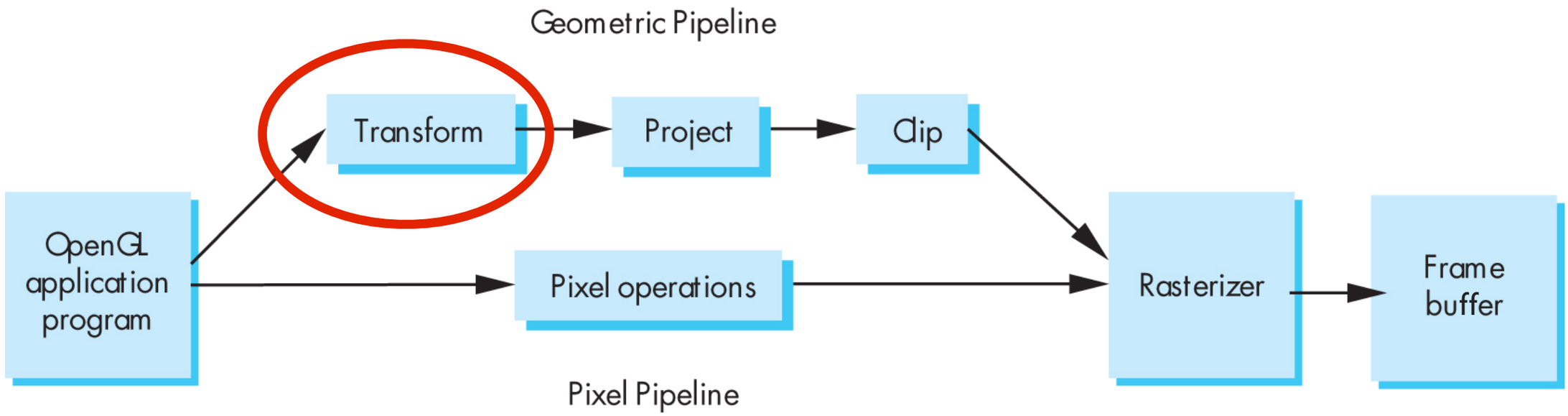
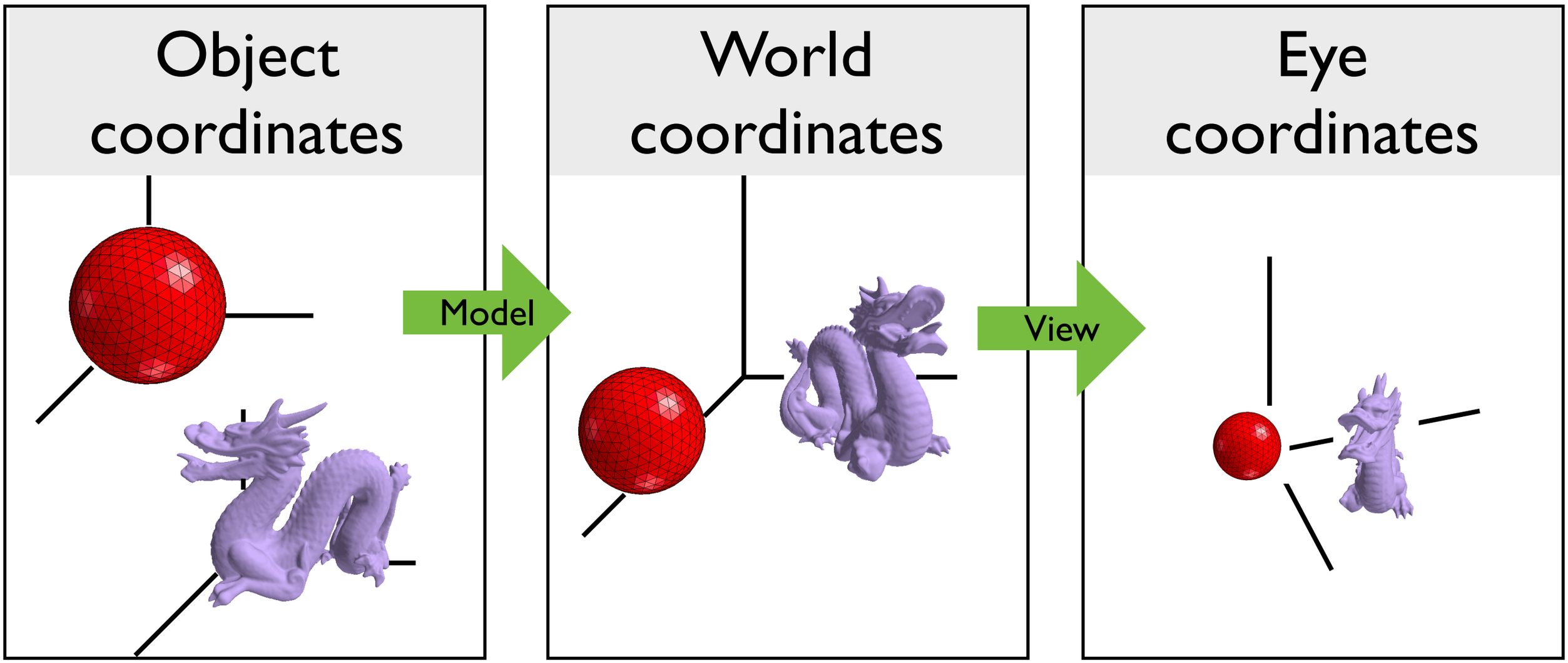
Graphics Pipeline



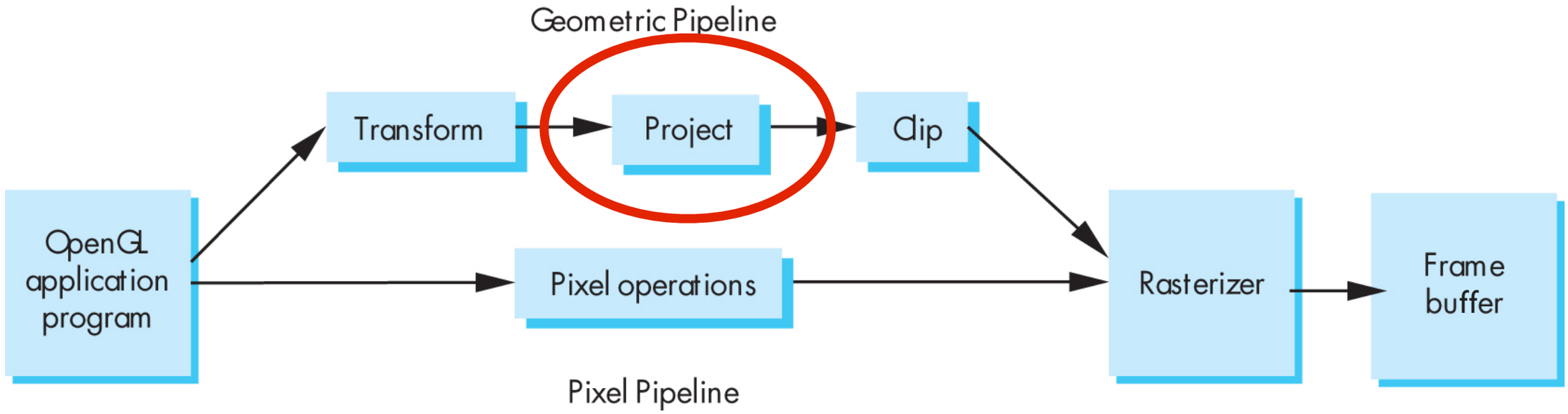
Transform


Geometric Pipeline
Transform
Project
Clip
OpenGL application program
Pixel operations
Rasterizer
Frame buffer
Pixel Pipeline

"Modelview" Transformation



Project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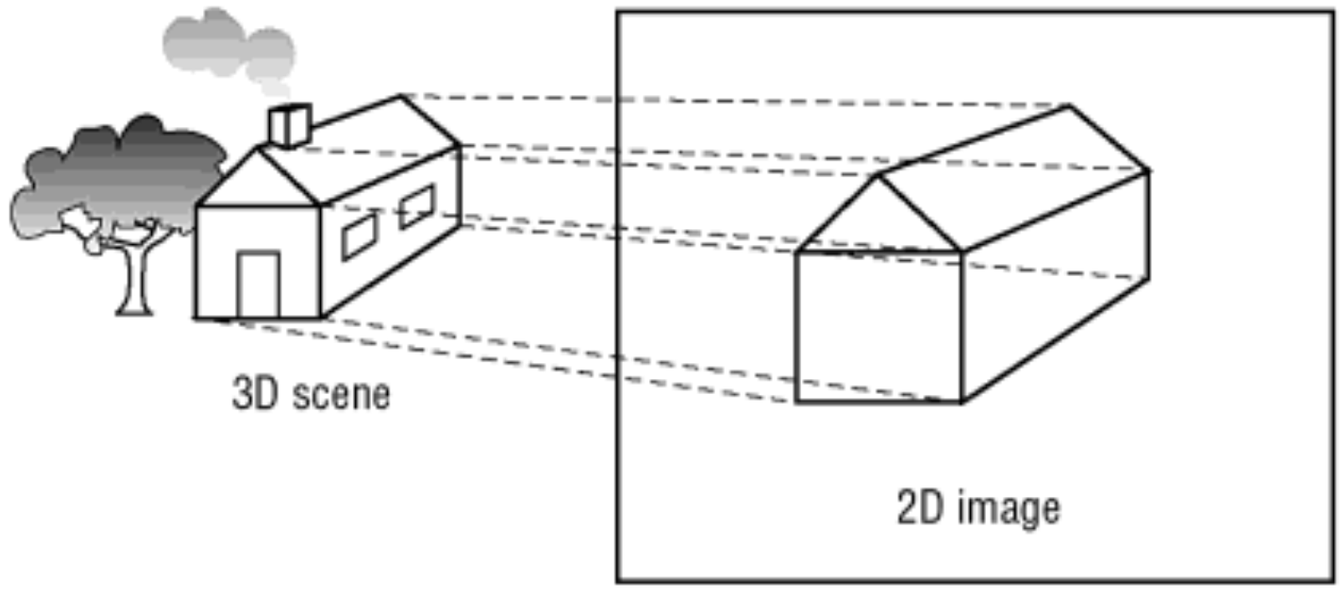
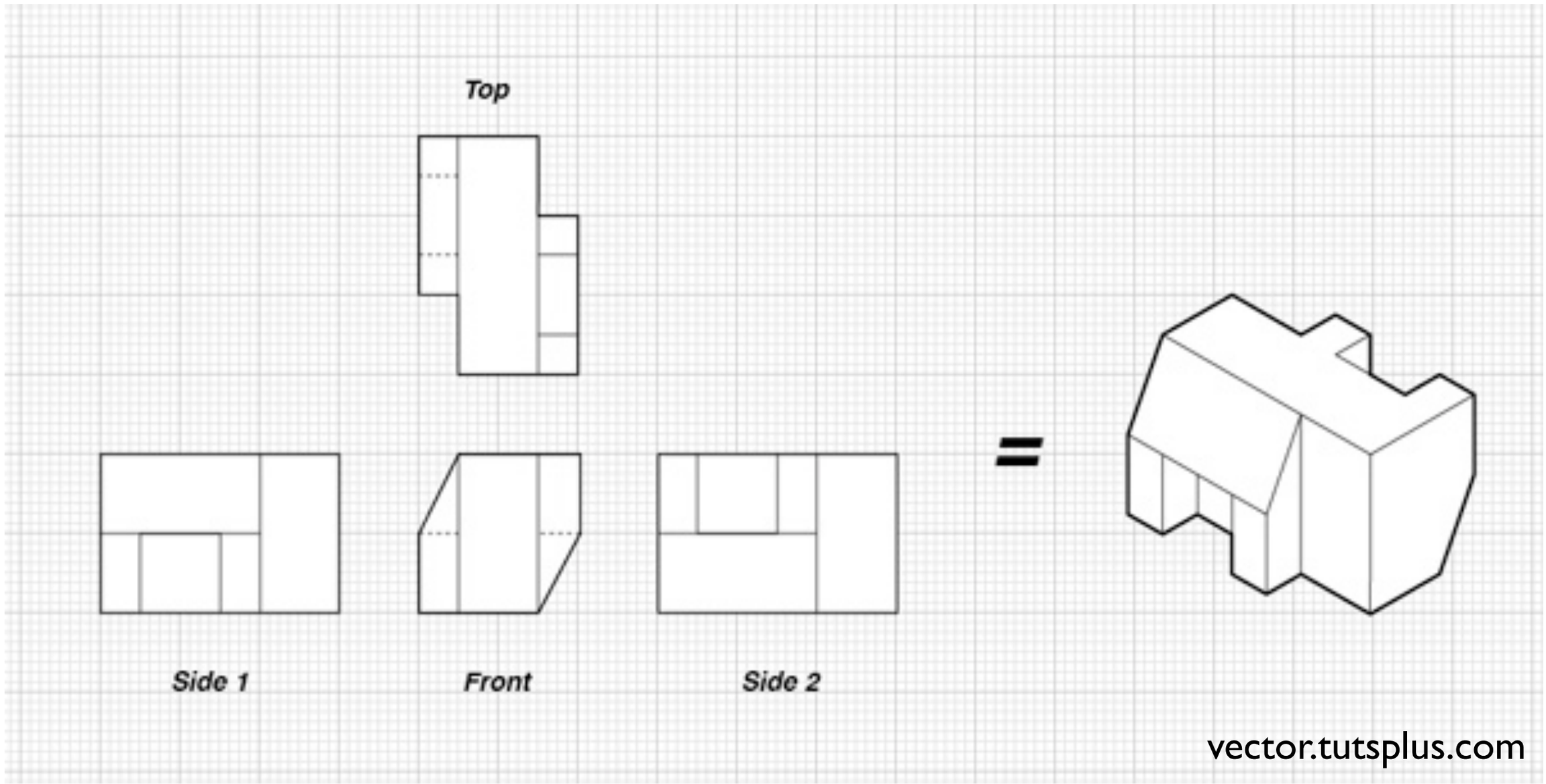
Projection: map 3D scene to 2D image



