CS230 : Computer Graphics

Lecture 2: Primitives and modeling

Tamar Shinar
Computer Science & Engineering
UC Riverside

Primitives and Attributes

Choice of primitives

- Which primitives should an API contain?
  - small set - supported by hardware, *or*
  - lots of primitives - convenient for user

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Performance is in **10s millions polygons/sec -- portability, hardware support** key

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GPUs are optimized for
points, **lines**, and **triangles**

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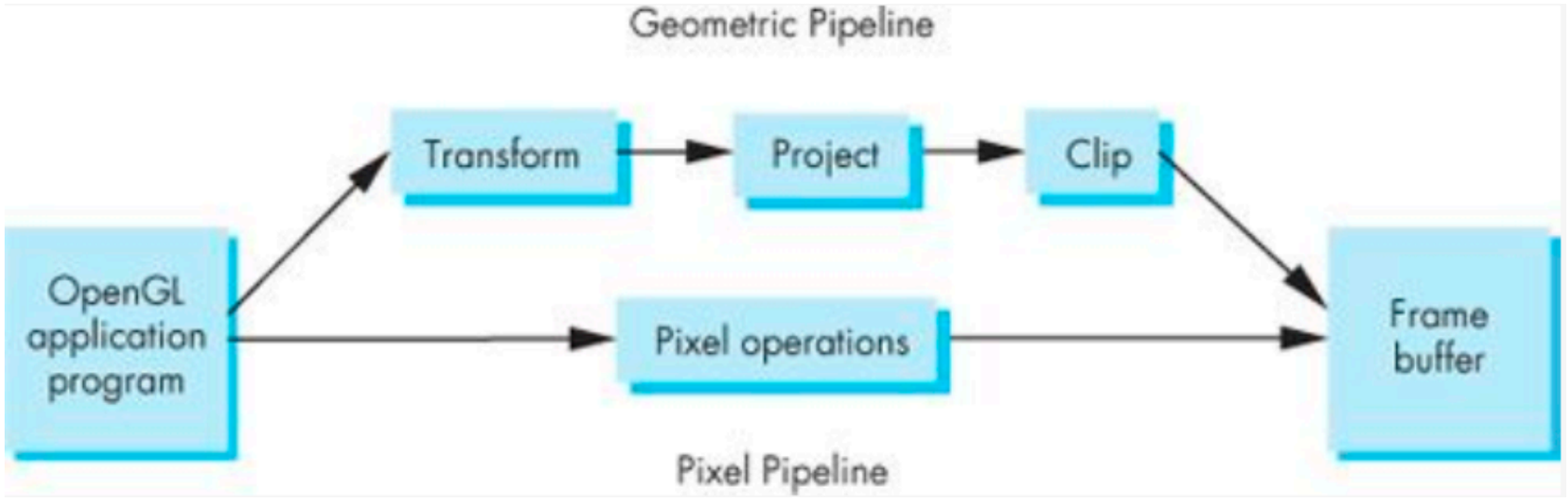
Other geometric shapes will be built out of these

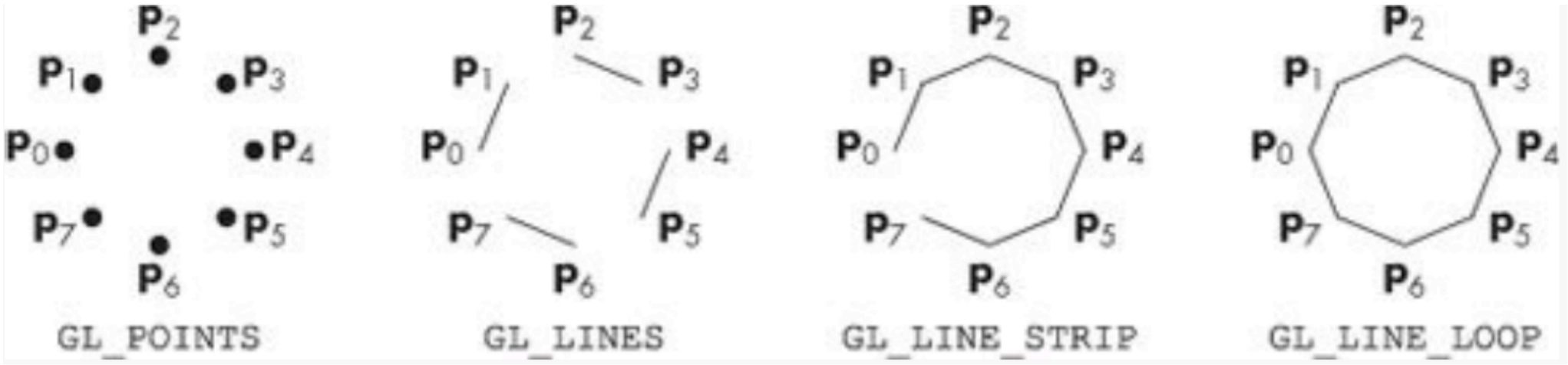
Two classes of primitives



Angel and Shreiner

Geometric : points, lines, polygons
Image : arrays of pixels

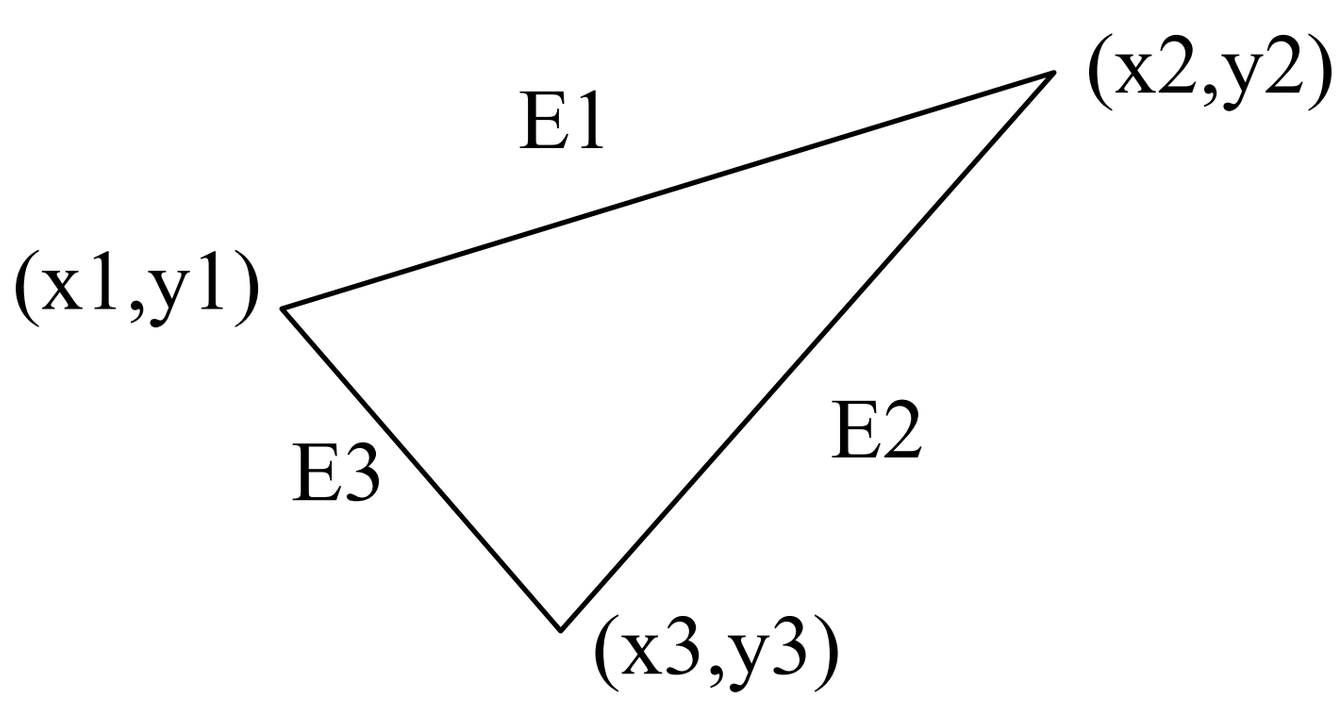
Point and line segment types



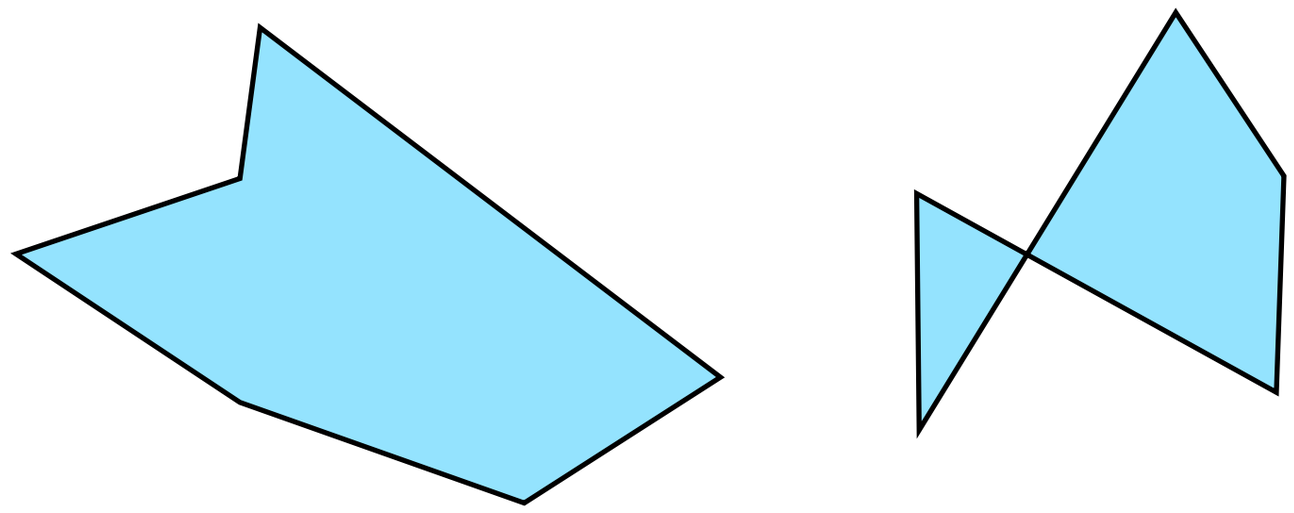
Angel and Shreiner

Polygons

- Multi-sided planar element composed of edges and vertices.
- Vertices (singular vertex) are represented by points
- Edges connect vertices as line segments

