CSI 3202 Micro-Computer Graphics Viewing & Projections

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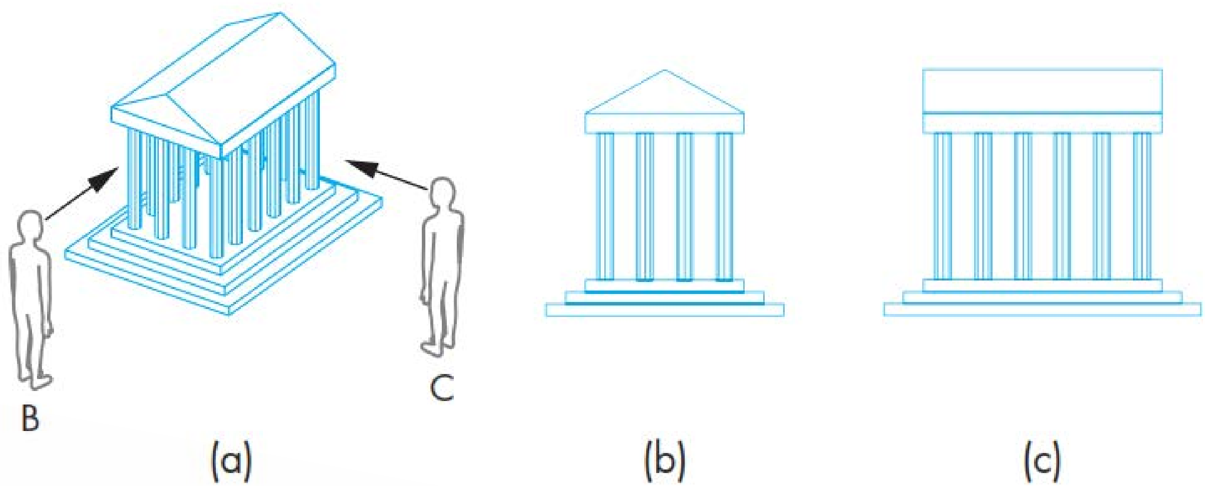
Outline

- Objects & Viewers
- Light & Objects
- Imaging Models
- What is Projection?
- Planar Geometric Projections
  - Non-planar geometric projections
- Parallel Projection
  - Orthographic Projection
  - Multi-view Orthographic Projection
  - Oblique Projection
- Perspective Projection
  - One point perspective
  - Two-point perspective
- Questions?
- Review Questions
- Resources

Objects & Viewers

- How an object looks depends on the position/location of the viewer. – True? Or False?
- Image Formation Process depends on the object & viewer and the spatial relationship between the two.



Light & Objects

- Image Formation also depend on light sources (presence of light).
- Light also influence the object's color and casts shadows.

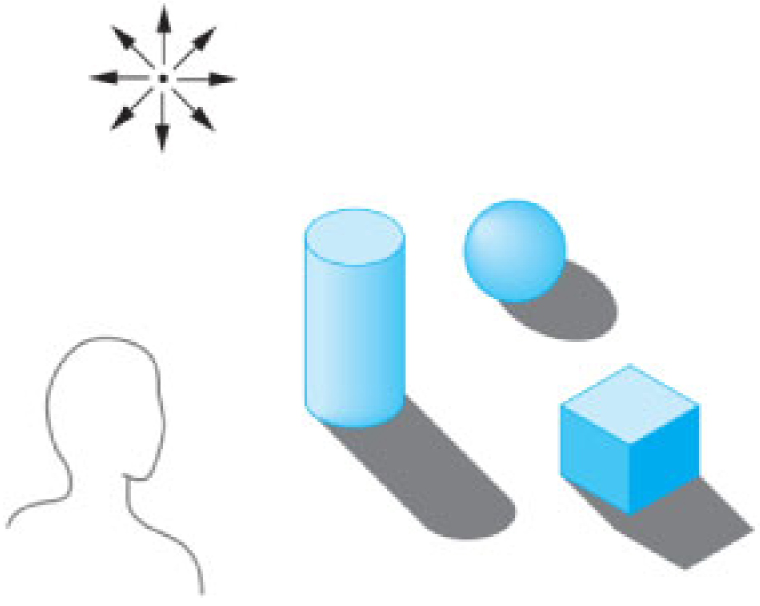


FIGURE 1.17 Scene with a single point light source.

Imaging Models

- Ray Tracing (Photon Mapping) –generally light travels in straight lines

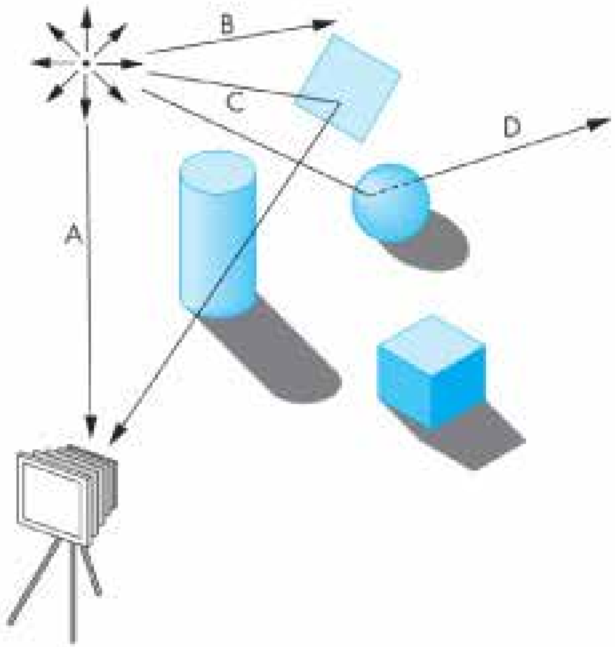


FIGURE 1.18 Ray interactions. Ray A enters camera directly. Ray B goes off to infinity. Ray C is reflected by a mirror. Ray D goes through a transparent sphere.