OpenGL Super Bible, 5th Ed.

Orthographic projection

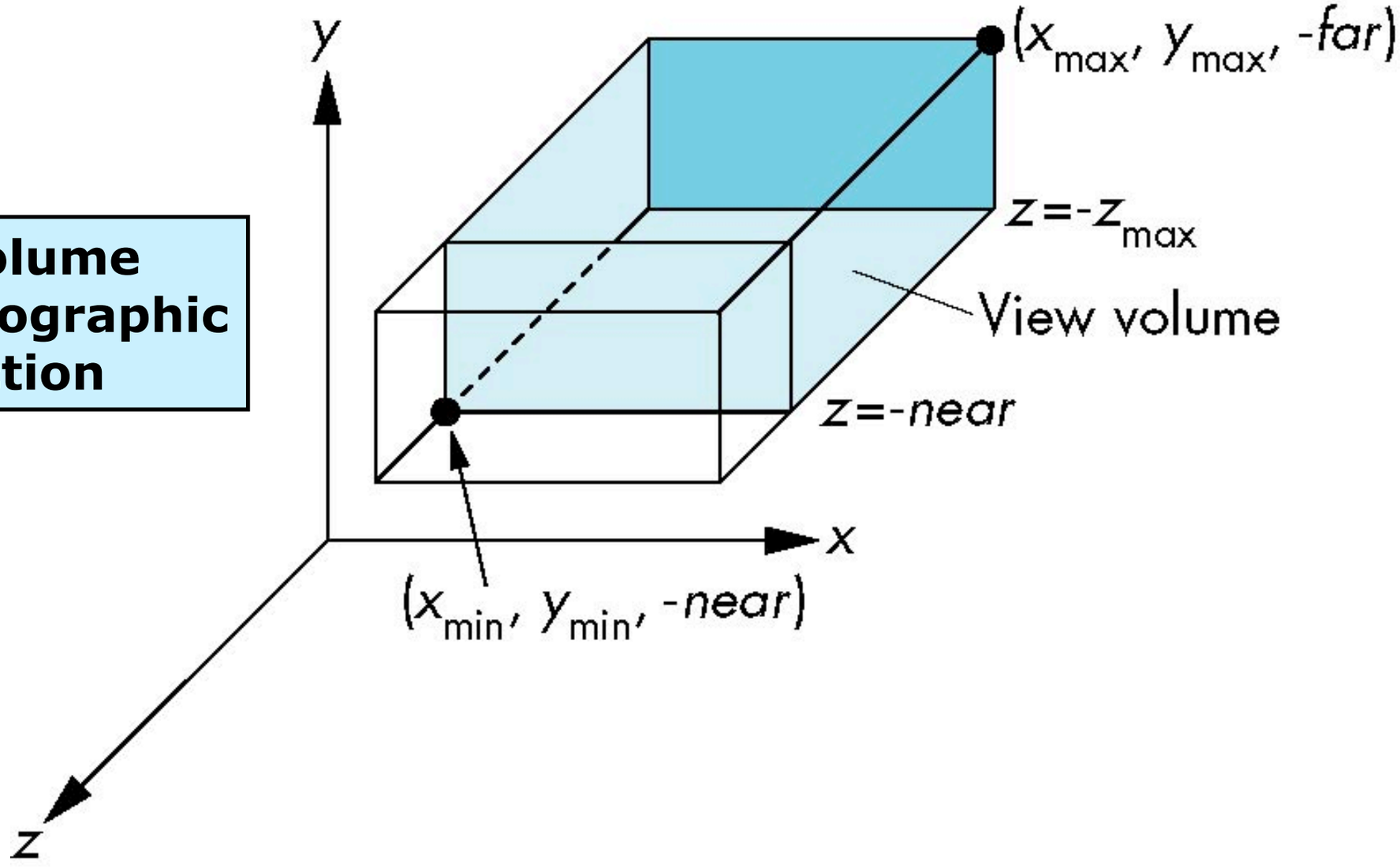


Orthographic, or parallel projection
- parallel lines appear parallel (unlike perspective proj.)
- equal length lines appear equal length (unlike perspective proj.)