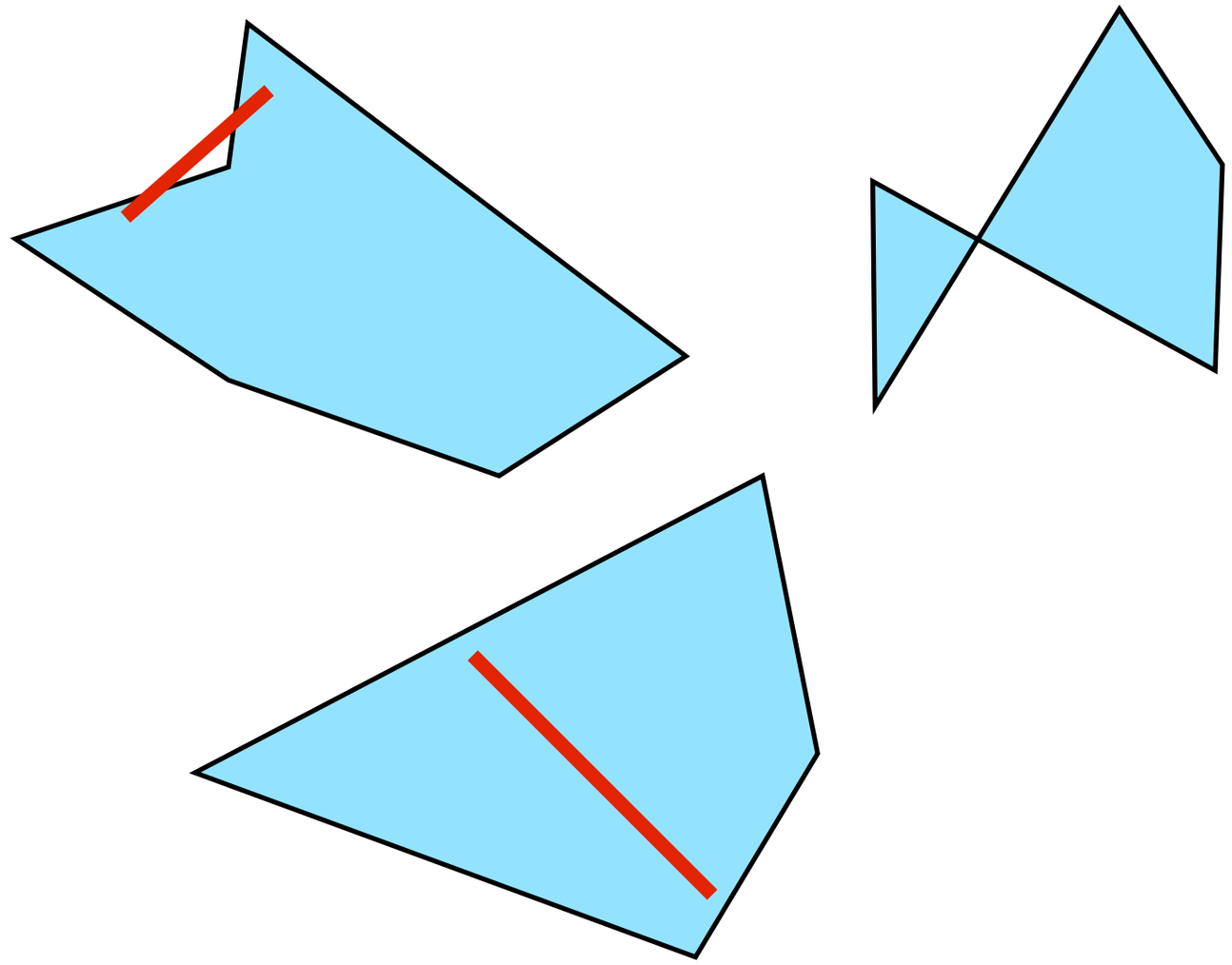


Valid polygons



- Simple
- Convex
- Flat

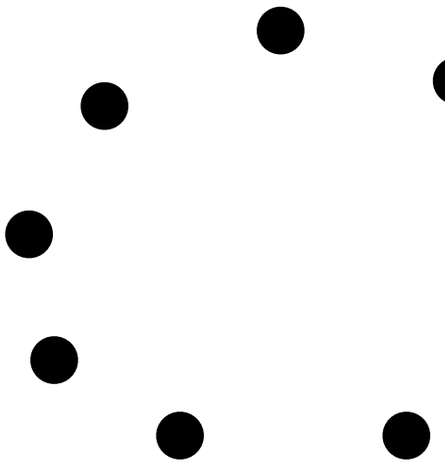
Valid polygons



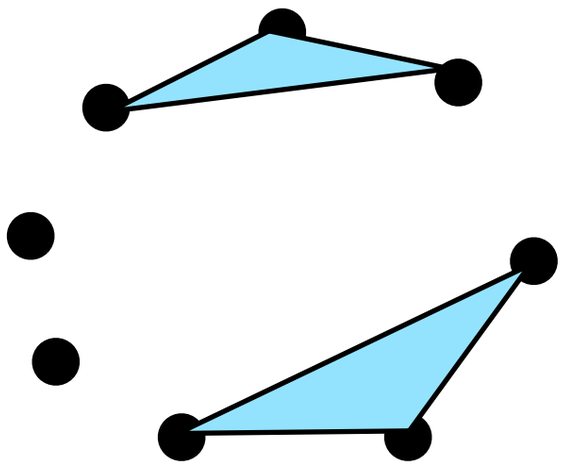
- Simple
- Convex
- Flat

OpenGL polygons

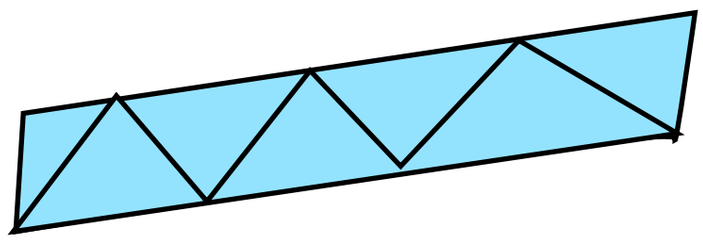
- Only triangles are supported (in latest versions)



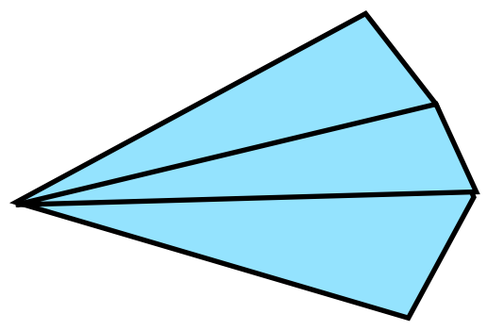
GL_POINTS



GL_TRIANGLES

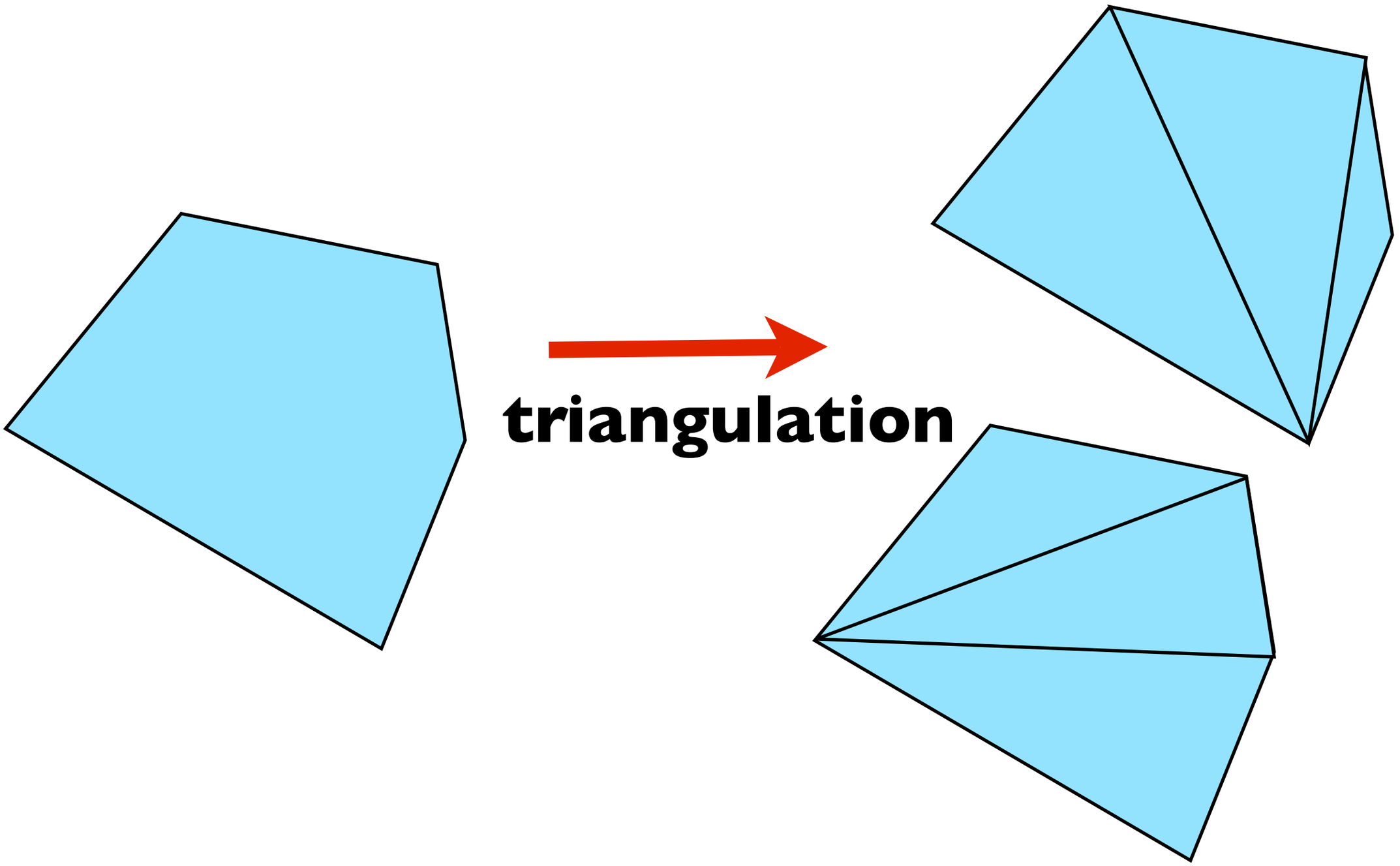


GL_TRIANGLE_STRIP



GL_TRIANGLE_FAN

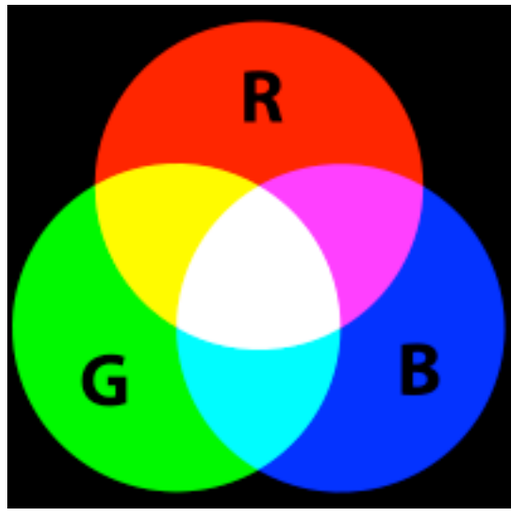
Other polygons



triangulation

as long as triangles are not **collinear**, they will be **simple**, **flat,** and **convex -- easy to render**

Sample attributes



- Color glClearColor(1.0, 1.0, 1.0, 1.0);
- Point size glPointSize(2.0);
- Line width glLineWidth(3.0);