Imaging Systems

- The Pinhole Camera

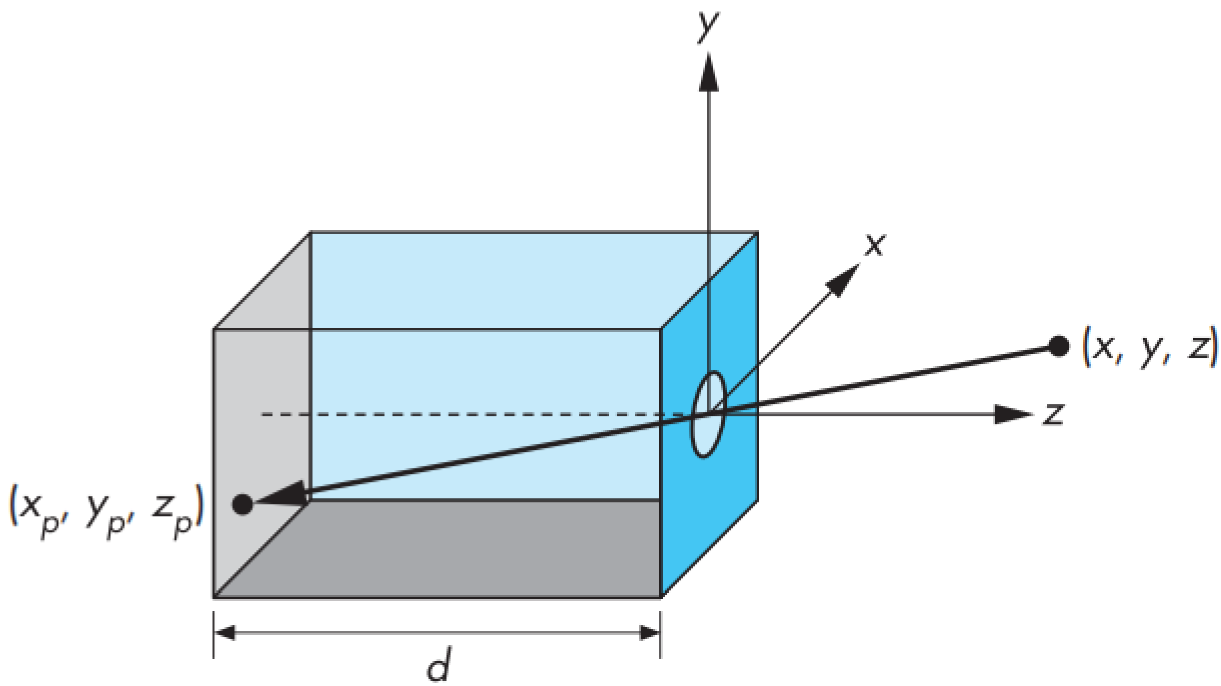
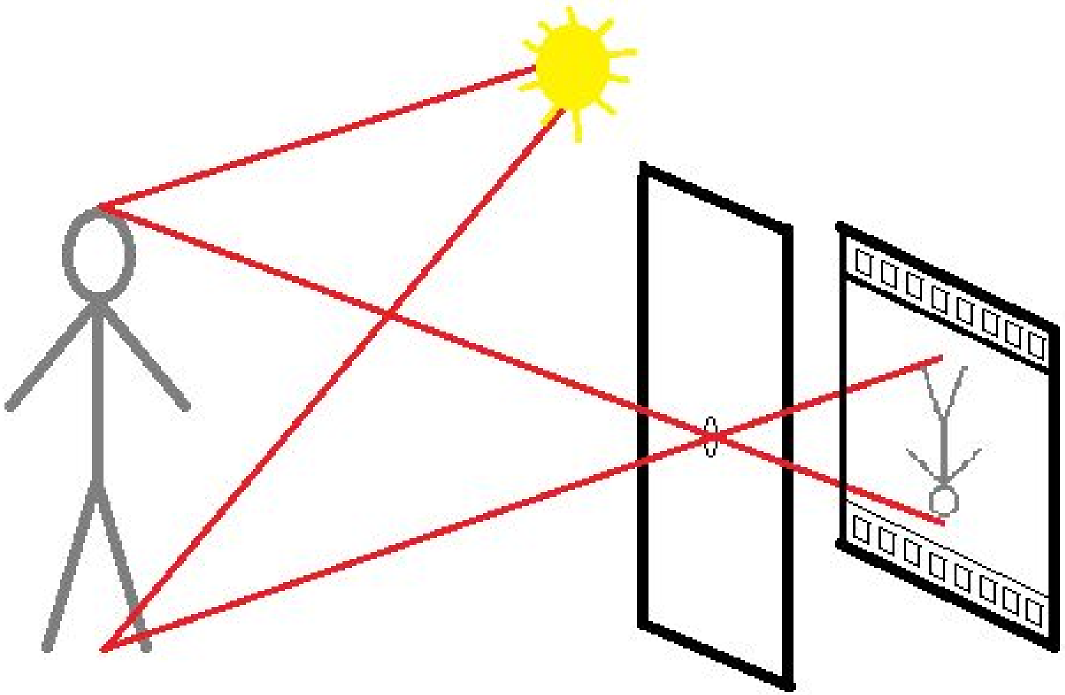


FIGURE 1.19 Pinhole camera.