OpenGL Orthogonal Viewing

`glOrtho(left,right,bottom,top,near,far)`

View volume for an orthographic projection

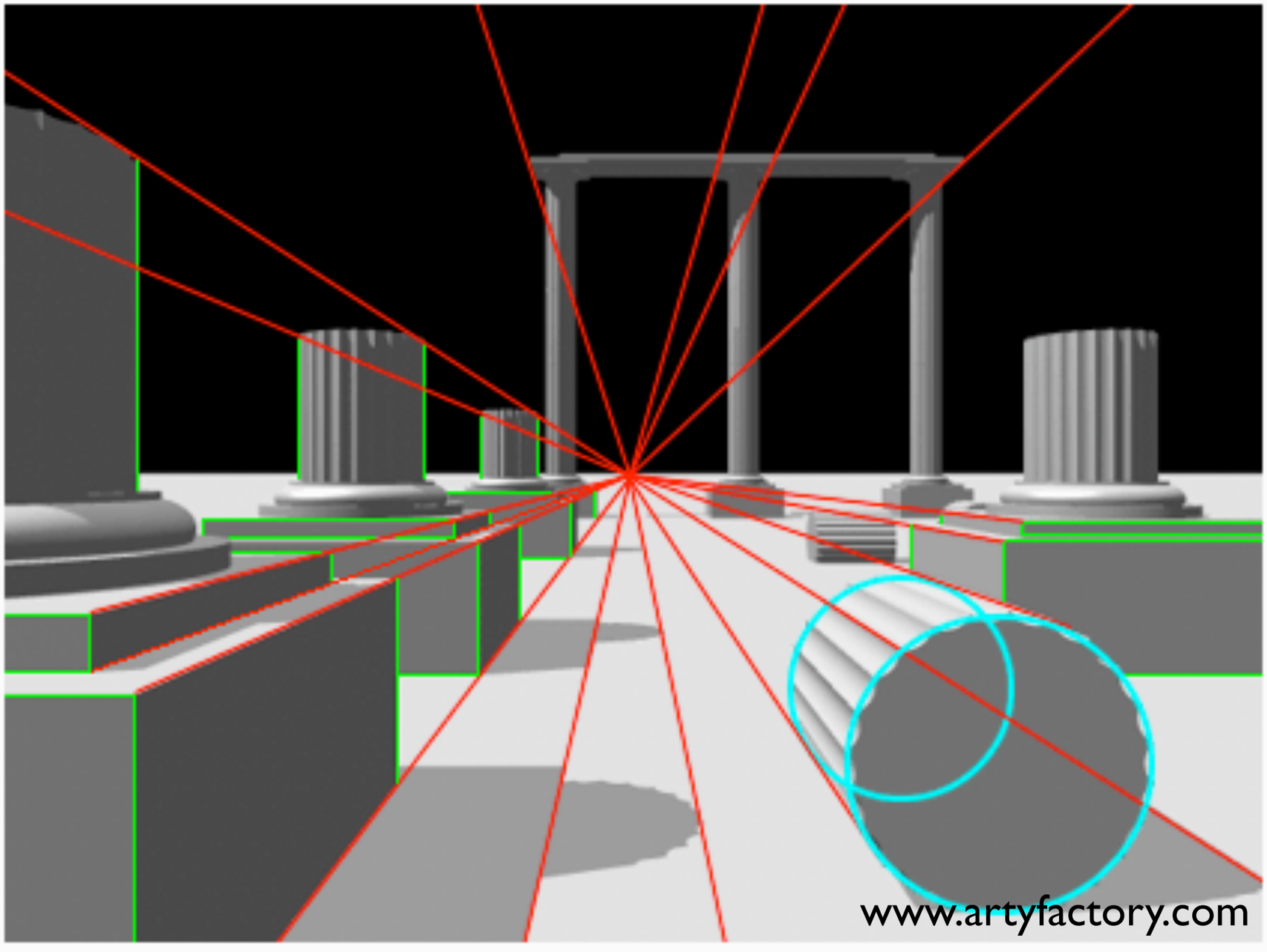


`near` and `far` measured from camera

Orthographic, or parallel projection

- square or rectangular viewing volume
- anything outside volume is not drawn

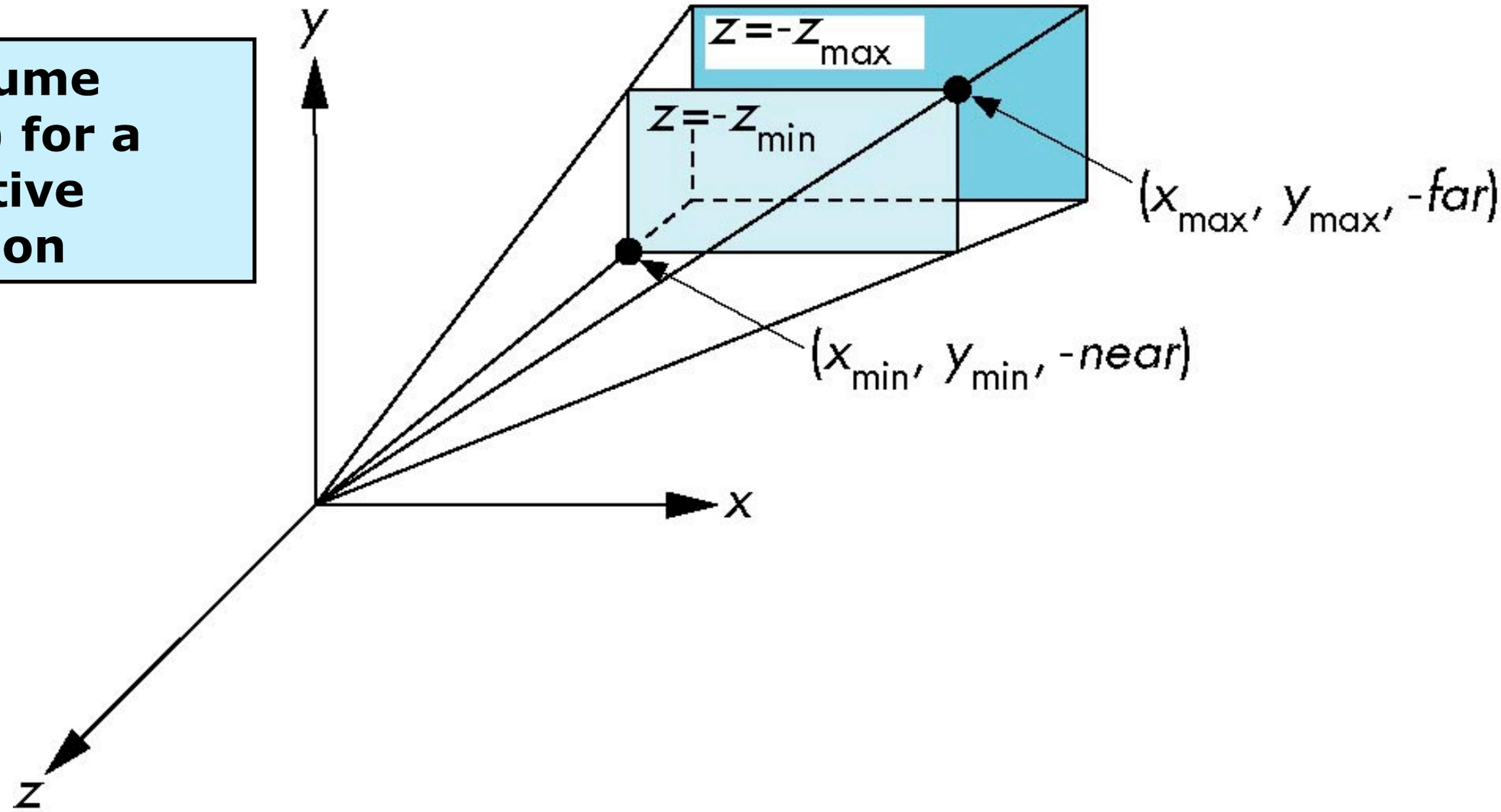
Perspective projection



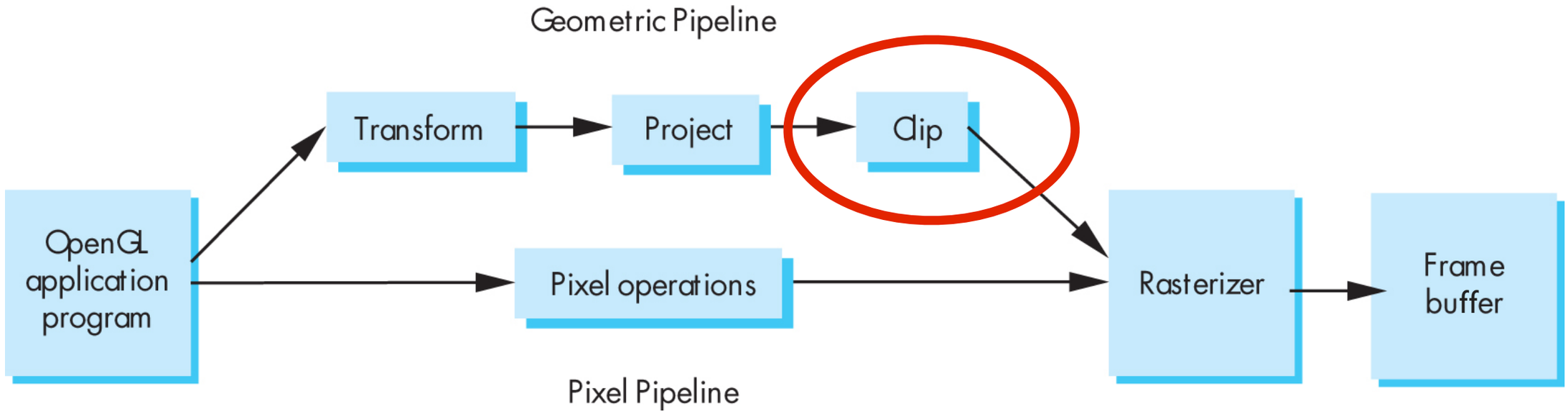
OpenGL Perspective Viewing

`glFrustum(xmin,xmax,ymin,ymax,near,far)`

View volume (frustrum) for a perspective projection



Clip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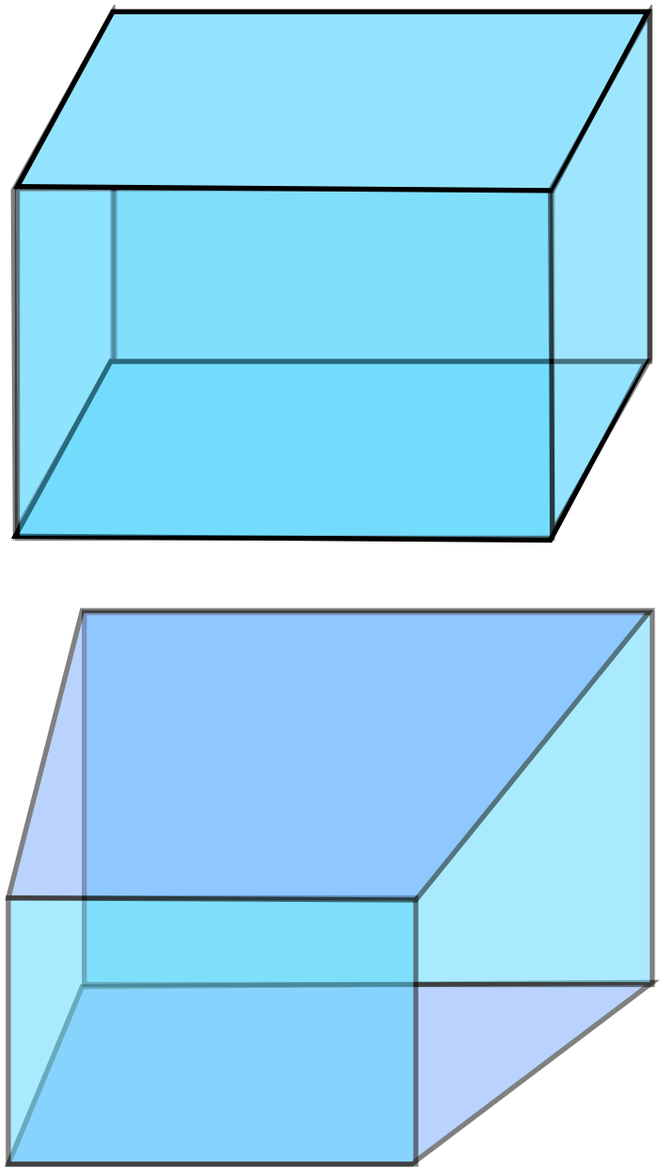
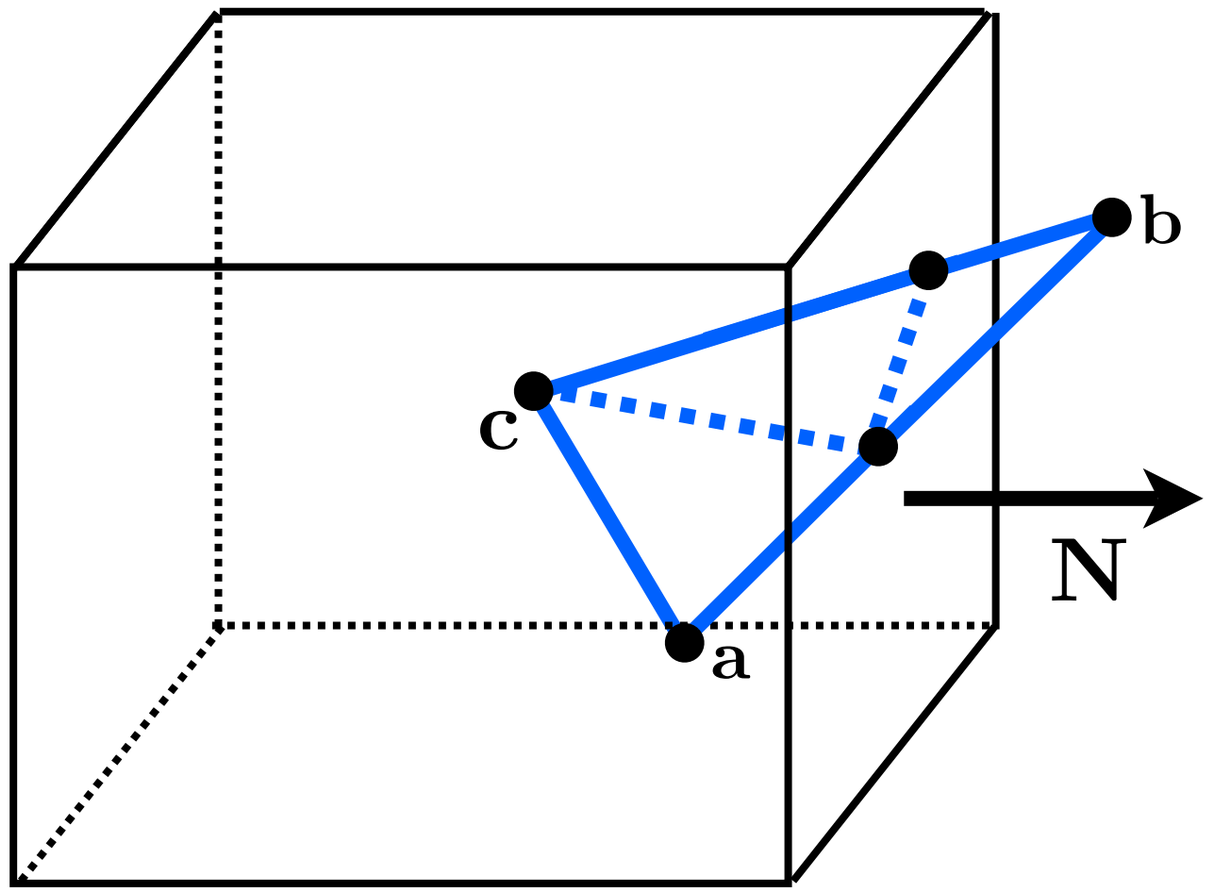
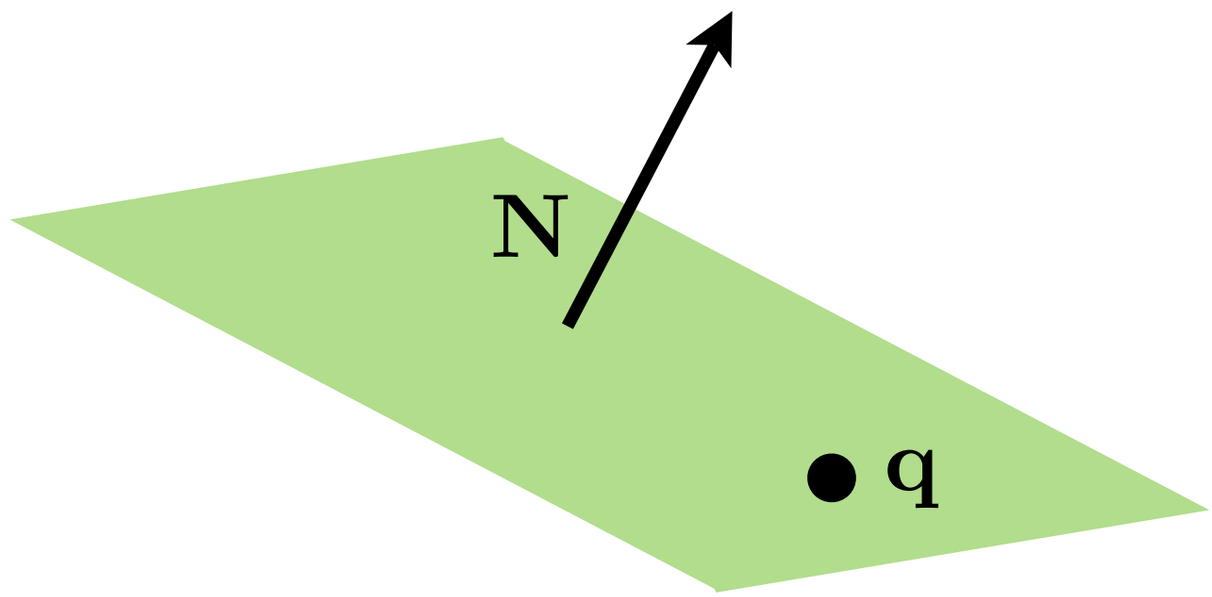
Clip against view volume