Coordinate systems and transformations

Viewing transformations

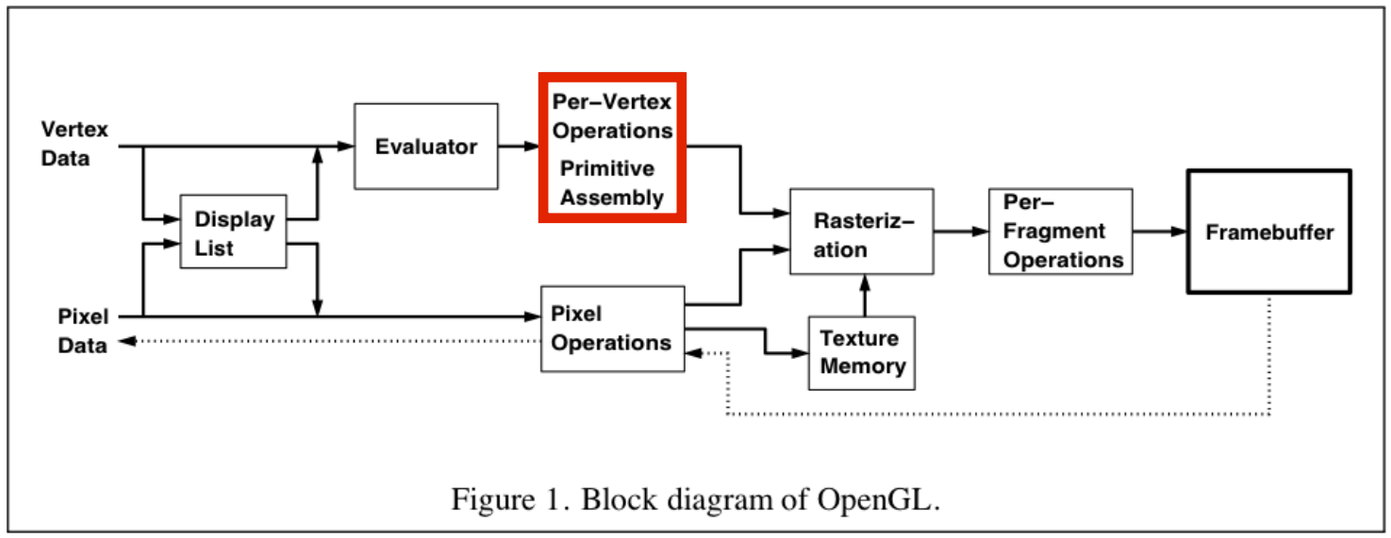
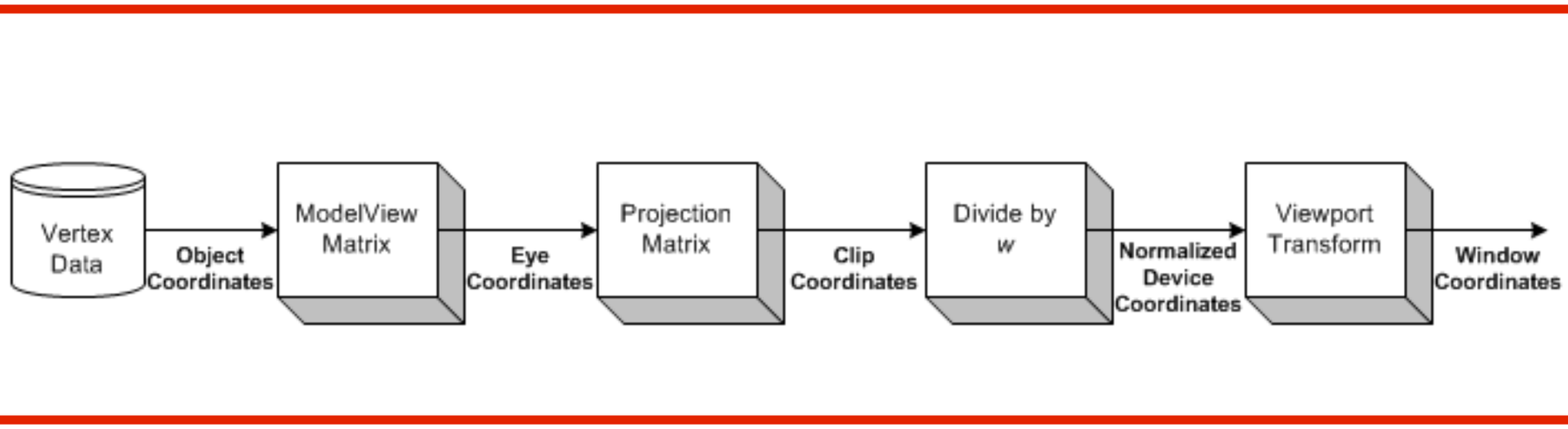
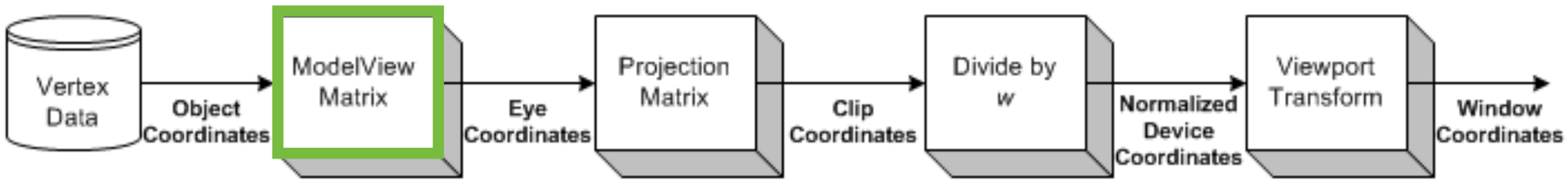
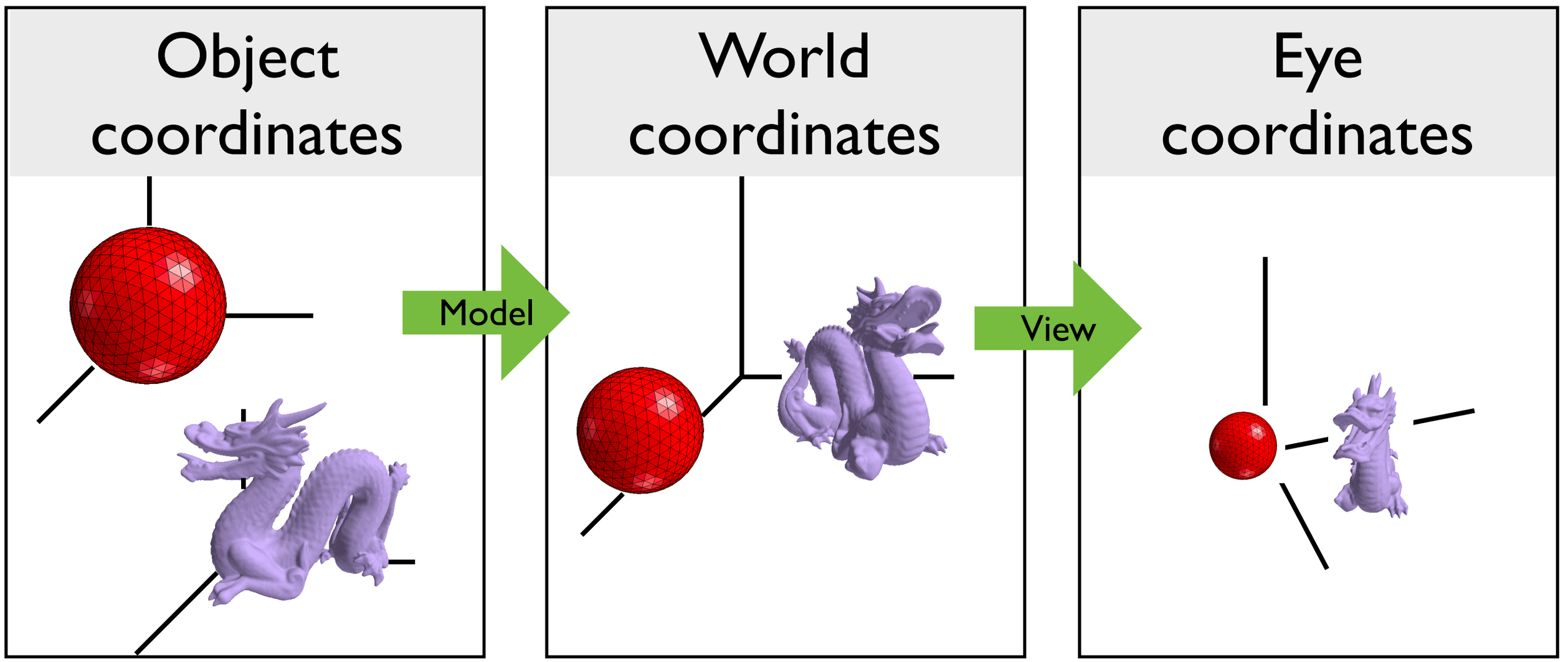


Figure 1. Block diagram of OpenGL.



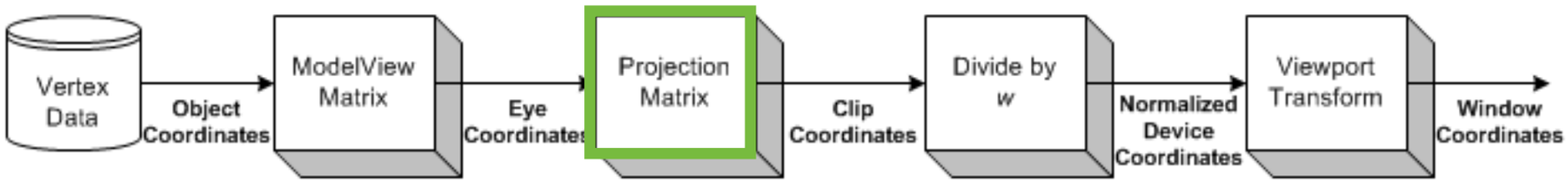
Viewing transformations



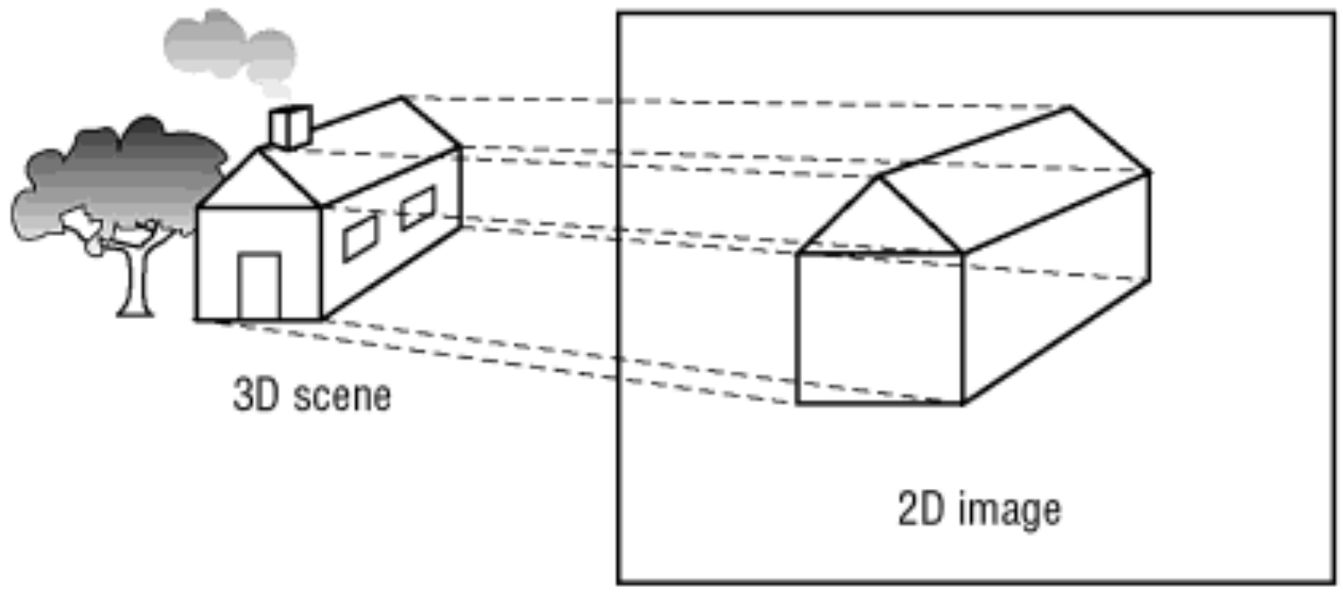


- viewing coordinates are based on the position and orientation of a the virtual camera
- 2D projection of the scene
- normalized device coordinates
- finally we get device or screen coordinates
- modeling -> world -> viewing -> projection -> normalized -> device

Viewing transformations



Projection: map 3D scene to 2D image



OpenGL Super Bible, 5th Ed.