Pinhole Camera



Synthetic-Camera Model

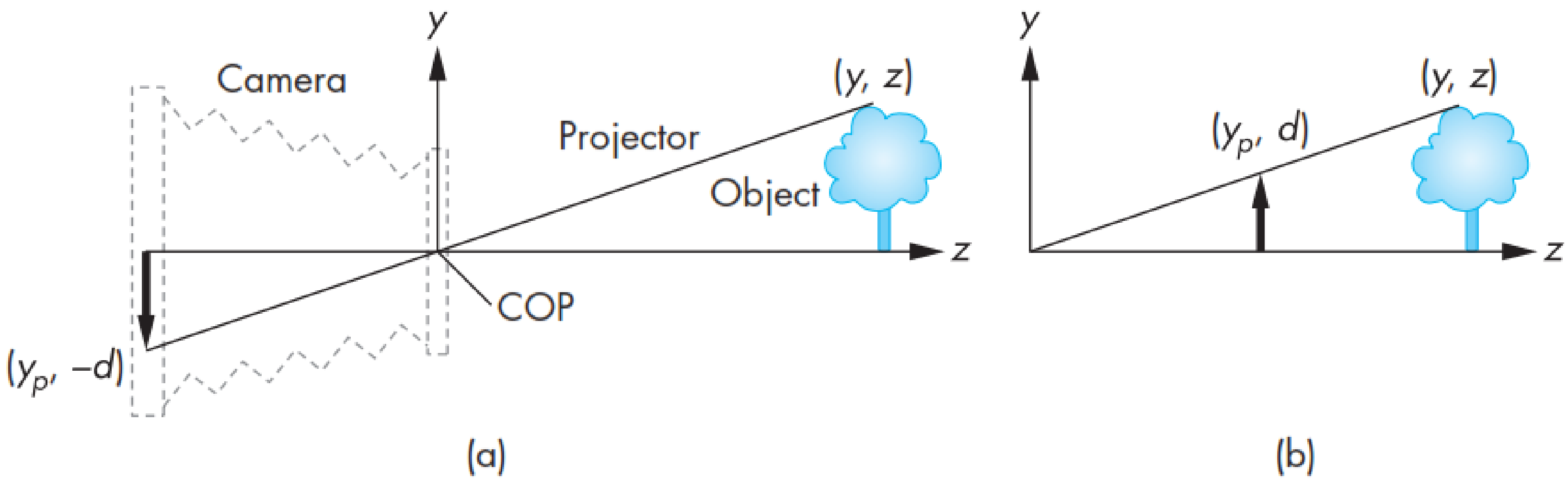


FIGURE 1.24 Equivalent views of image formation. (a) Image formed on the back of the camera. (b) Image plane moved in front of the camera.

Projection Plane

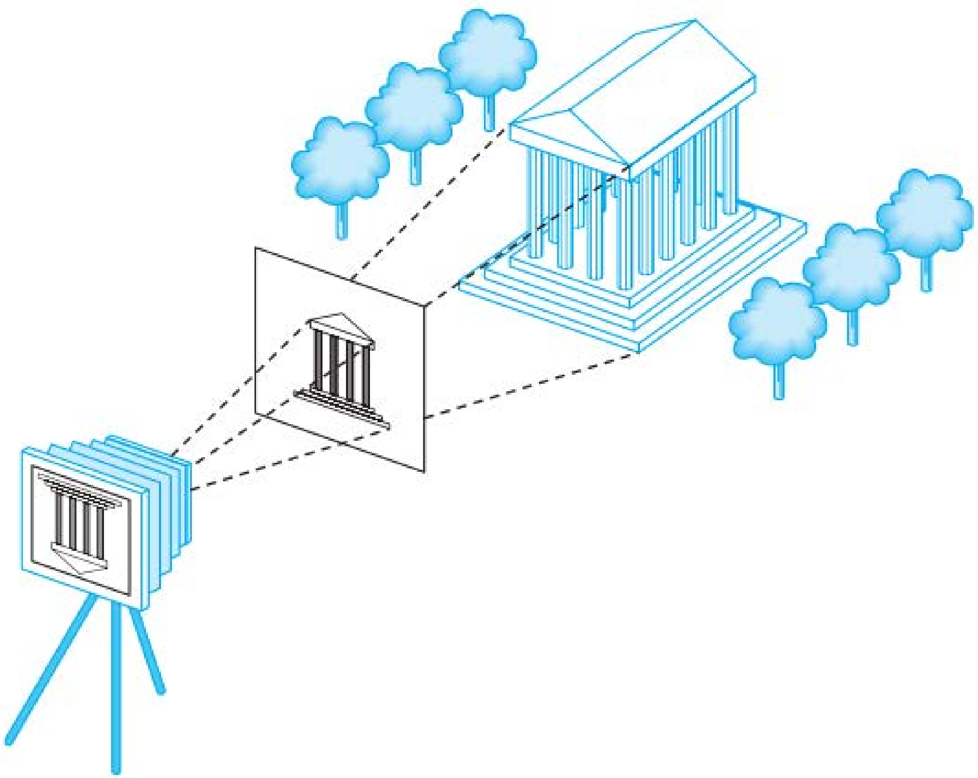


FIGURE 1.25 Imaging with the synthetic camera.