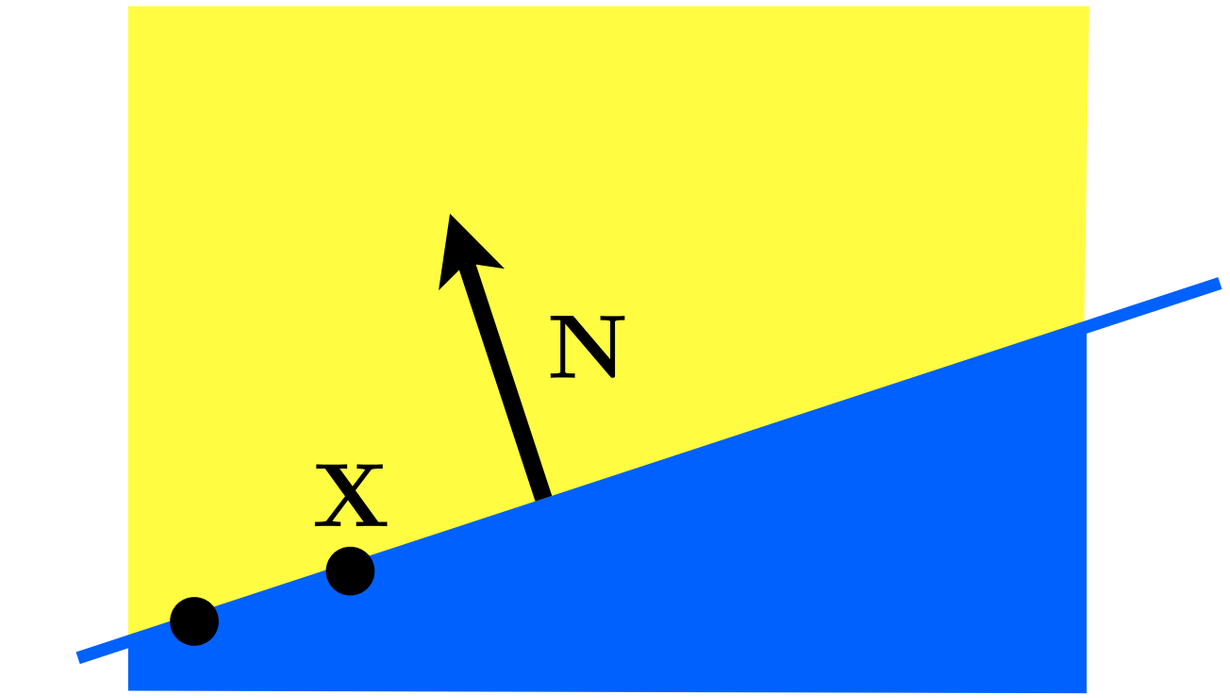




Clipping against a plane

What's the equation for the plane through **q** with normal **N**?





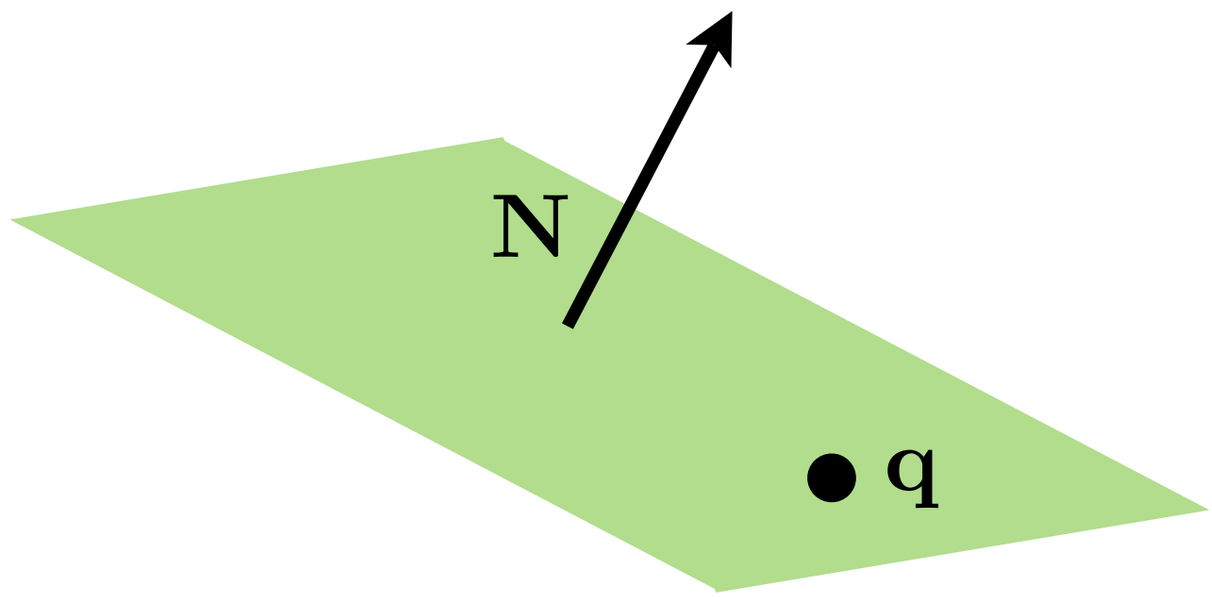
$\mathbf{X}_0 = (x_0, y_0)$

implicit line equation:

$$f(\mathbf{X}) = \mathbf{N} \cdot (\mathbf{X} - \mathbf{X}_0) = 0$$

Clipping against a plane

What's the equation for the plane through **q** with normal **N**?