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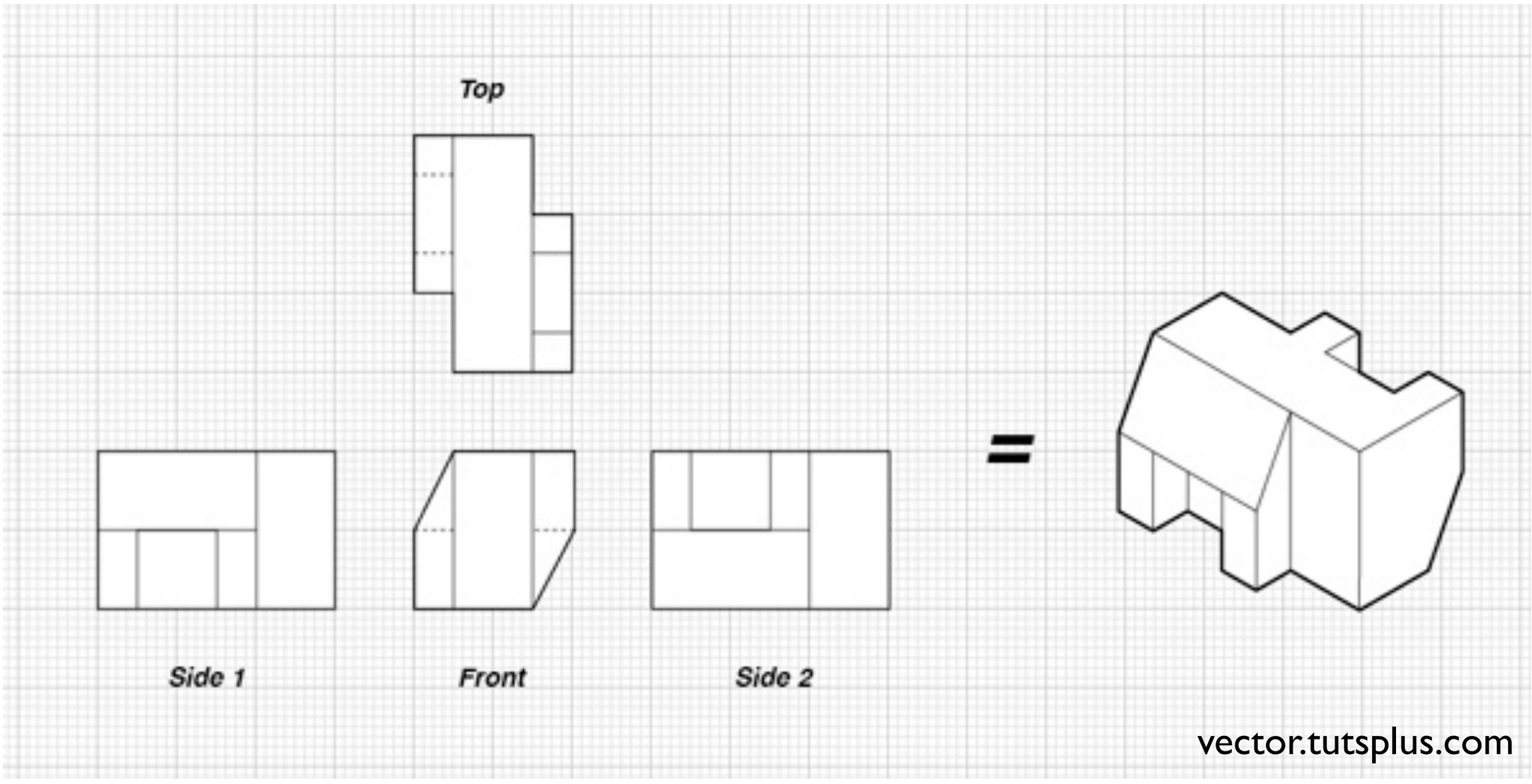
Orthographic projection

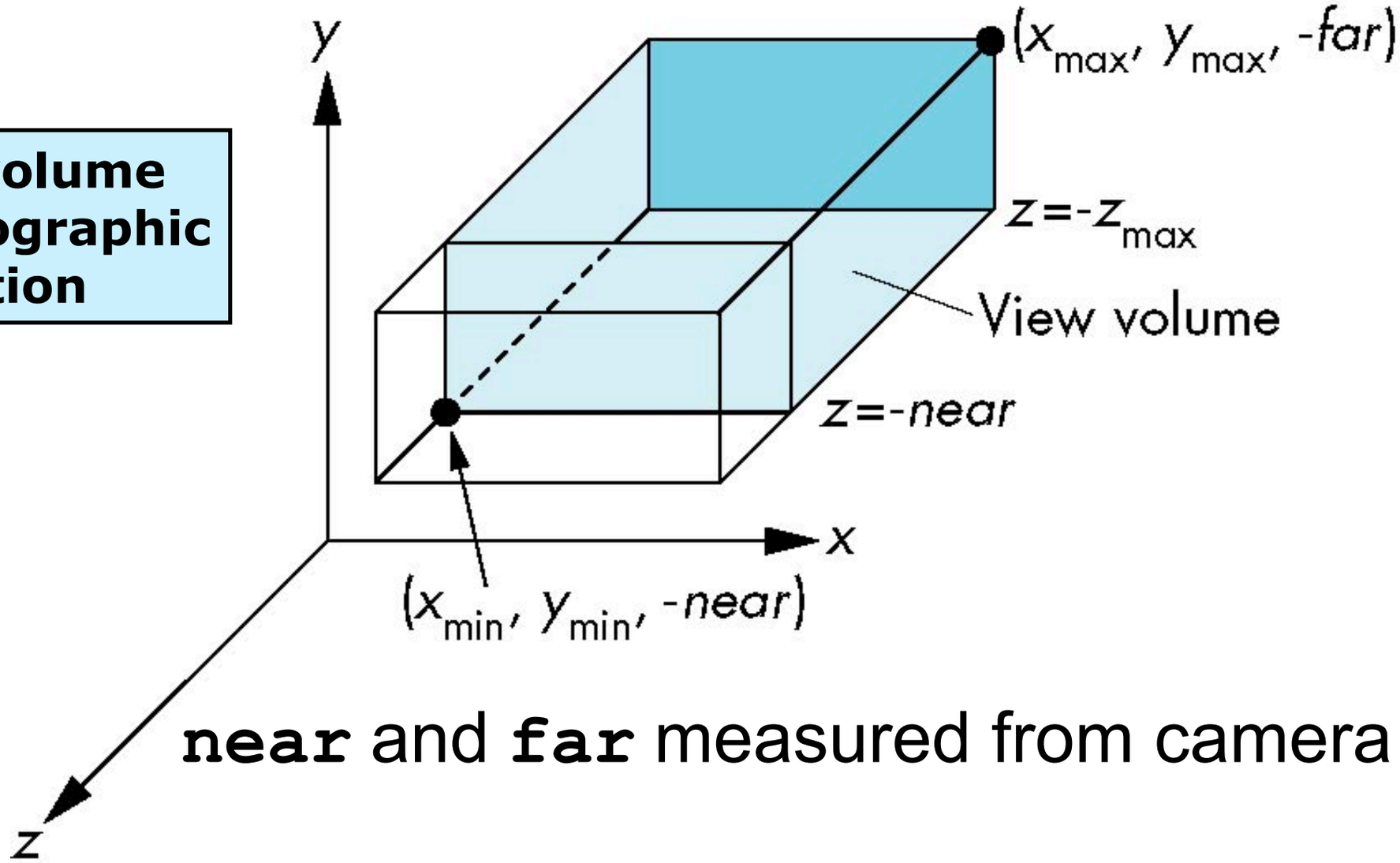


Orthographic, or parallel projection
- square or rectangular viewing volume
- anything outside volume is not drawn
- all objects of same dimension appear the same regardless of distance from camera

OpenGL Orthogonal Viewing

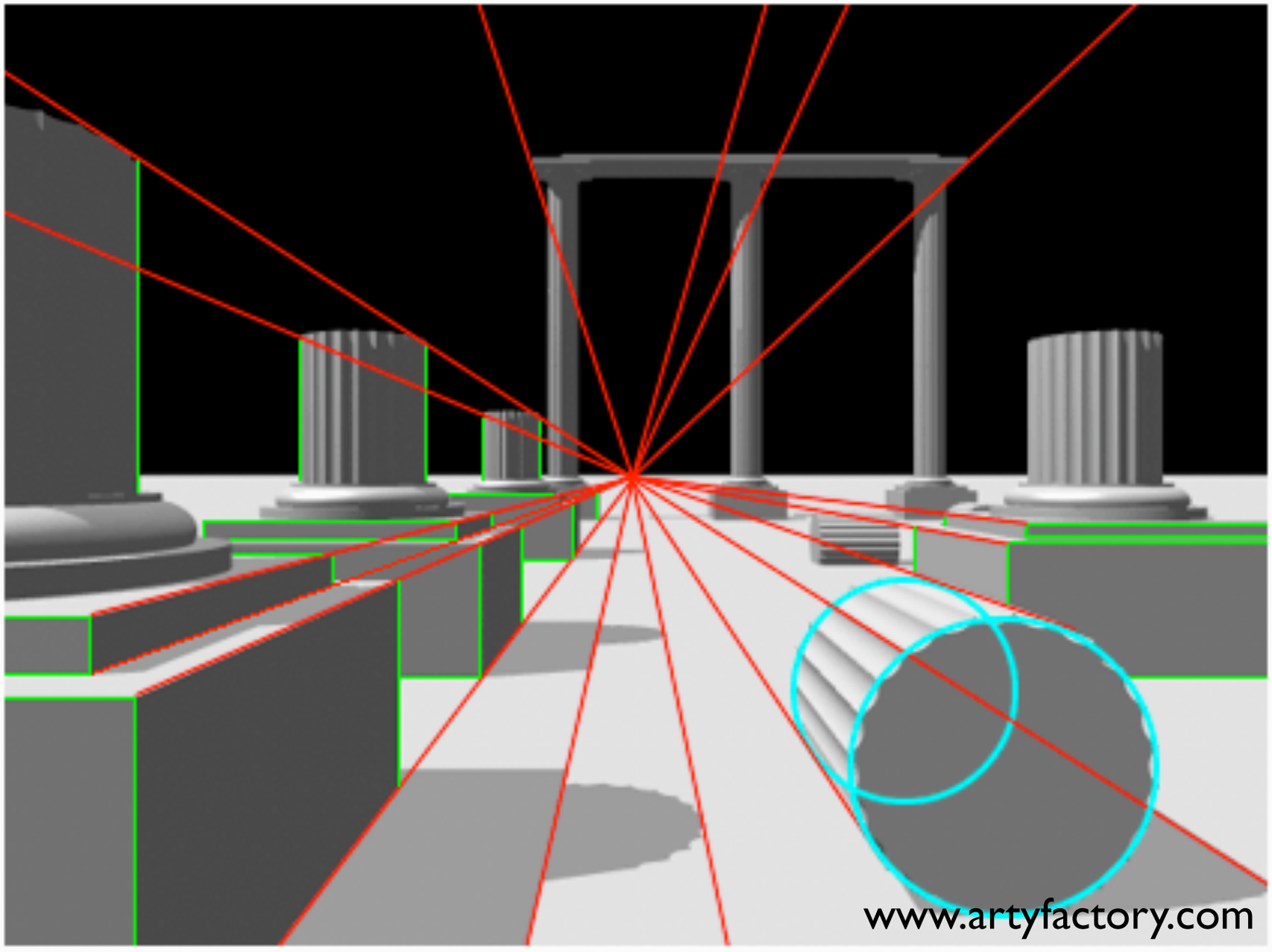
```
glOrtho(xmin,xmax,ymin,ymax,near,far)
glOrtho(left,right,bottom,top,near,far)
```