Projection Plane with Clipping

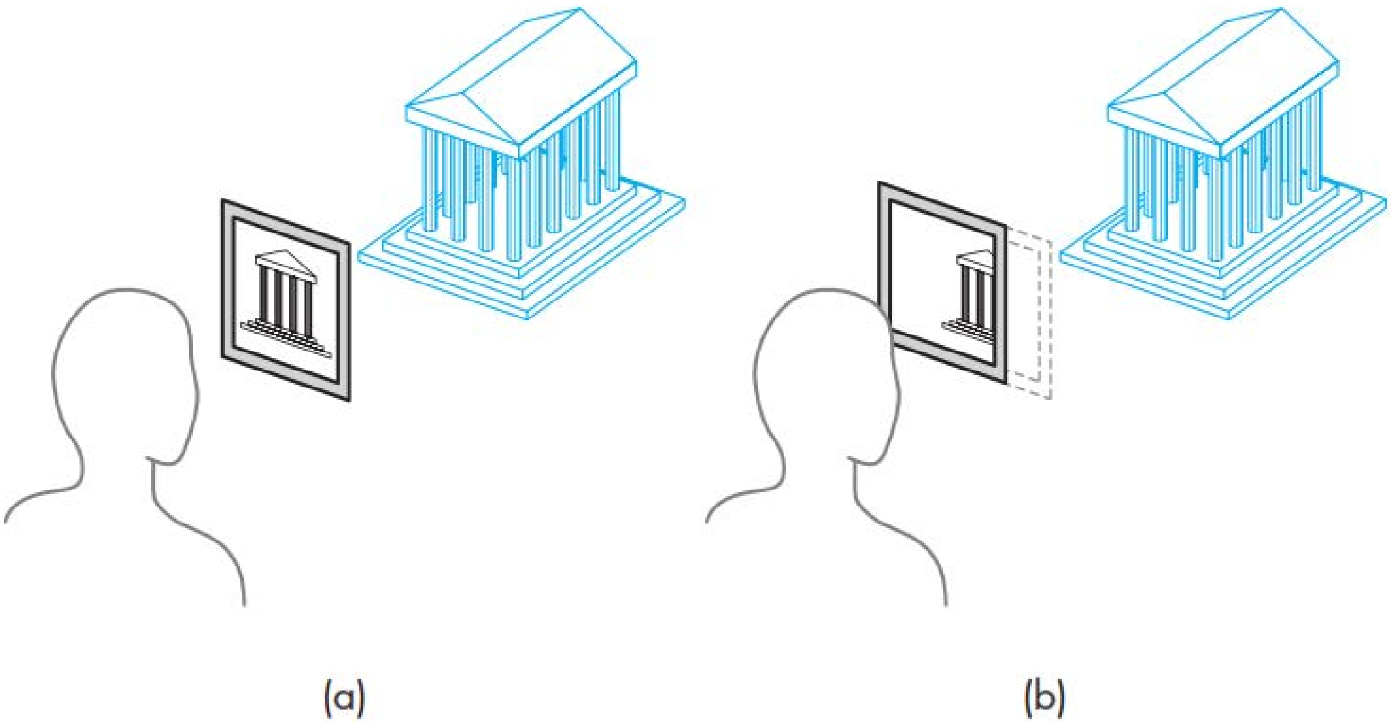


FIGURE 1.26 Clipping. (a) Window in initial position. (b) Window shifted.