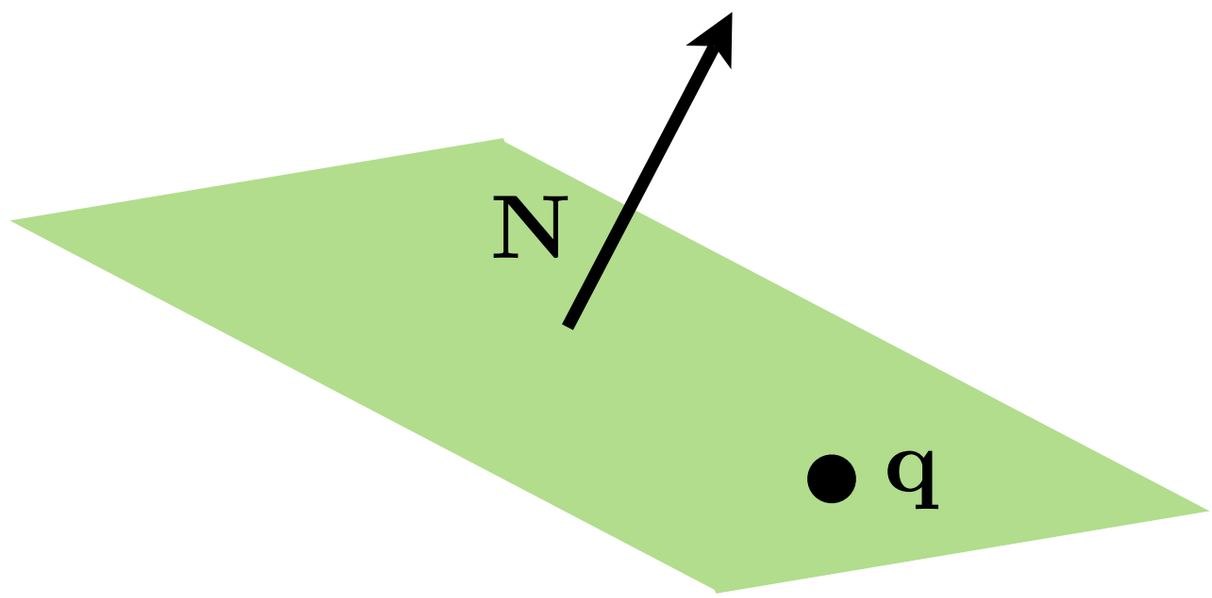


$$f(\mathbf{p}) =? = 0$$

<whiteboard>

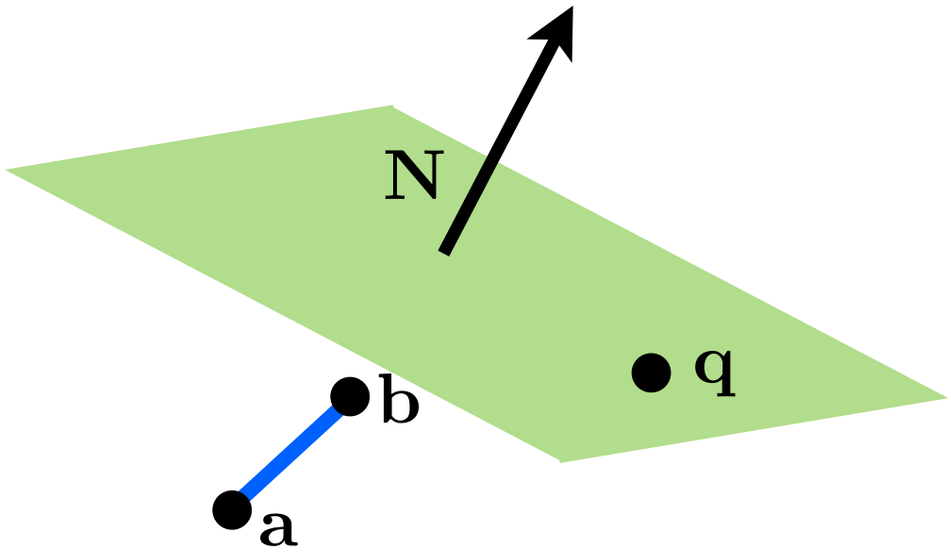
Clipping against a plane

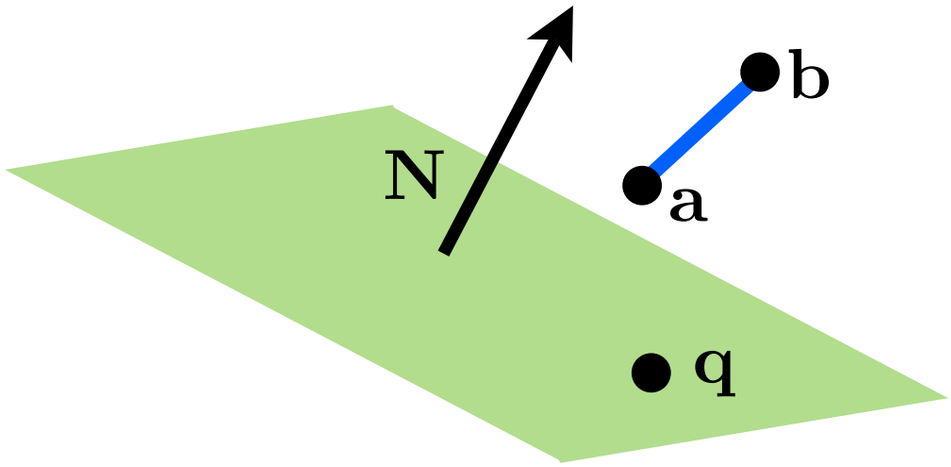
What's the equation for the plane through **q** with normal **N**?



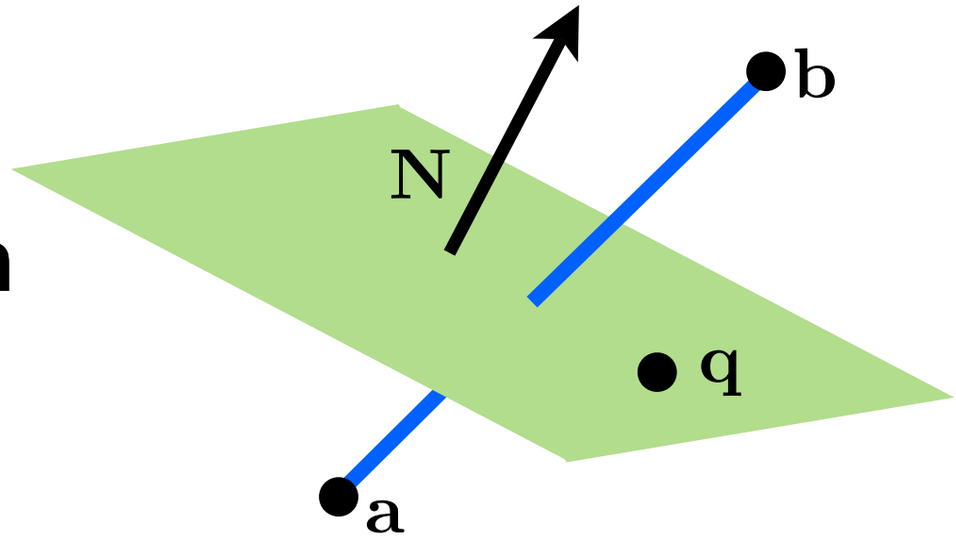
$$f(\mathbf{p}) = \mathbf{N} \cdot (\mathbf{p} - \mathbf{q}) = 0$$

Intersection of line and plane



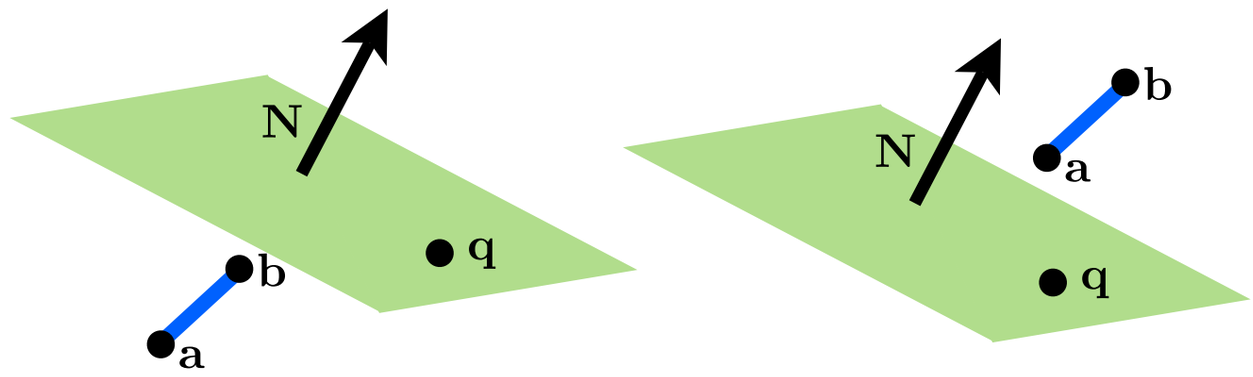


How can we distinguish between these cases?

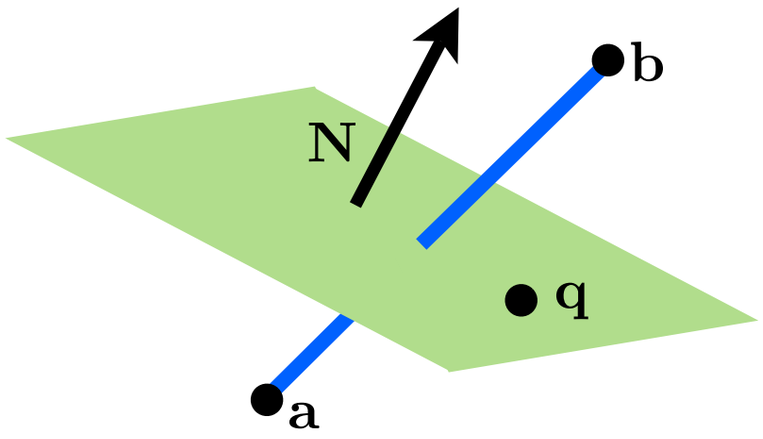


Intersection of line and plane

$$f(\mathbf{a})f(\mathbf{b}) \geq 0$$

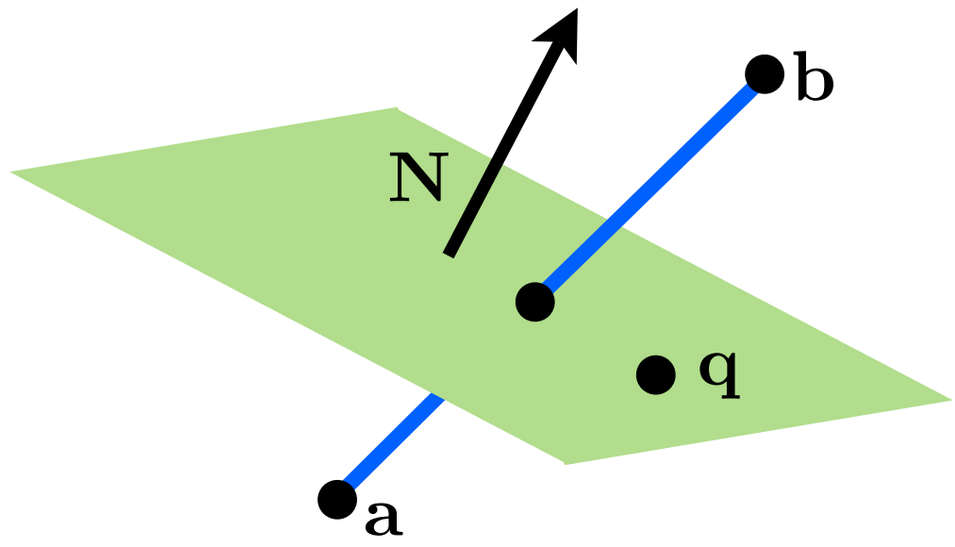


$$f(\mathbf{a})f(\mathbf{b}) < 0$$



Intersection of line and plane

How can we find the intersection point?