Clipping volume for an orthographic projection



`near` and **`far`** measured from camera

Perspective projection

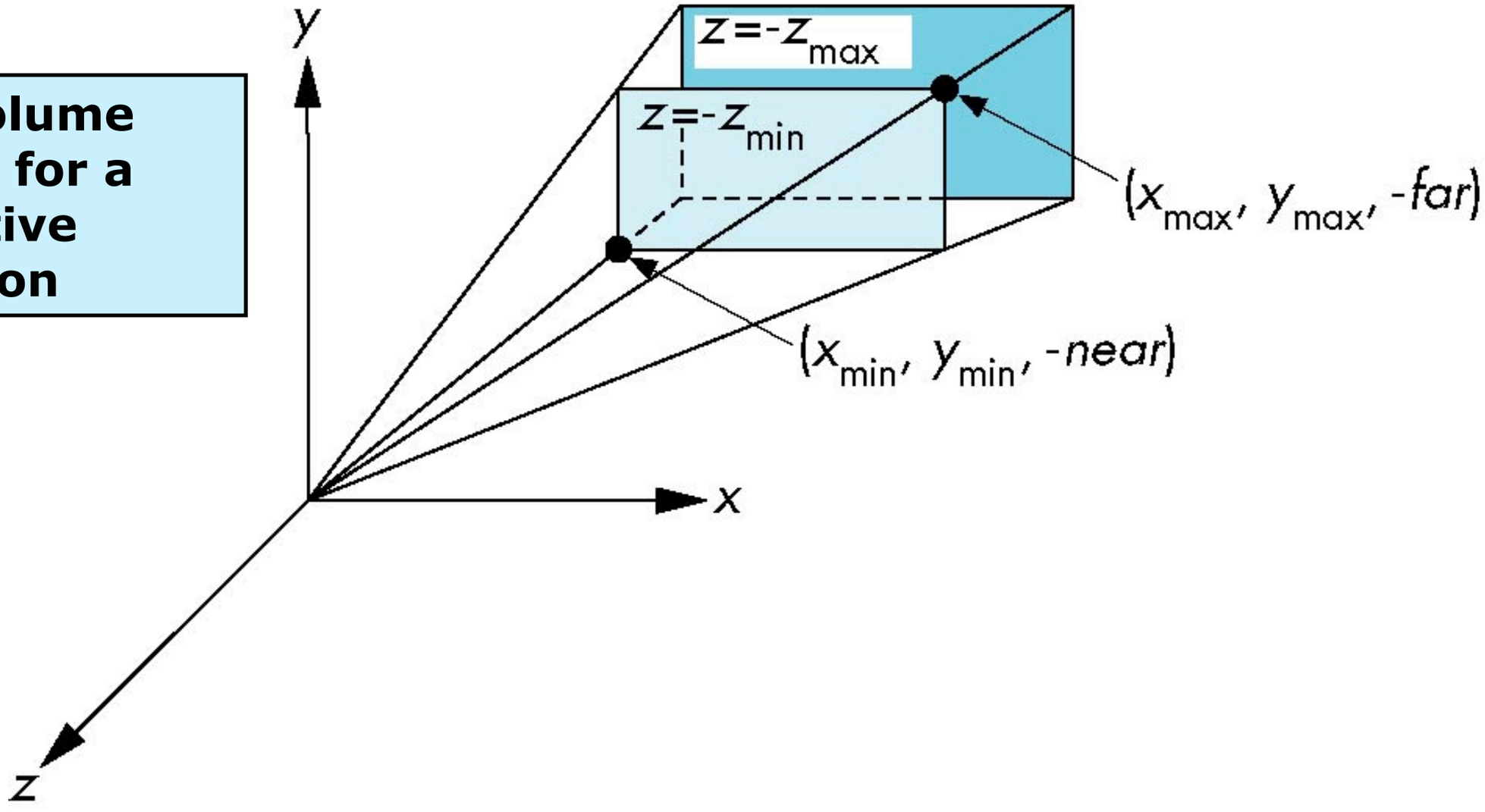


Orthographic, or parallel projection
- square or rectangular viewing volume
- anything outside volume is not drawn
- all objects of same dimension appear the same regardless of distance from camera

OpenGL Perspective Viewing

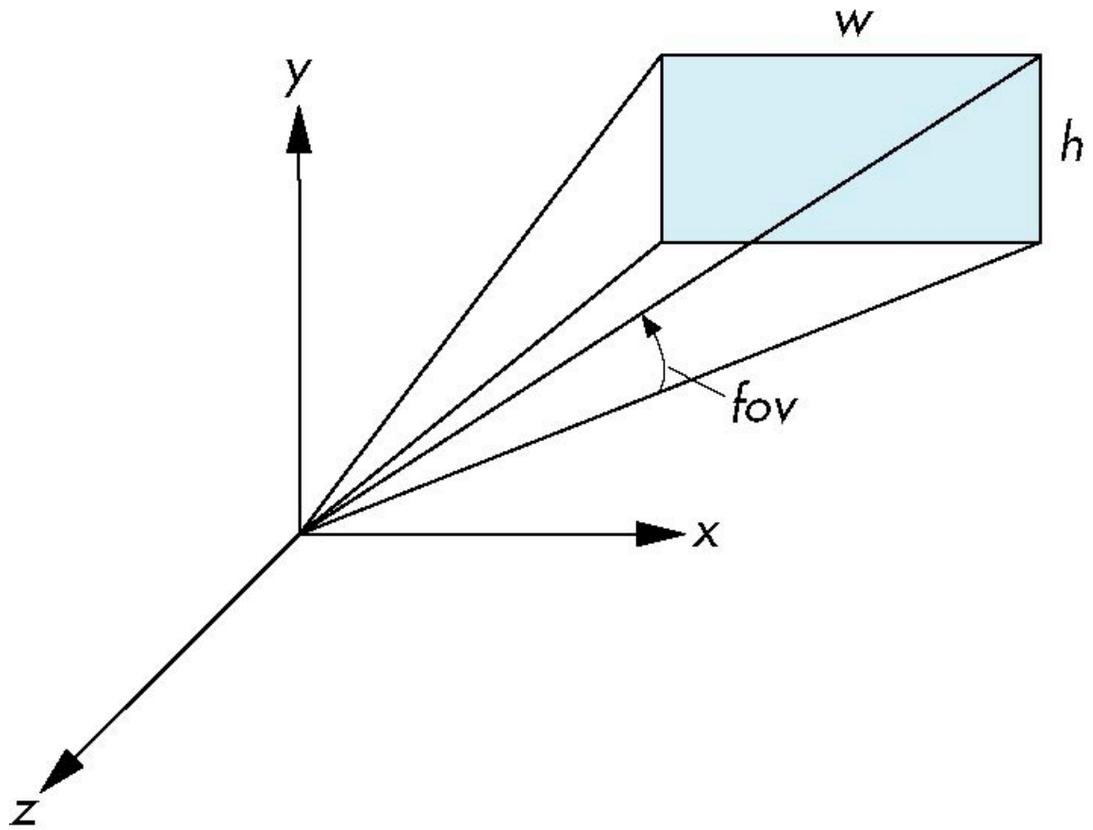
`glFrustum(xmin,xmax,ymin,ymax,near,far)`

Clipping volume (frustrum) for a perspective projection



Using Field of View

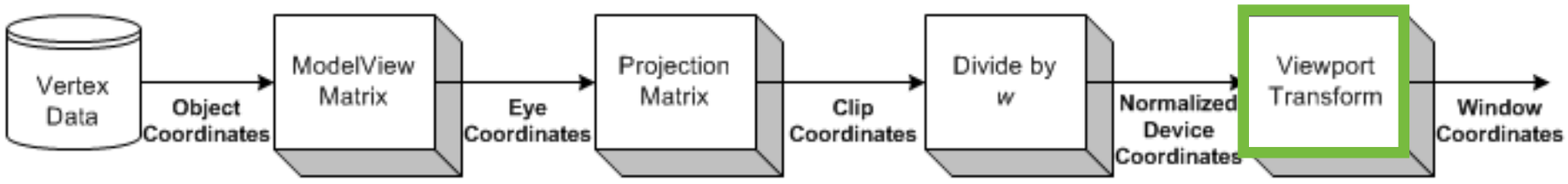
With **`glFrustum`** it is often difficult to get the desired view **`gluPerpective(fovy, aspect, near, far)`** often provides a better interface