Viewing

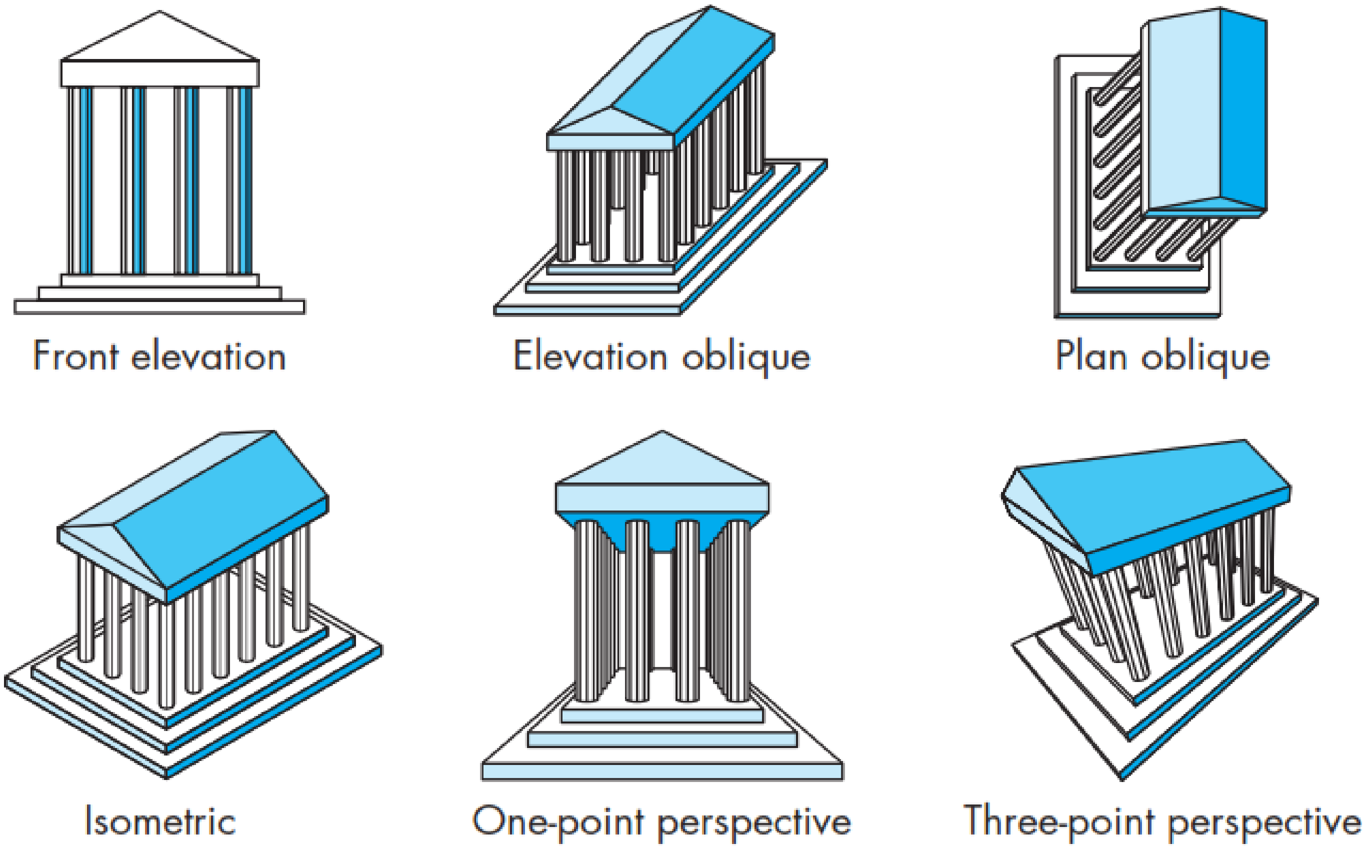
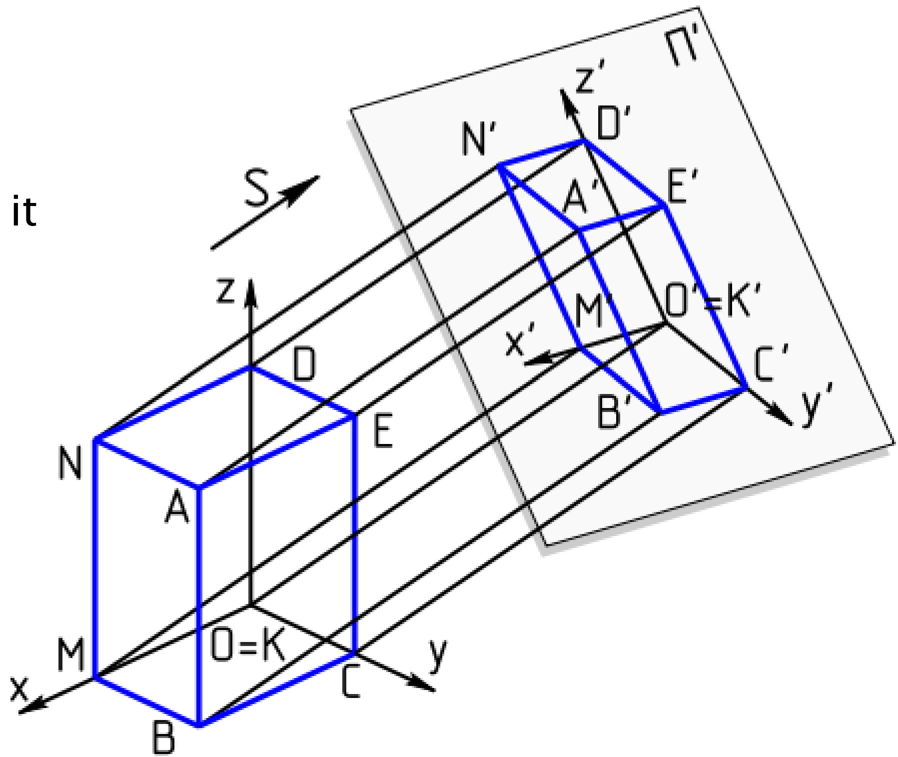


FIGURE 4.3 Classical views.

What is projection?

- Specifying the projection transformation is like choosing a lens for a camera
  - what the field of view
  - viewing volume is
  - and therefore what objects are inside it
  - and to some extent how they look

- **3D projection** is any method of mapping three-dimensional points to a two-dimensional plane*



*http://en.wikipedia.org/wiki/3D_projection

Planar Geometric Projections

- Standard projections project onto a plane
- Projectors are lines that either
  - converge at a center of projection (COP)
  - are parallel (DOP)
- Such (COP) projections preserve lines
  - but not necessarily angles

- Non-planar projections
  - needed for applications such as map construction

Planar Projections

- **Parallel Projection**
  - Orthographic Projection
  - Multi-view Orthographic Projection
  - Oblique Projection