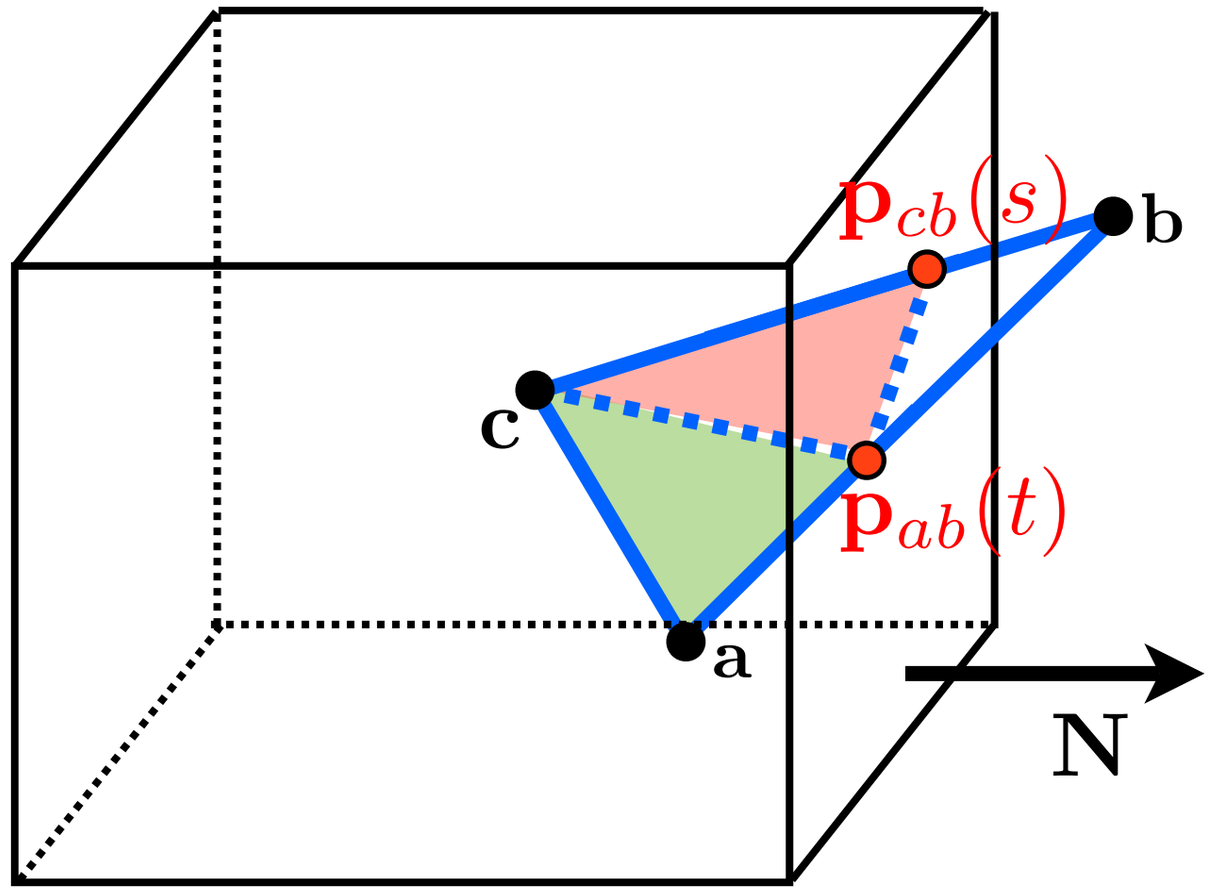
<whiteboard>

Clip against view volume

$$s = \frac{\mathbf{N} \cdot (\mathbf{q} - \mathbf{c})}{\mathbf{N} \cdot (\mathbf{b} - \mathbf{c})}$$

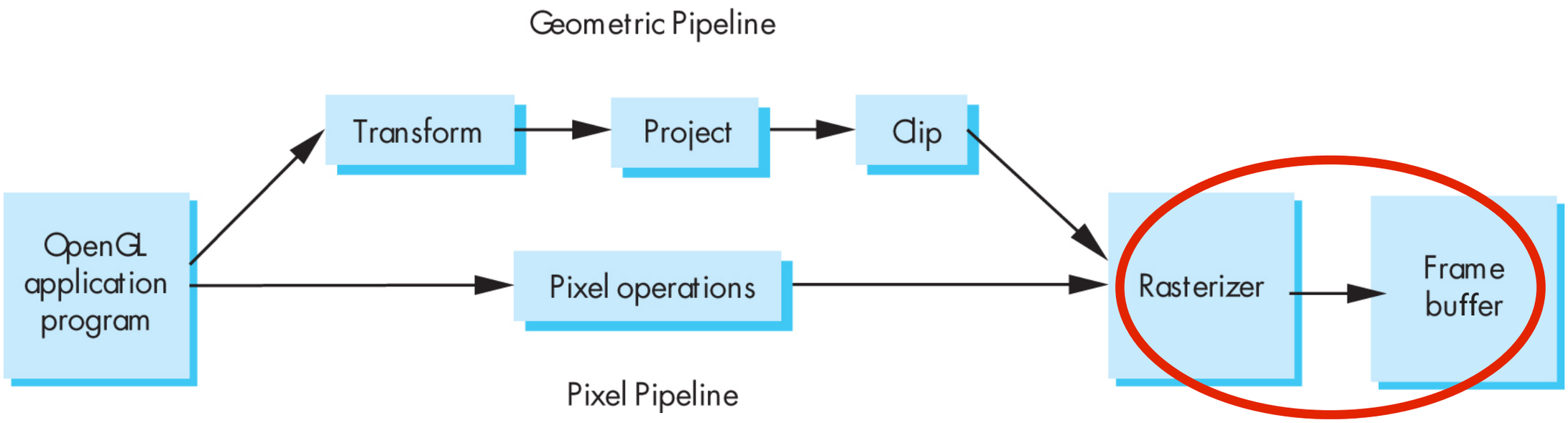
$$t = \frac{\mathbf{N} \cdot (\mathbf{q} - \mathbf{a})}{\mathbf{N} \cdot (\mathbf{b} - \mathbf{a})}$$

need to generate new triangles

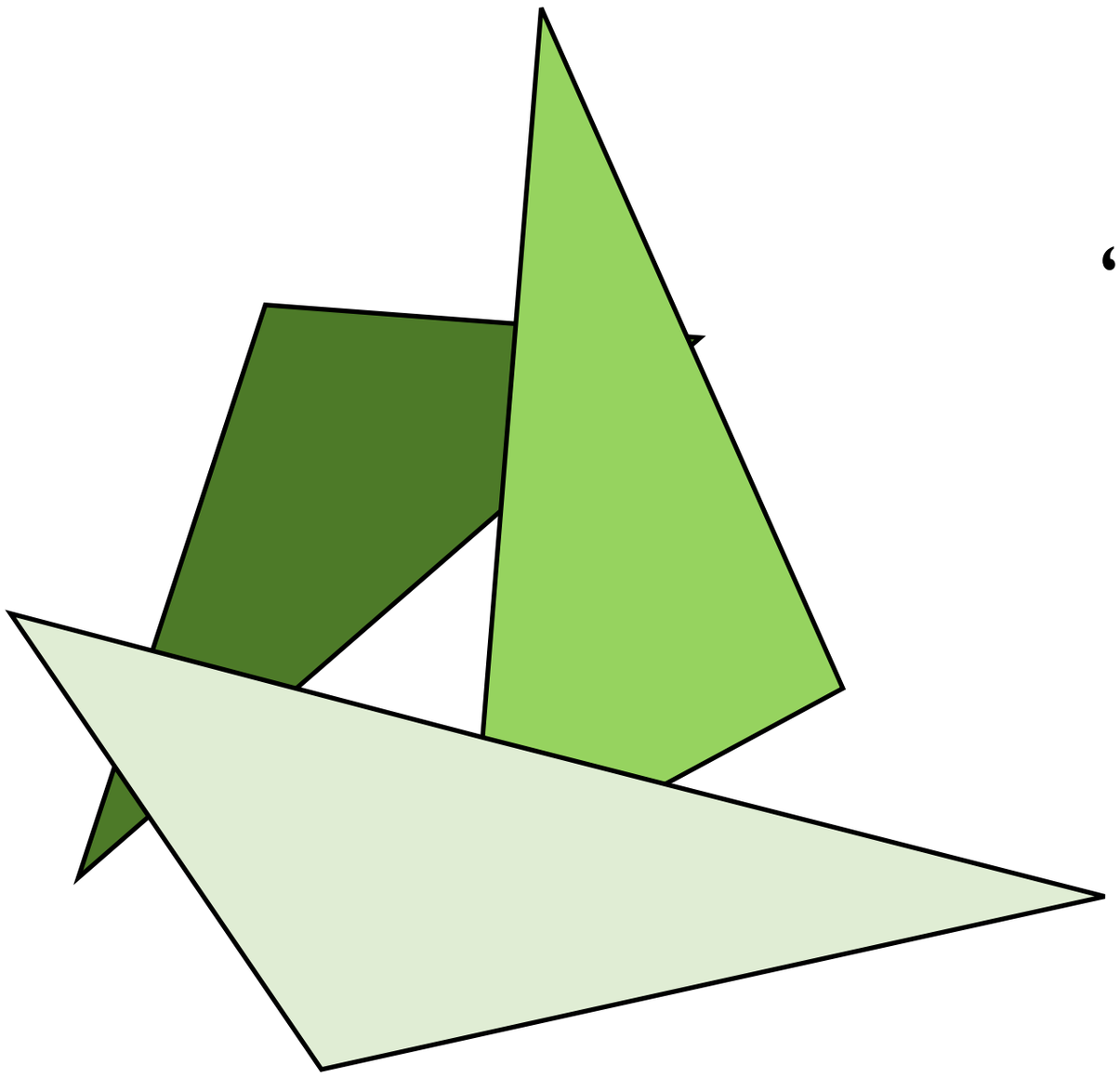


We write down the line equations p_cb(s) and p_ab(t) and find the s and t where they intersect the plane.