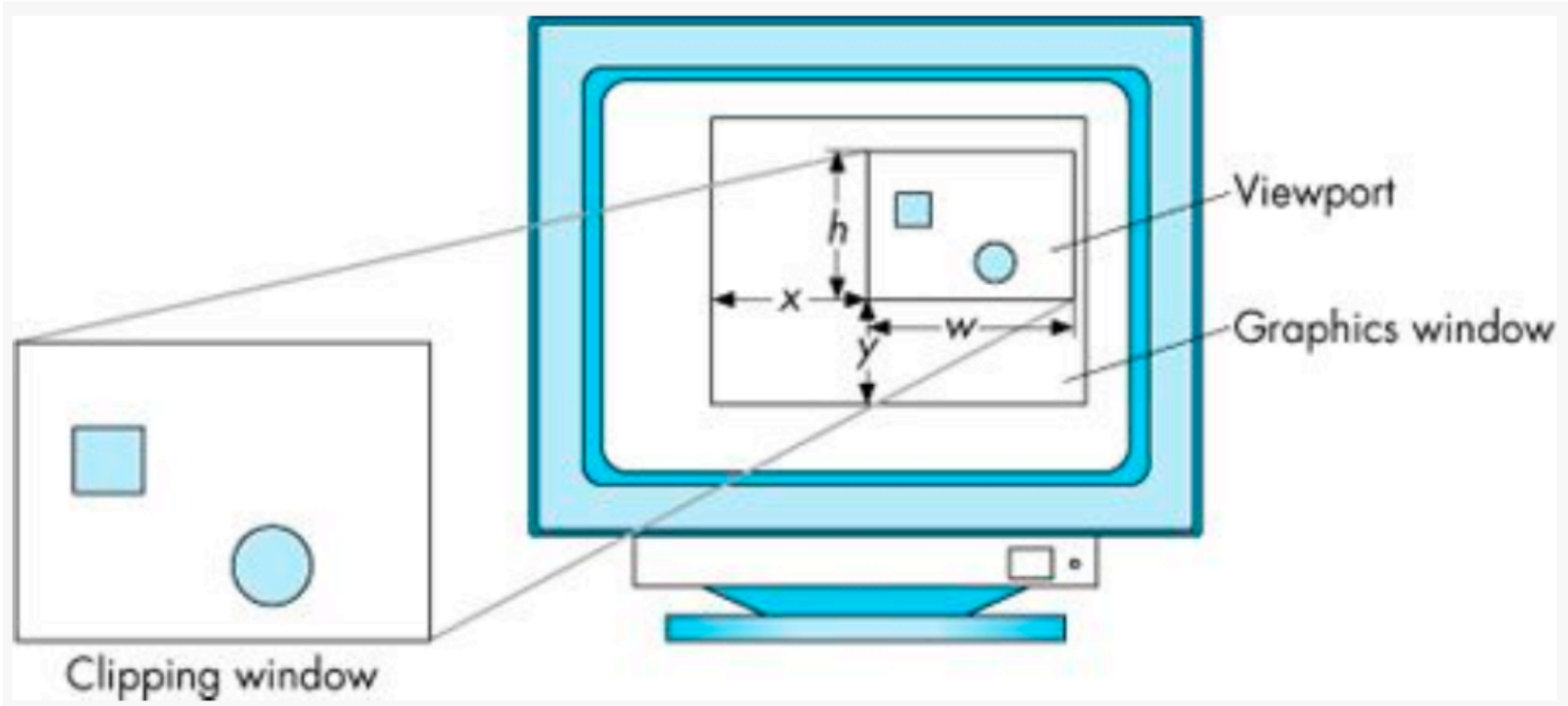


front plane

`aspect = w/h`

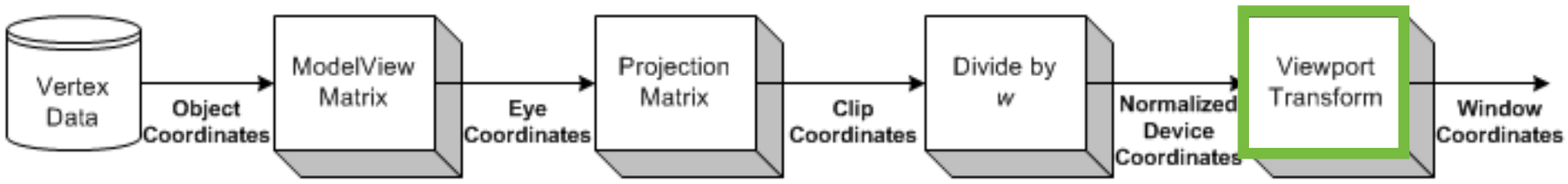
Viewport transformation

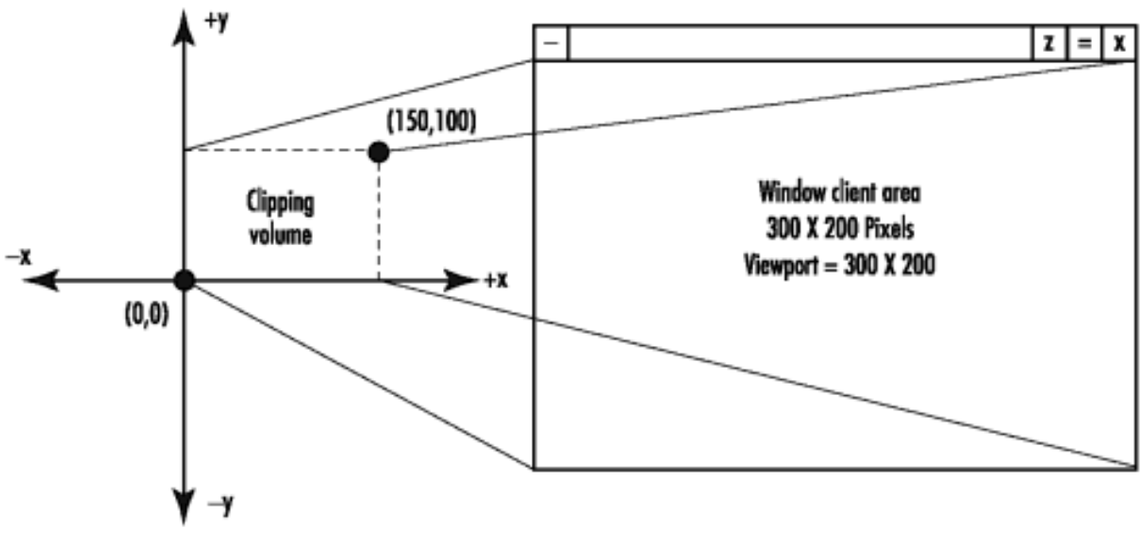




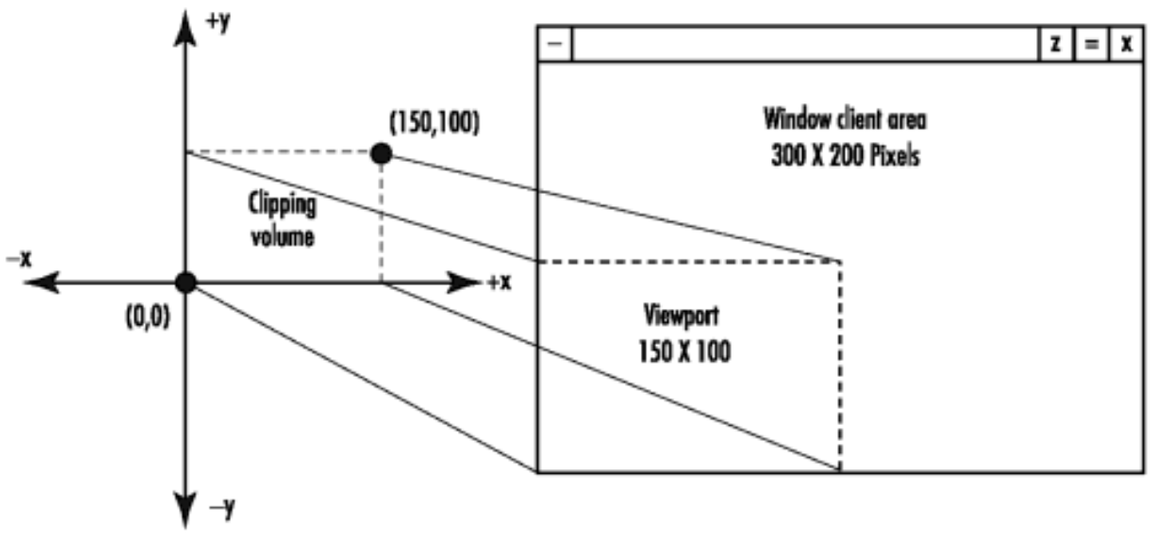
Angel and Shreiner

Viewport transformation



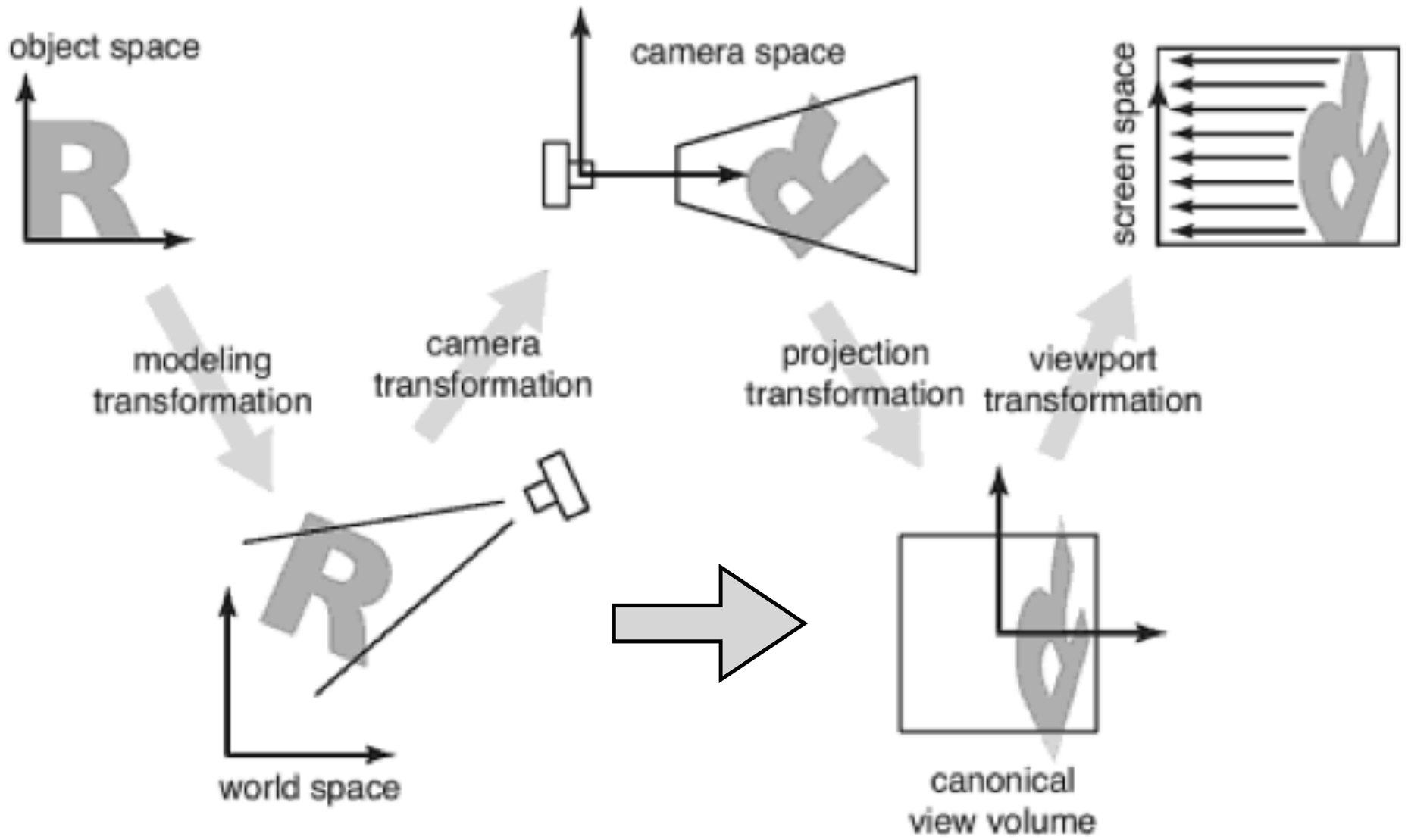


Viewport is the whole window



Viewport is the lower left corner

Viewing transformations

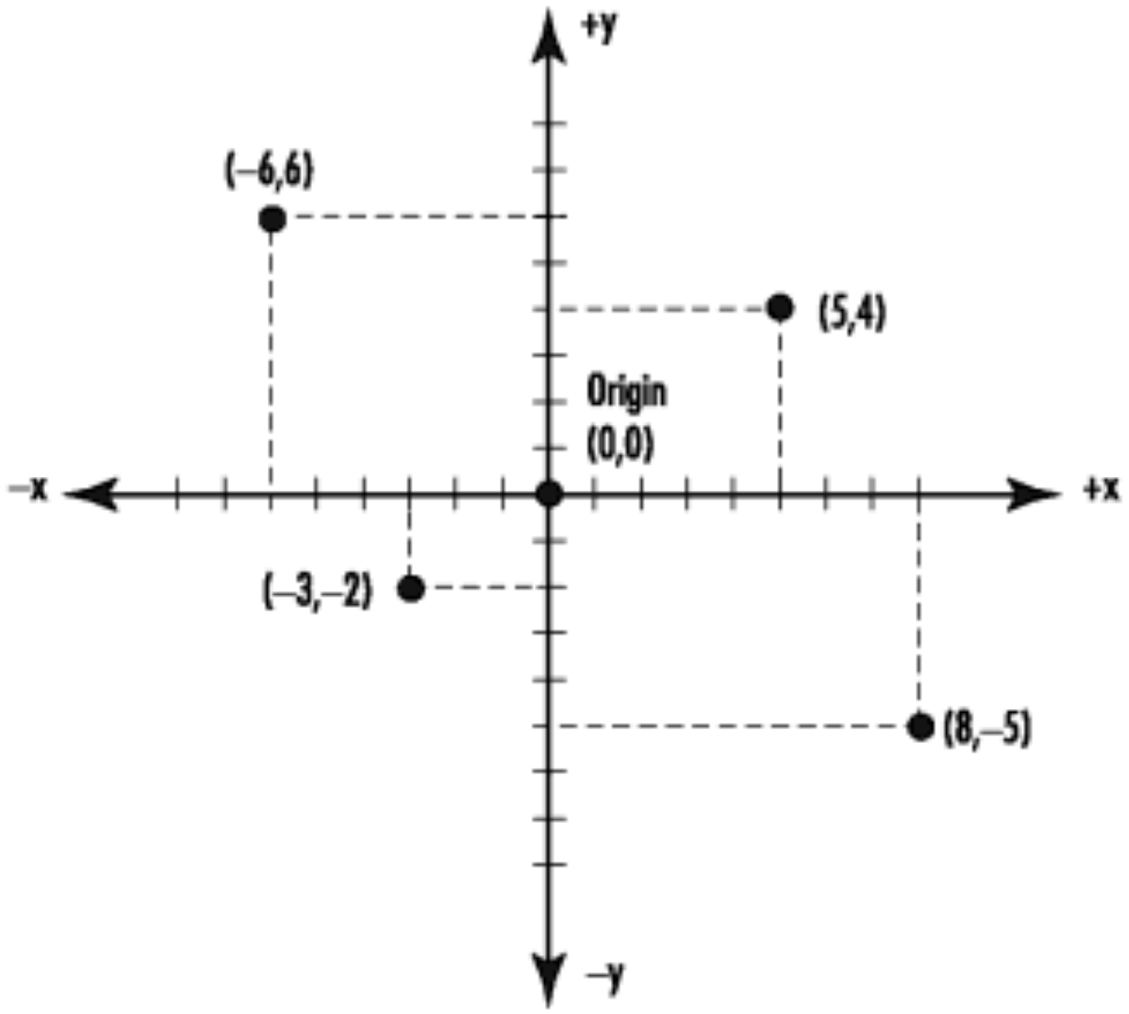


Fundamentals of Computer Graphics, Shirley and Marschner

- **Camera transformation**: rigid body transformation that places the camera at the origin and in a convenient orientation