- Perspective Projection
  - One point perspective
  - Two-point perspective

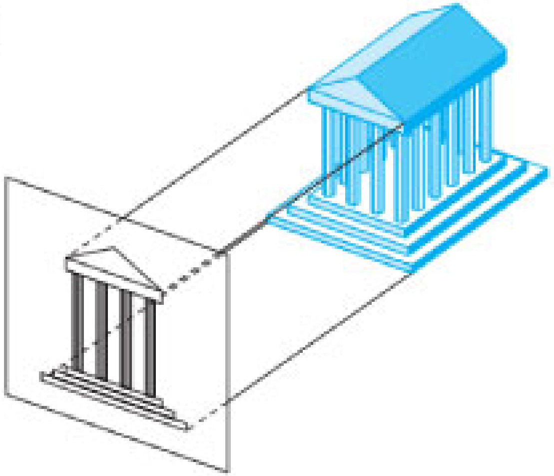
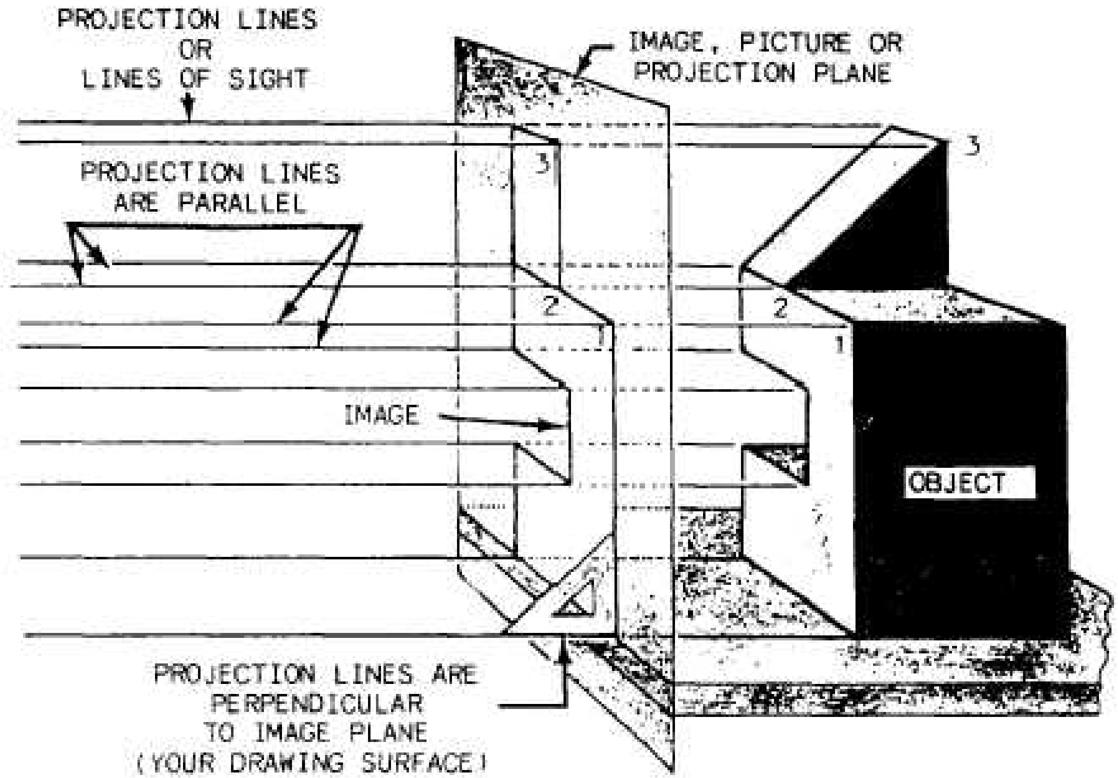


FIGURE 4.4 Orthographic projections.

Orthographic Projection

- Projectors are orthogonal to projection plane

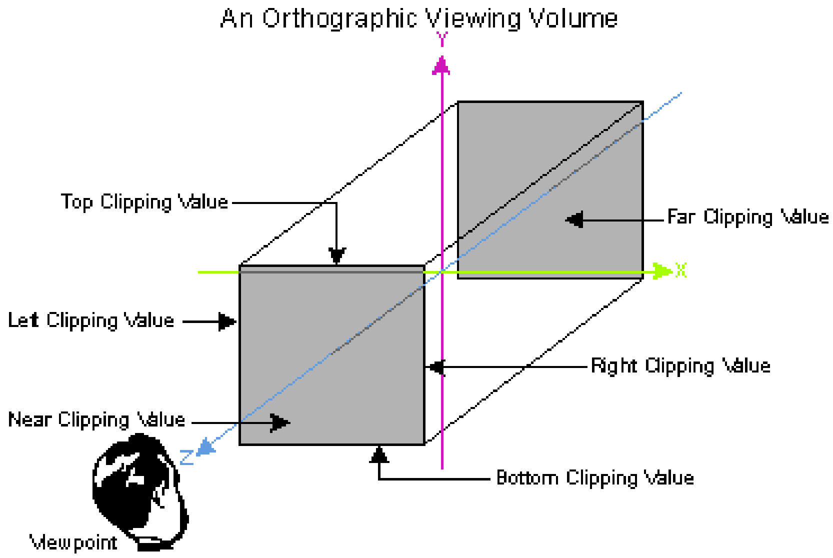


Orthographic Projection

- Formula:
  - If the normal of the viewing plane (the camera direction) is parallel to one of the 3D axes,
  - 3D point a_x, a_y, a_z onto the 2D point b_x, b_y using an orthographic projection parallel to the y axis (profile view), the following equations can be used:
    - $b_x = s_x a_x + c_x$
    - $b_y = s_z a_z + c_z$
  - where the vector **s** is an arbitrary scale factor, and **c** is an arbitrary offset. These constants are optional, and can be used to properly align the viewport

Orthographic Projection

- glOrtho(left, right, bottom, top, near, far);
- gluOrtho2D(left, right, bottom, top);