Hidden Surface Removal

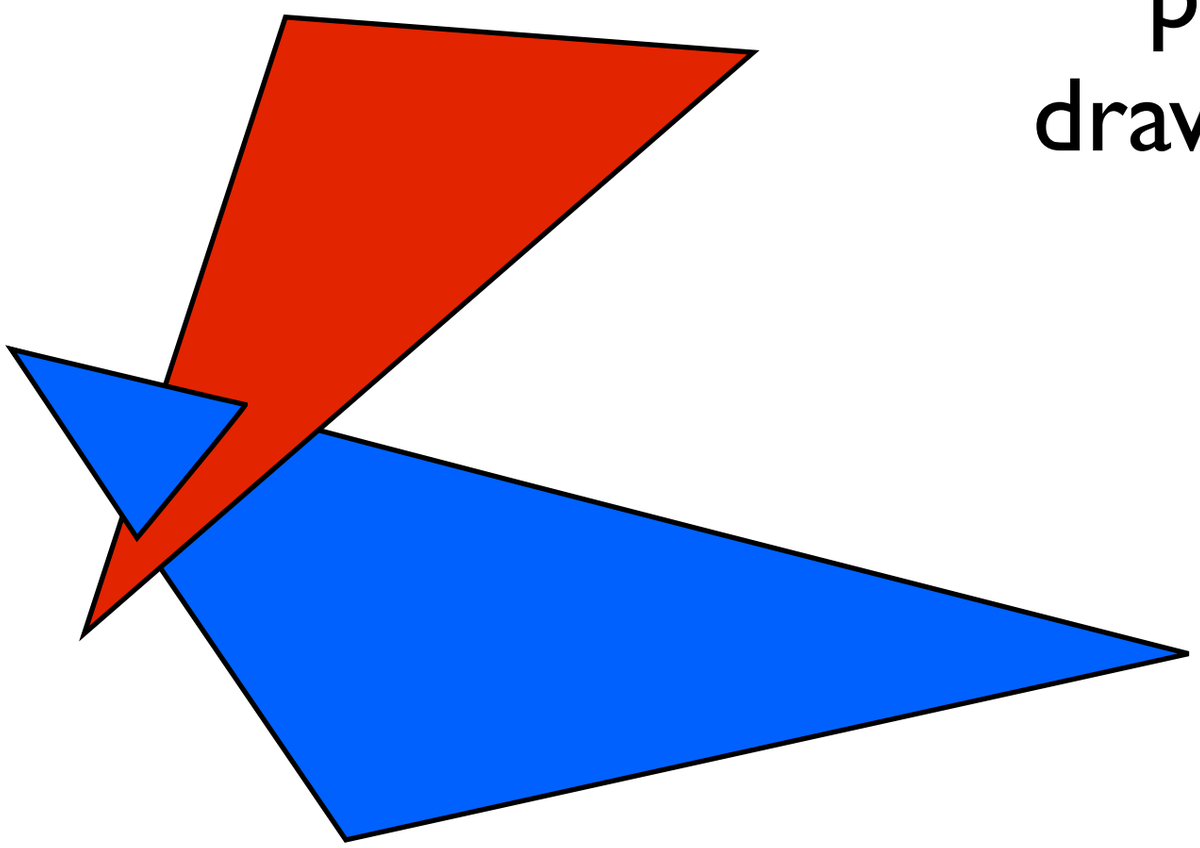


Occlusion



"painter's algorithm"
draw primitives in
back-to-front order

Occlusion

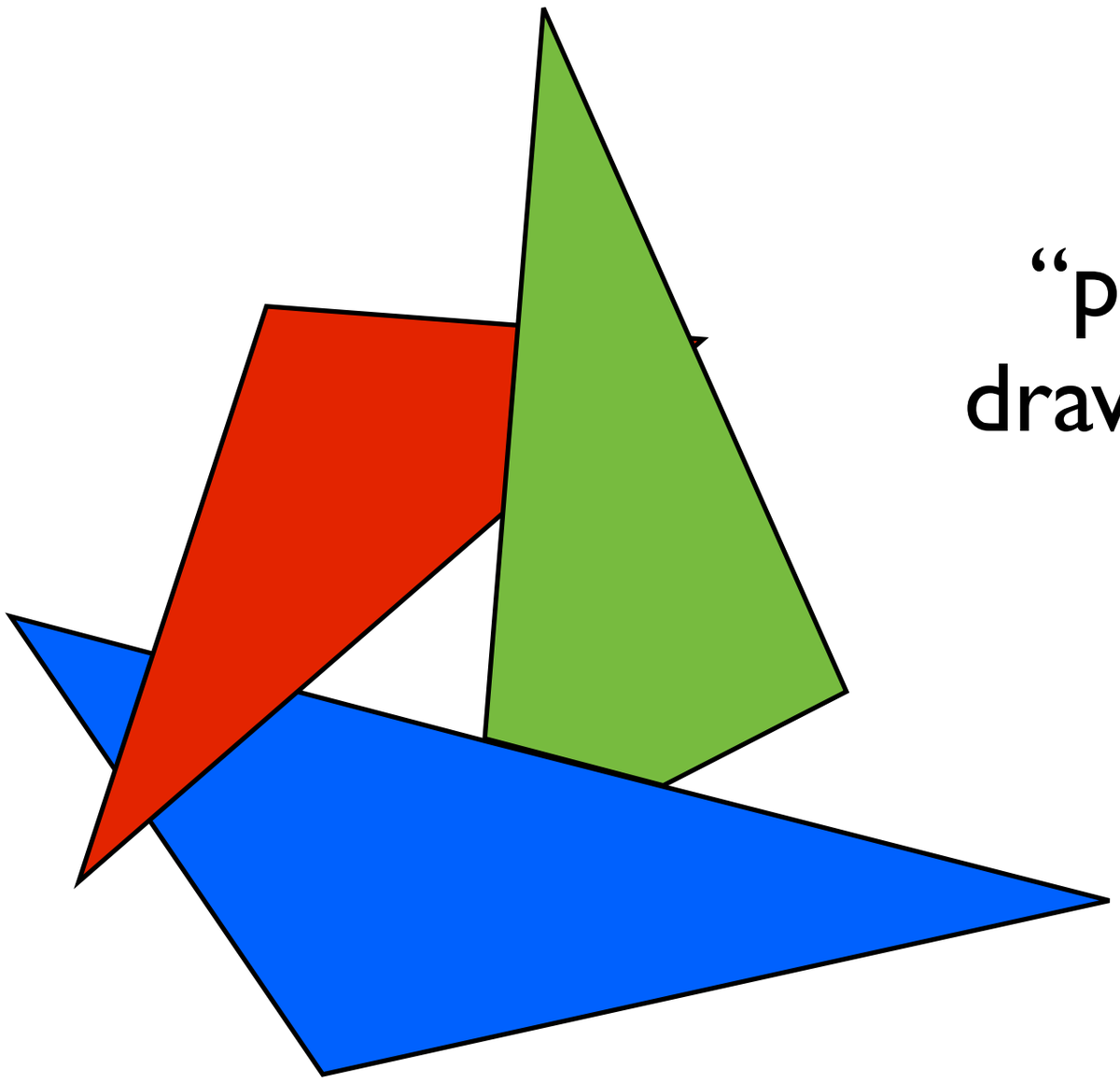


"painter's algorithm"
draw primitives in back-to-front order

problem:
triangle intersection

who's in front of whom?

Occlusion



"painter's algorithm"
draw primitives in back-to-front order

problem:
occlusion cycle

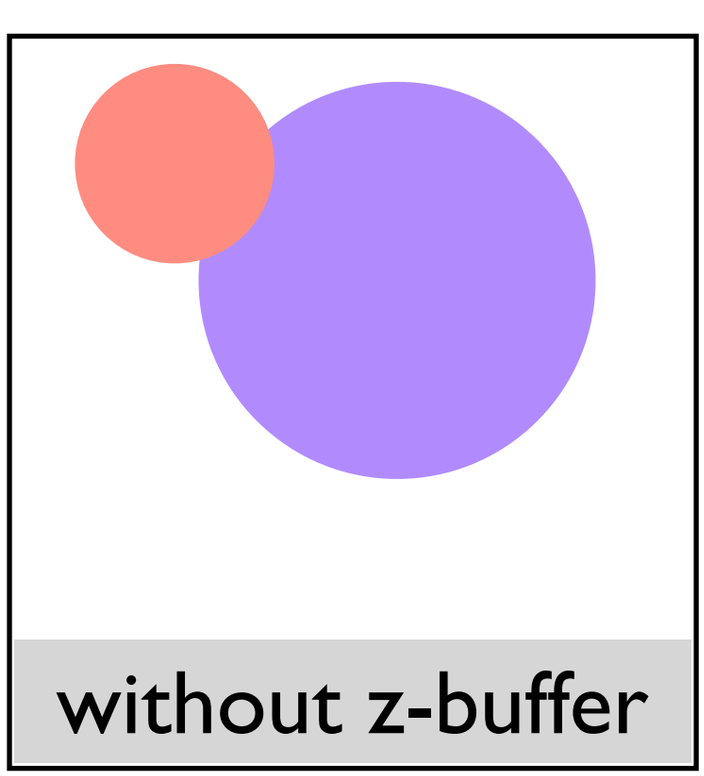
also, sorting primitives by depth is **slow**

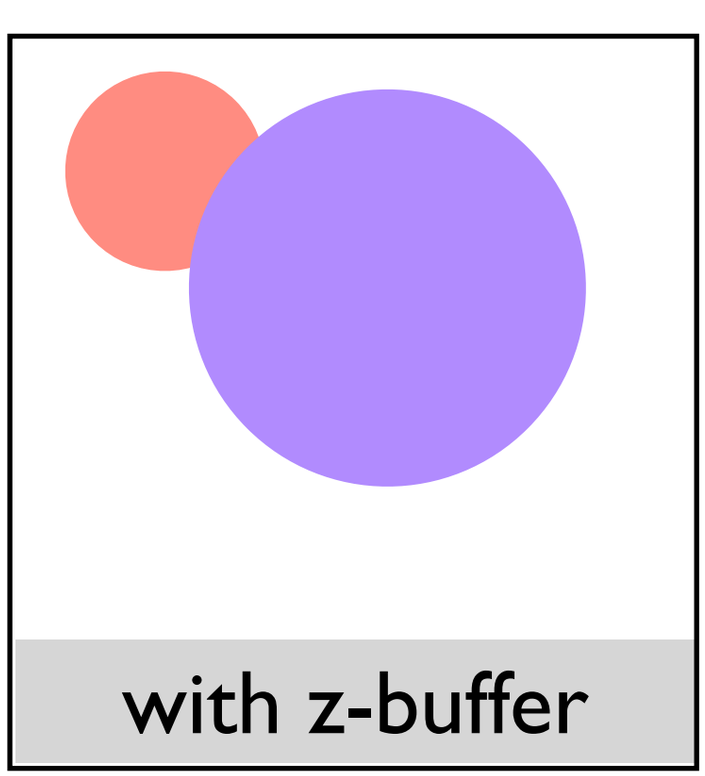
Use a *z-buffer* for hidden surface removal

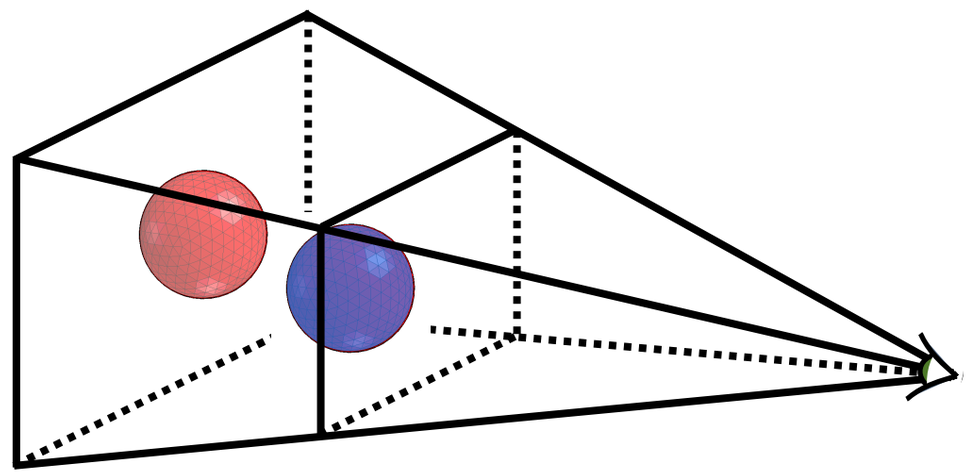
at each pixel, record distance to the closest object that has been drawn in a *depth* buffer

Use a *z-buffer* for hidden surface removal

at each pixel, record distance to the closest object that has been drawn in a *depth* buffer