- **Projection transformation:** project to canonical view volume all coordinates end up between 0 and 1 or −1 and 1
- **Viewport or windowing transformation:** normalized coordinates to pixel coordinates

Scalars, points and vectors

Cartesian coordinates



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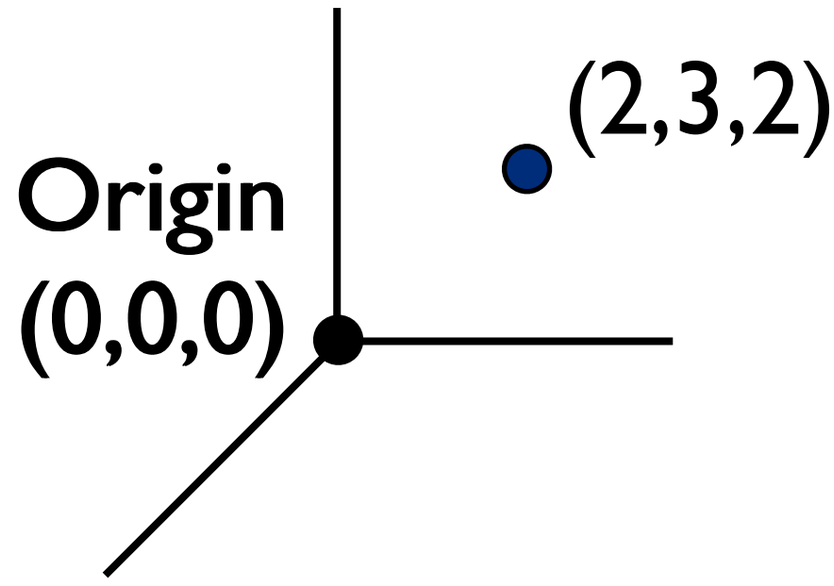


two-dimensional	three-dimensional

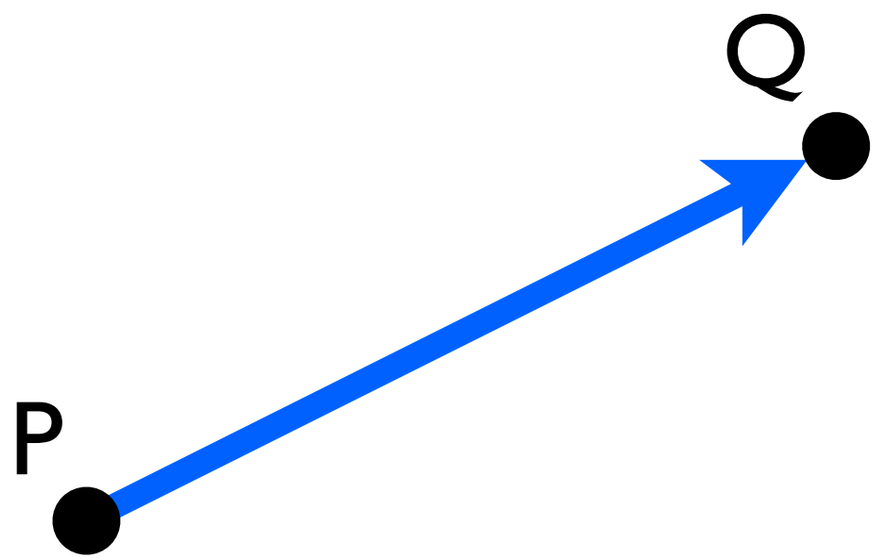
Points

- A point is a location in space

Reference: Angel, Chapter 3

Vectors

- A vector is a directed line segment



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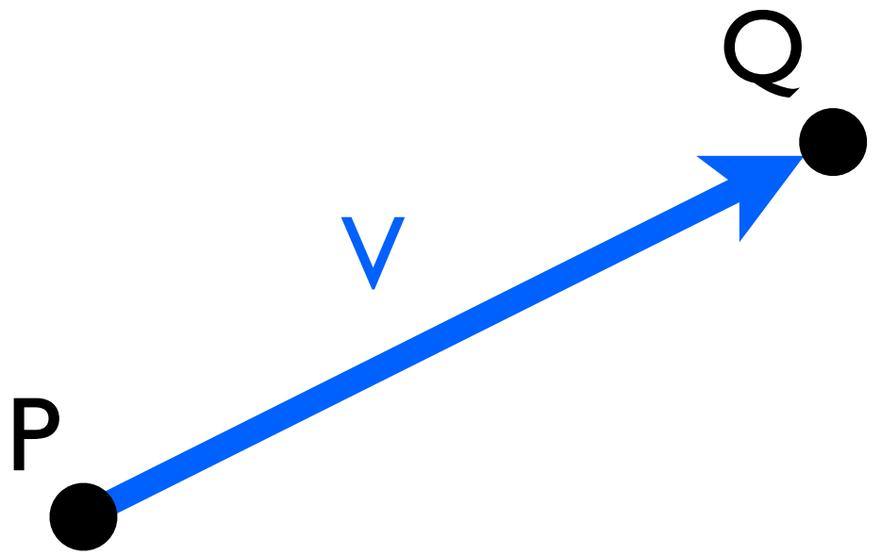
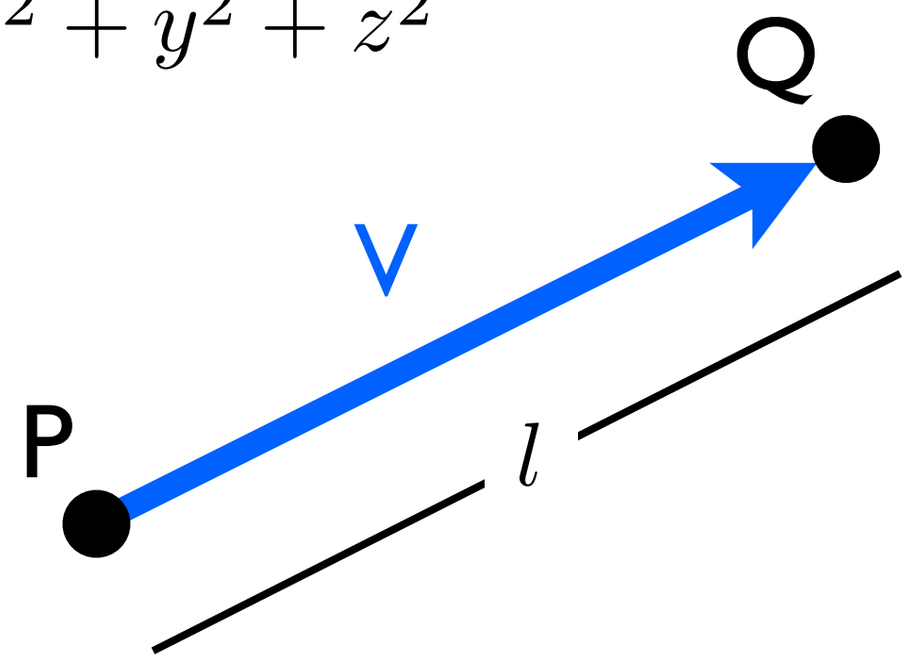


