Assignments

**Due Today:** Read Chapter 8: Prospective Viewing

**Due Thursday Night (for Friday's class):** In Blackboard Learn, turn in a link to a cool and interesting, <5 minute video on ray tracing (Lab 3).

**Due Monday (for show and tell in class):** Photo that you create illustrating some ray tracing phenomena (Lab 4).

**Due Wednesday:** Implement axis-aligned perspective viewing as discussed in chapter 8 (Lab 5, next slide for detail). OR show progress on project.
Lab 5: Axis-aligned Perspective Viewing

Render a scene from two directions of axis-aligned perspective viewings:
1) Eye point \((0, y_e, 0)\) through a view plane \((*, y_{vp}, *)\)
2) Eye point \((0, y_e, 0)\) through a view plane \((*, *, z_{vp})\)

The scene must include:
- A checkerboard plane with \(y=0\).
- Four differently sized, axis-aligned rectangular solids. Each of these blocks must be a different color and each side of each block must be a different shade of the block's color.

Hint: Hit functions for axis-aligned boxes are in chapter 19.
Frustum

In computer graphics, the viewing frustum is the three-dimensional region which is visible on the screen which is formed by a clipped pyramid.

Properties of Prospective Projections

Property 1: The perspective projection of an object becomes smaller as the object gets farther away from the center of projection.

What are some non-obvious, and interesting effects of this?
Properties of Prospective Projections

**Property 2:** As an object is rotated, its projected width becomes smaller. This is known as *foreshortening*.

![Diagram of foreshortening](image.png)

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**Property 3:** Perspective projections preserve straight lines.

![Diagram of perspective projections](image.png)
Properties of Prospective Projections

Property 4: Sets of parallel lines that are parallel to the view plane remain parallel when projected onto the view plane.

Property 5: Sets of parallel lines that are not parallel to the view plane converge to a vanishing point on the view plane.

Equation of a Checkerboard

// Checkerboard in x-z plane with y = 0.

```java
public static Color getCheckerboardGroundColor(double x, double y, double z)
{
    if (Math.abs((Math.floor(x))) % 2 == Math.abs((Math.floor(z))) % 2)
        return Color.BLACK;
    return Color.WHITE;
}
```
Axis-Aligned Perspective Projection
Straight down Y-Axis

- Eye: (0, 10, 0)
- One Point on View Plane: (xvp, 5, zvp)

\[
\text{ray} = \text{eye} + d (\text{ViewPlanePt} - \text{eye})
\]

\[
\begin{align*}
x_{hit} &= 0 + d (x_{vp} - 0) \\
z_{hit} &= 0 + d (z_{vp} - 0)
\end{align*}
\]

Chapter 9: A Practical Viewing System

- The virtual pinhole camera implements perspective viewing with the following features:
  - An arbitrary eye point.
  - An arbitrary view direction (The view plane is defined as being perpendicular to the view direction and centered on the ray from the eye point).
  - An arbitrary orientation about the view direction.
  - An arbitrary distance between the eye point and the view plane.
Physical Pinhole Camera

- Clear inverted image with small pinhole
- Fuzzy out-of-focus image with larger hole

Lens Aperture

- Aperture ≠ Shutter
- Why color reflections?
Large Glass is Expensive

Canon, Prime 50mm f/1.8 USM Lens: $125.00
Canon, Prime 50 mm f/1.4 USM Lens: $399.00
Canon, Prime 50 mm f/1.2 USM Lens: $1,549.00

Depth of Field
Circle of Confusion

Real lenses do not focus all rays perfectly.
Thus, at best focus, a point is imaged as a spot rather than a point.
The smallest such spot that a lens can produce is often referred to as the *circle of least confusion*.

Perspective Views of Boxes (figure 9.10)

- How many vanishing points are there in each image?
- In each image, does the view direction point up or down or is it horizontal? How can you tell when it's horizontal?
Assignments 6 and 7

- Lab 6 Due Monday (5 points): Create a photograph of a scene that illuminates non-obvious idea about perspective viewing.

- Lab 7 Due Friday Sept 19th (20 points): Pinhole Camera:
  a) Implement a pinhole camera and use the images in chapter 9 for testing. Hit functions for axis-aligned boxes and triangles are in chapter 19.
  b) Allow the user to specify an arbitrary up vector.
  c) Allow the user to specify an arbitrary view direction.
  d) Allow the user to specify a field of view of the camera in degrees.
  e) Implement the roll angle as described in section 9.8

Quiz

1) What is an orthonormal basis (ONB)?

2) In the equation: \( \tilde{a} = \tilde{b} \times \tilde{c} / \| \tilde{b} \times \tilde{c} \| \)

\( \tilde{a} , \tilde{b} \) and \( \tilde{c} \) are vectors. This means they have both magnitude and direction. What can be said about the magnitude and direction of \( \tilde{a} \)?
Virtual Pinhole-Camera Viewing System

User Input:
- The eye point, \( e \).
- The look-at point, \( l \).
- The up vector, \( up \).
- The view-plane distance \( d \).

Primary-Ray Calculation

The \((x_v, y_v)\) coordinates of a sample point \( p \) on the pixel in row \( r \) and column \( c \) are:

\[
\begin{align*}
x_v &= s(c - h_{\text{res}}/2 + p_x) \\
y_v &= s(r - v_{\text{res}}/2 + p_y)
\end{align*}
\]

The primary-ray direction \( d \) is:

\[
\vec{d} = x_v \vec{u} + y_v \vec{v} - d \vec{w}
\]