- assume both spheres of the same size, red drawn last

Use a *z-buffer* for hidden surface removal

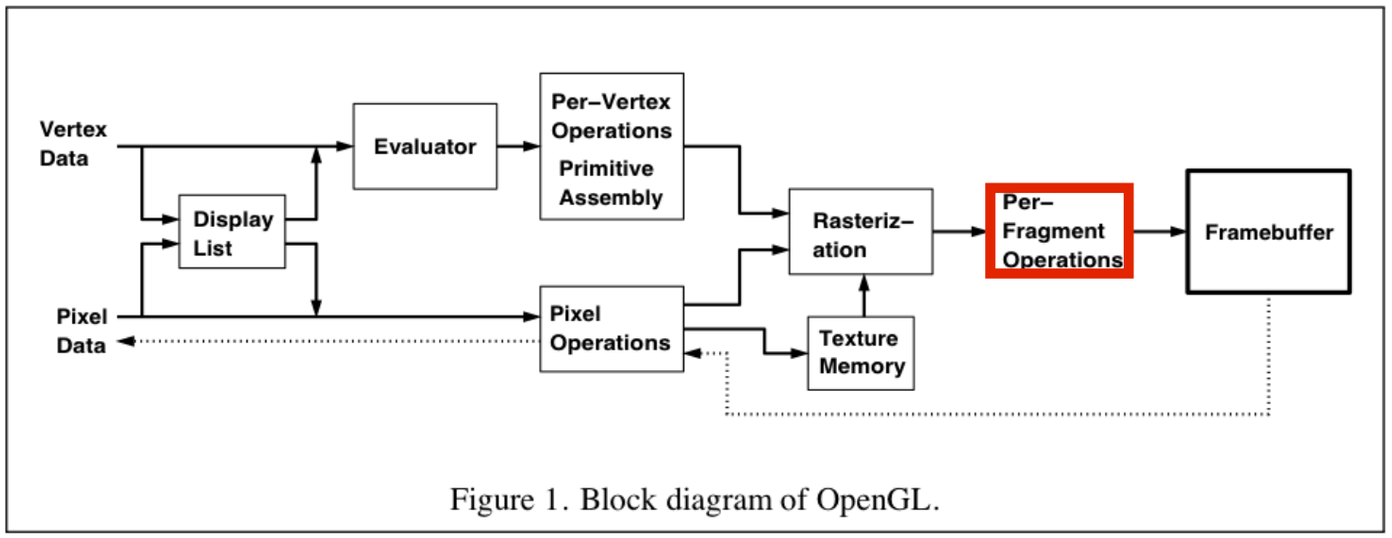
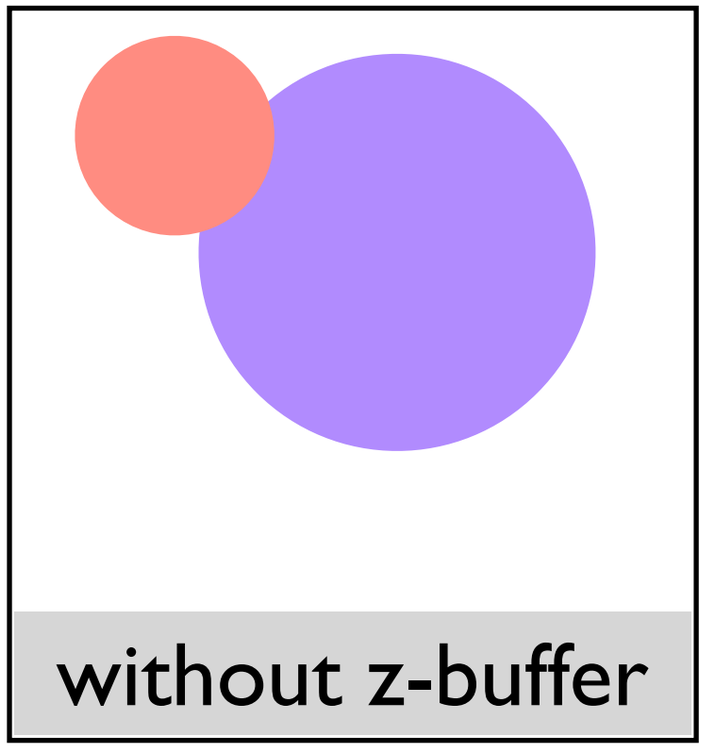
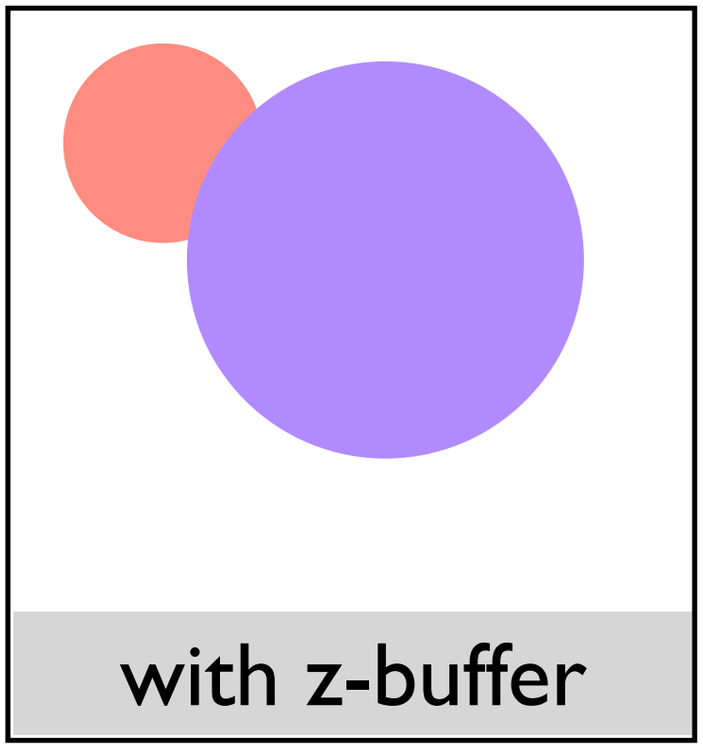
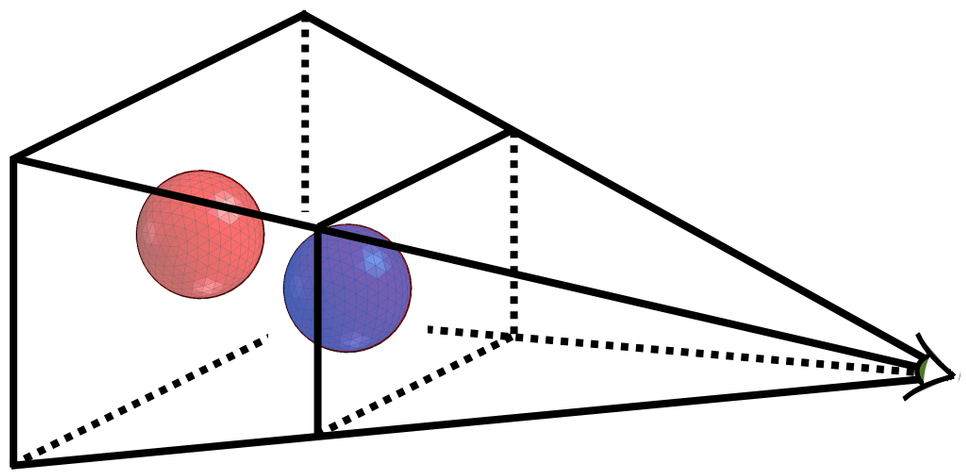


Figure 1. Block diagram of OpenGL.

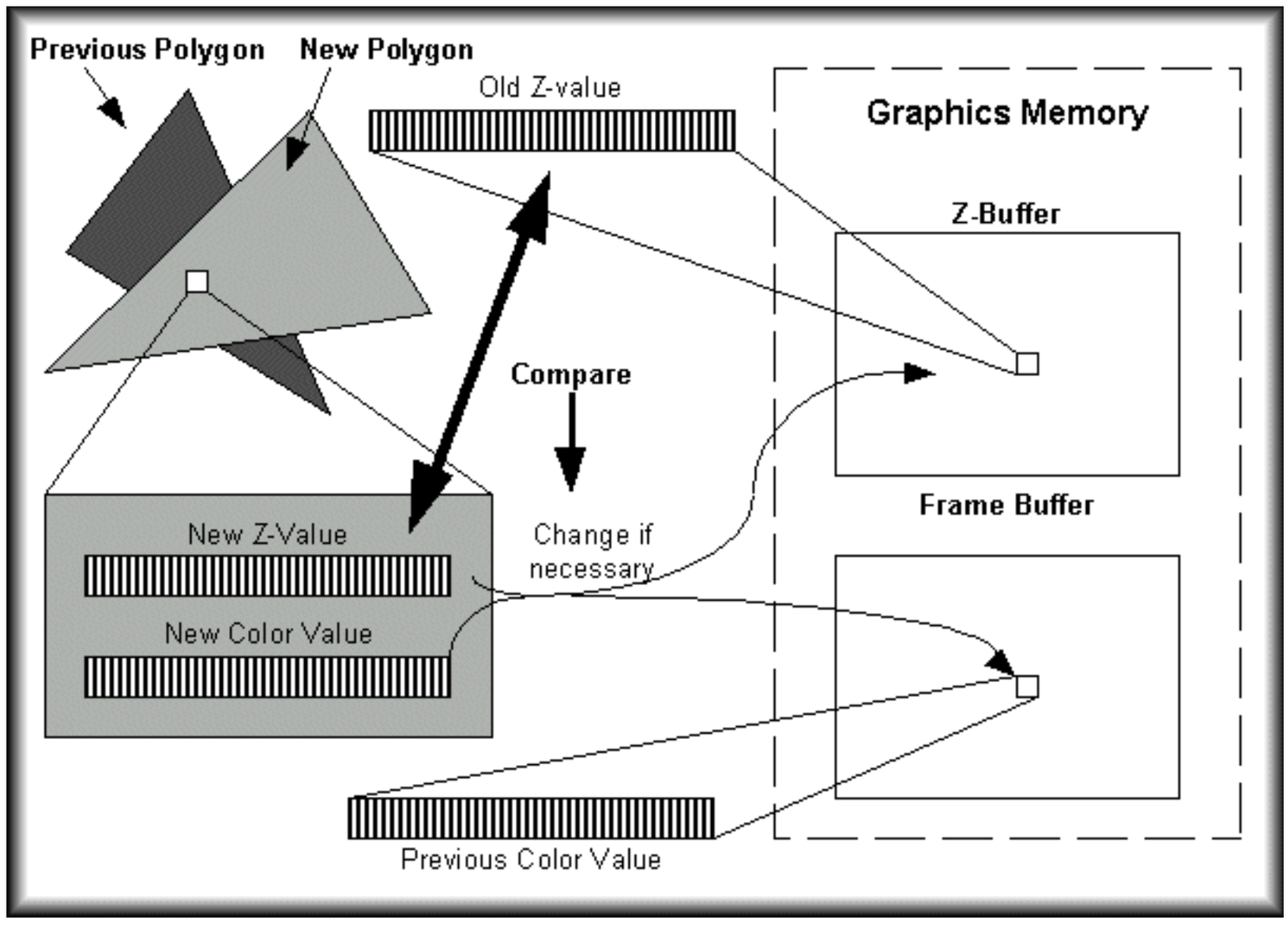






done in the **fragment blending** phase
- each fragment must carry a depth

Use a *z-buffer* for hidden surface removal



http://www.beyond3d.com/content/articles/41/