Vectors

- Vectors have length and direction

$$l = |V| = \sqrt{x^2 + y^2 + z^2}$$

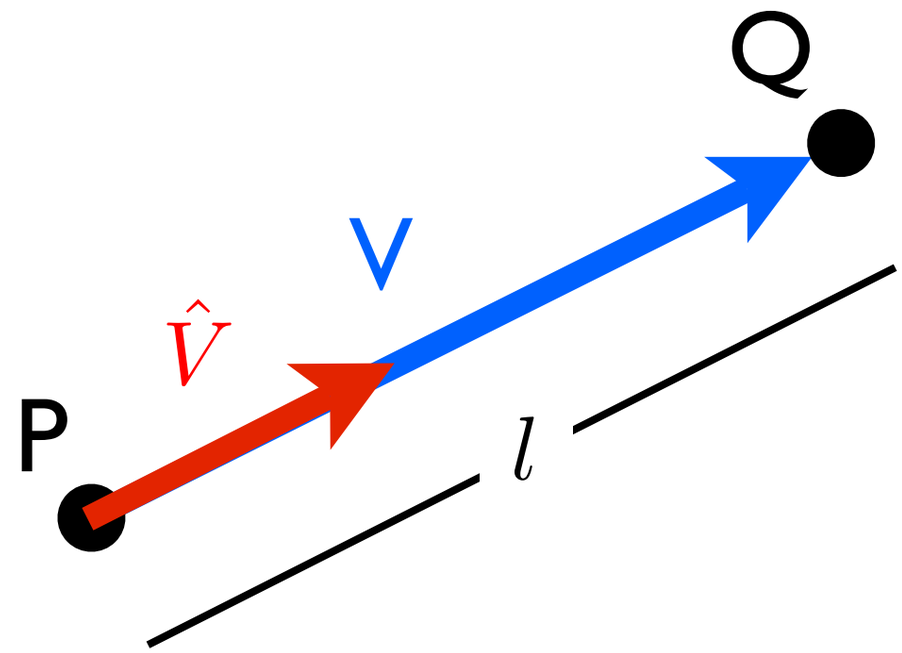


Vectors

- Vectors have length and direction

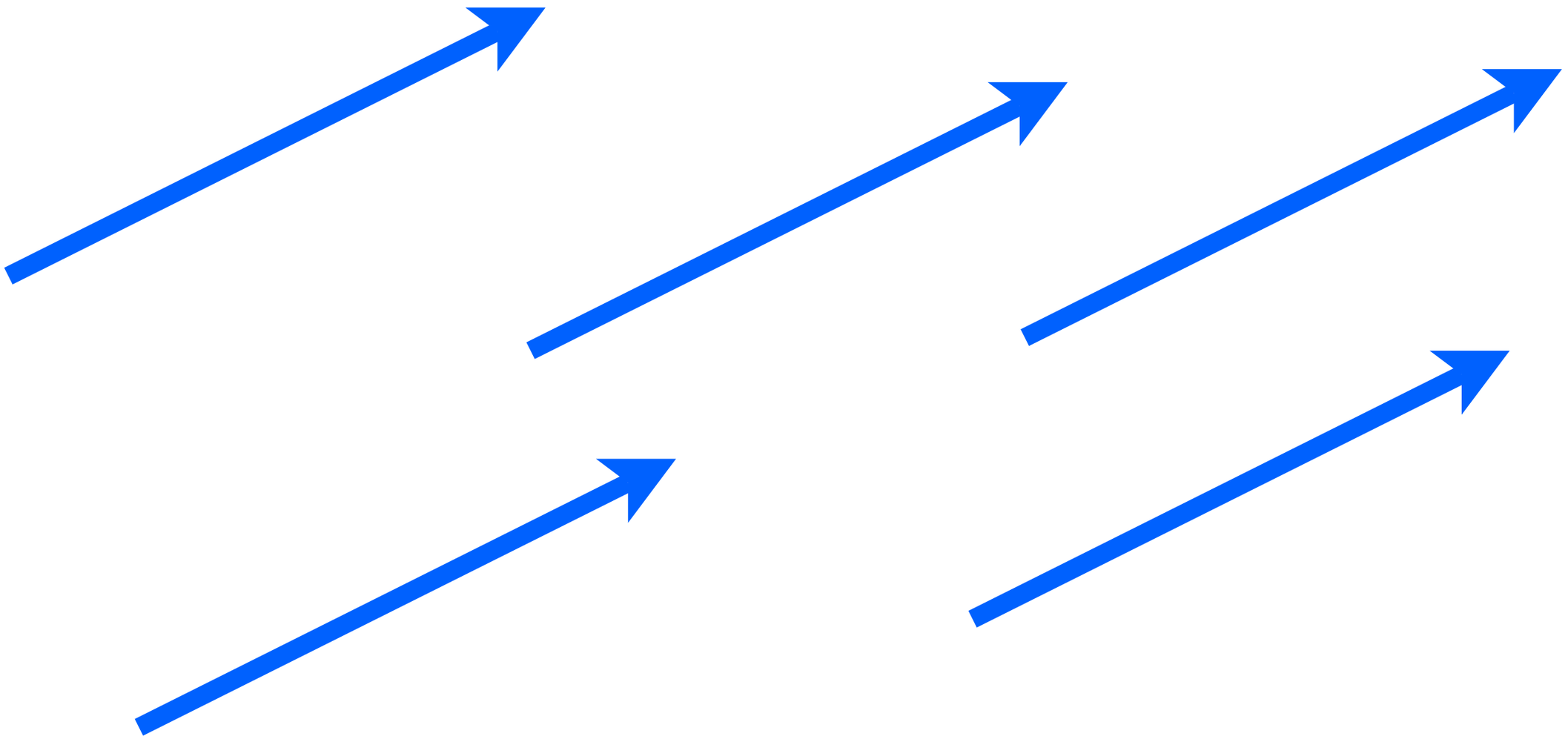
$$\hat{V} = \frac{V}{|V|}$$

$$|\hat{V}| = 1$$



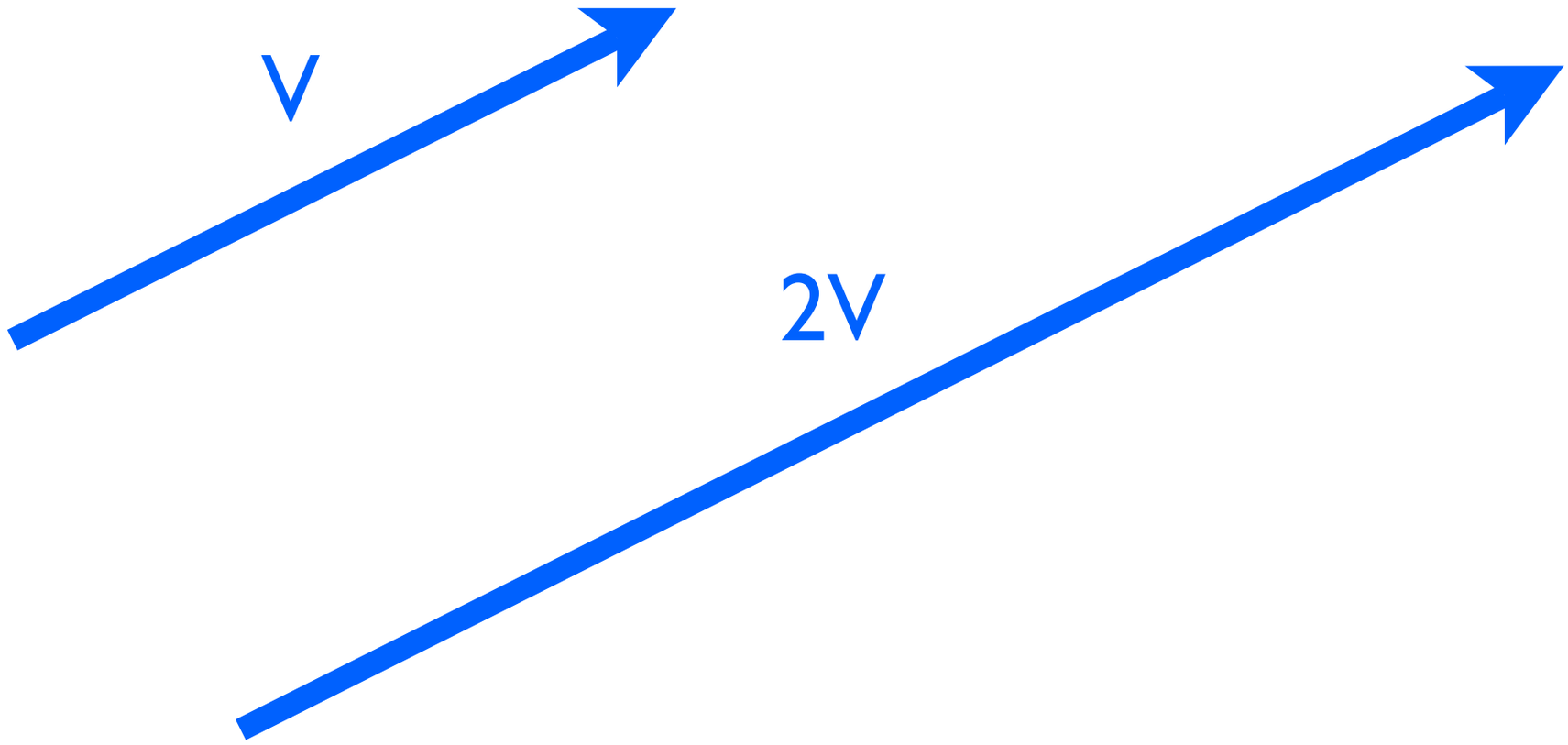
Vectors

- These vectors are all the same



Vectors

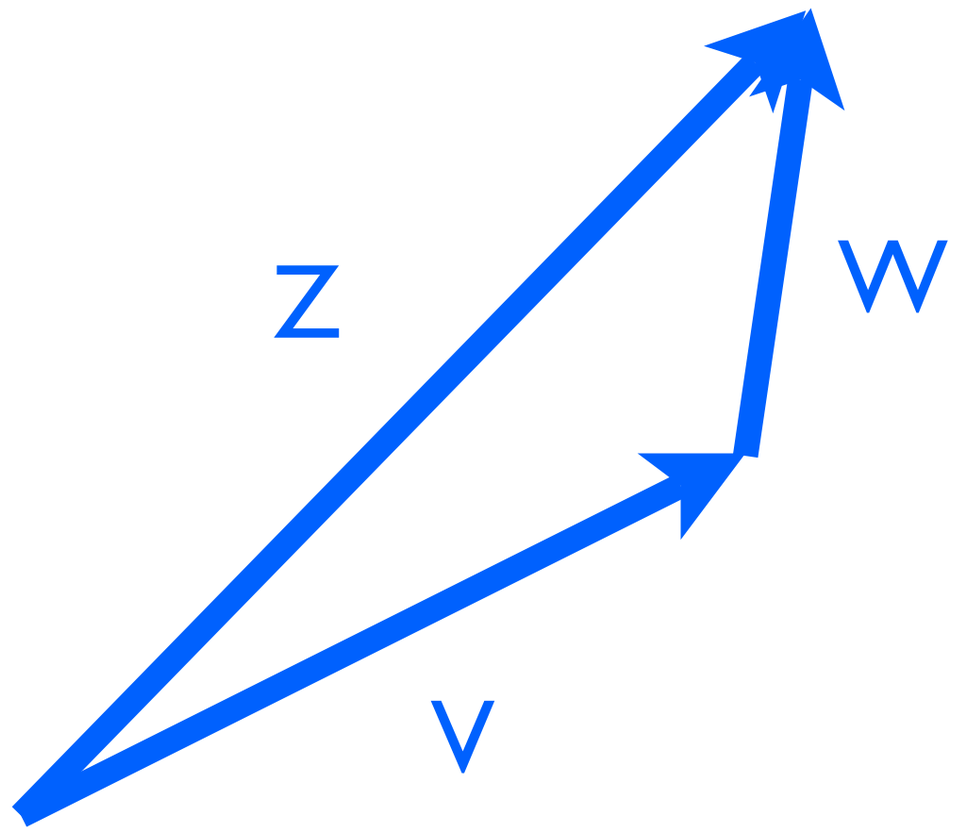
- Vector scaling



Vectors

- Vector addition $Z = V + W$

  " head-to-tail rule "



<whiteboard>