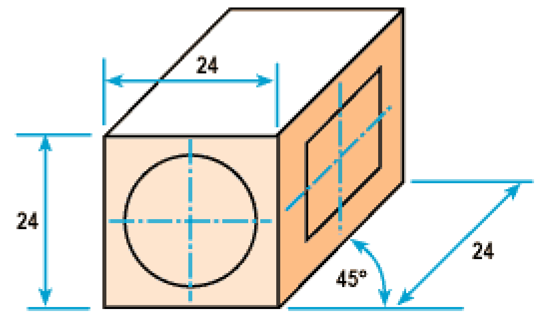


Pros and Cons – Orthographic Projection

- Preserves both distances and angles
  - Shapes preserved
  - Can be used for measurements
    - Building plans
    - Manuals
- Cannot see what object really looks like because many surfaces hidden from view
  - Often we add the isometric

Oblique Projection

- Arbitrary relationship between projectors and projection plane
  - $x'' = x + \cos\alpha \cdot y$;
  - $y'' = z + \sin\alpha \cdot y$.



Cavalier projection

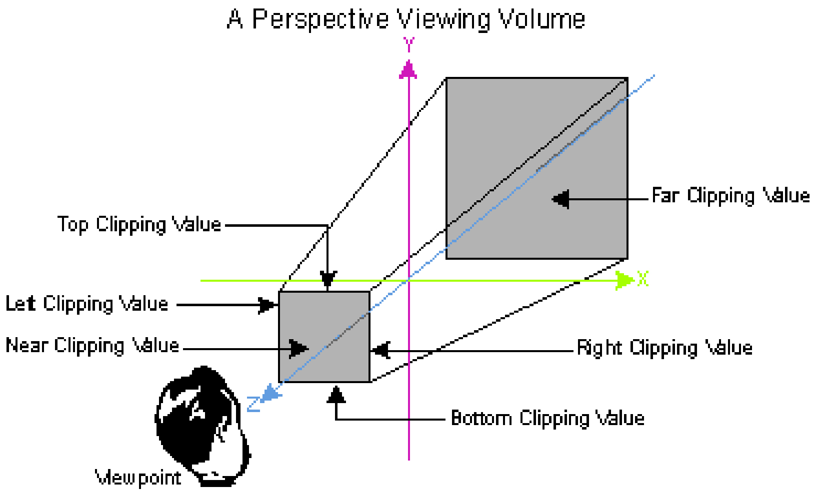
- OpenGL – no support
  - To implement oblique projections, we must first apply a shear transformation on the object(s) and then apply orthographic projection

Pros and Cons – Oblique Projection

- Can pick the angles to emphasize a particular face
  - Architecture: plan oblique, elevation oblique
- Angles in faces parallel to projection plane are preserved while we can still see "around" side
- In physical world, cannot create with simple camera; possible with bellows camera or special lens (architectural)

Perspective Projection

- Perspective projections create more realistic looking scenes
  - as an object gets farther from the viewer it will appear smaller on the screen
  - the viewing volume for a perspective projection is a frustum, which looks like a pyramid with the top cut off, with the narrow end toward the user



Perspective Viewing

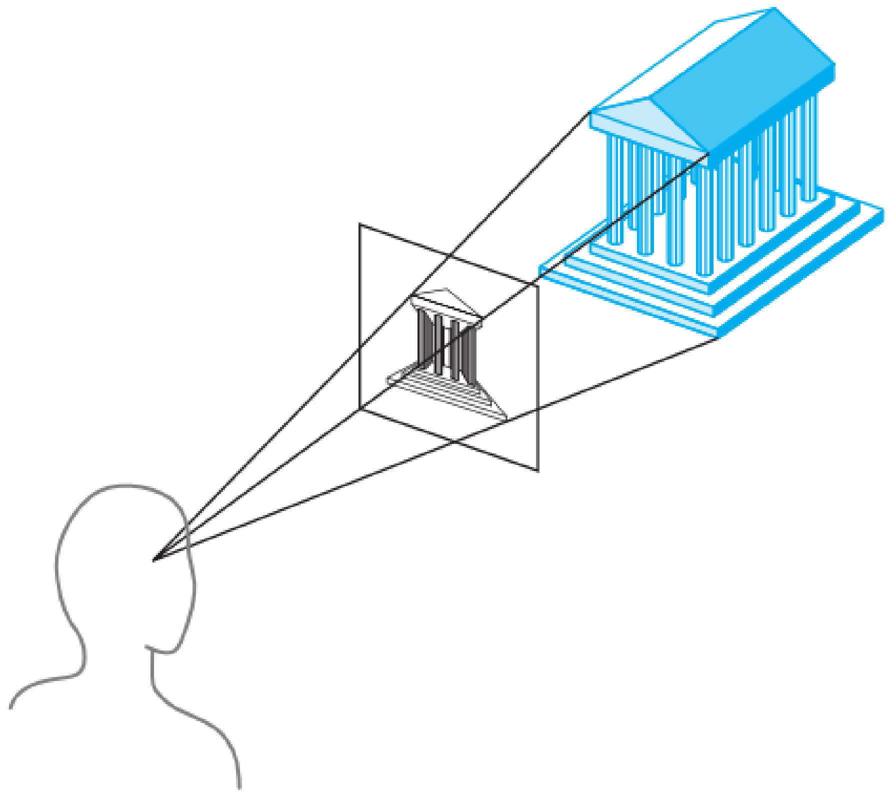


FIGURE 4.9 Perspective viewing.

Perspective Views

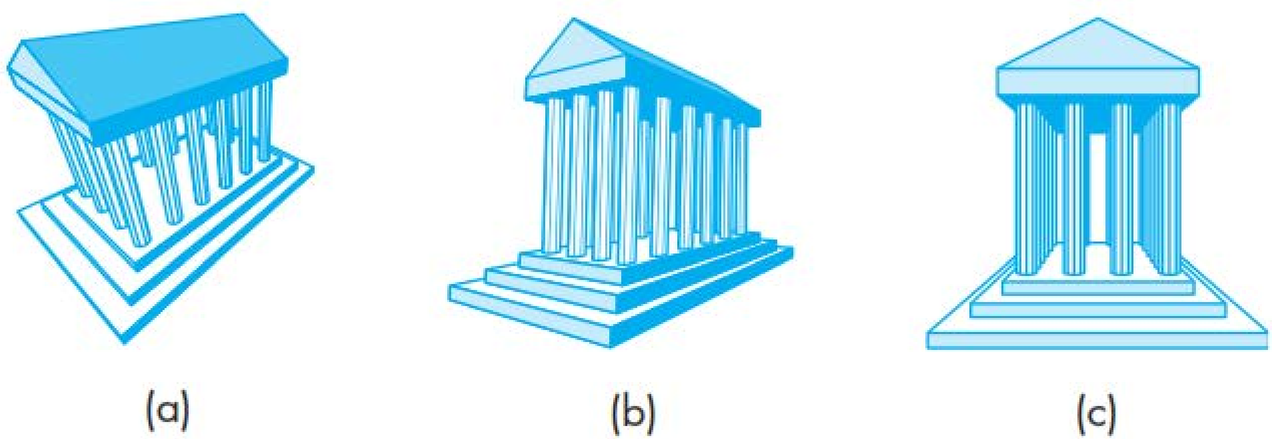


FIGURE 4.10 Classical perspective views. (a) Three-point. (b) Two-point. (c) One-point.

Viewing Transformations

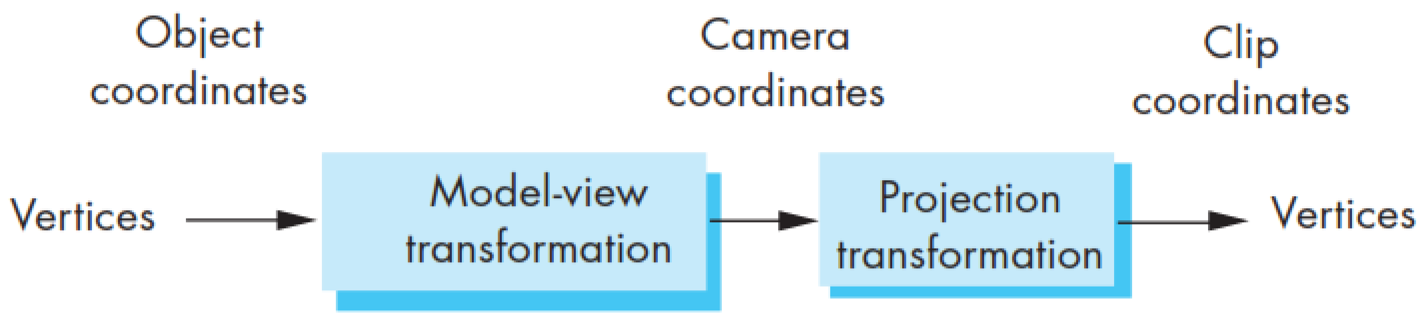


FIGURE 4.11 Viewing transformations.

Perspective Projection

- See calculations on Chapter 4 of text "Interactive Computer Graphics 6th Edition"

(p. 226 – …)

- OpenGL Command:
  - glFrustum(left, right, bottom, top, near, far);
  - gluPerspective(fov, aspect, near, far);

Pros & Cons – Perspective Projection

- Pros
  - Objects further from viewer are projected smaller than the same sized objects closer to the viewer
    - Looks realistic

- Cons
  - Equal distances along a line are not projected into equal distances
  - Angles preserved only in planes parallel to the projection plane
  - More difficult to construct by hand than parallel projections (but not by computing)

Review

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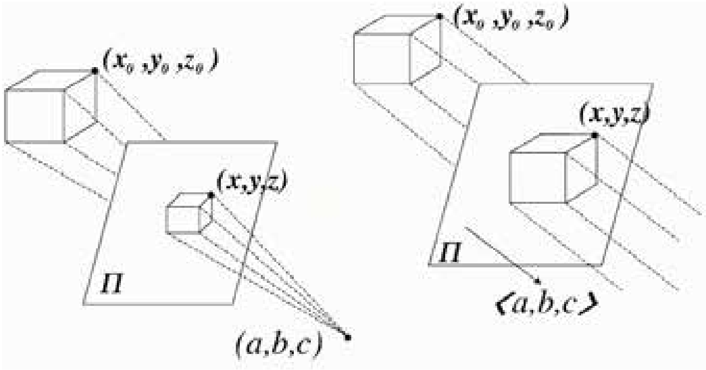
Questions?

Review Question

- Study the diagram



- What projection is represented on the right?
  - When it might be appropriate to use this?

Resources

- Interactive computer graphics: a top down approach with OpenGL / Edward Angel. ISBN: 0-201-38597-X
- http://www.songho.ca/opengl/gl_projectionmatrix.html
- http://en.wikipedia.org/wiki/3D_projection