

# cs155 - z sweedyk

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## viewing

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# 3d scene

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The diagram shows a 3D scene with a light source (labeled 'lights') at the top, a camera (labeled 'view (eye/camera)') at the bottom left, and a world coordinate system with X, Y, and Z axes. A cylinder and a square are shown as 'models' in the scene.

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# overview

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- models
  - simple primitives (for now)
  - modeling transforms
  - hierarchical coordinates
- view system (eye/camera)
  - view volume
  - projection
  - image coordinates
- lights and material properties
- illumination models
  - local
  - global

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# 3d scene

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This diagram is identical to slide 2, but the camera and its view volume are enclosed in a rectangular box labeled 'view (eye/camera)'.

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# pinhole camera model

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The diagram illustrates the pinhole camera model. A 3D object (a trapezoid) is shown on the right. A point representing the camera's center of projection is shown in the middle. Lines representing projection rays extend from the corners of the object to the camera point. On the left, a 2D image plane is shown, and the projected 2D image of the object is formed on it.

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# projection

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This diagram shows a camera's view volume (a frustum) on the left. A 3D object is positioned within the view volume. Projection rays from the object's corners pass through the camera's center of projection and hit a 2D image plane, illustrating the projection process.

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### how is eye situated?

world coordinate system

up:  $u$

towards:  $t$

position:  $P_0$

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### how is eye situated?

world coordinate system

up:  $u$

towards:  $t$

right:  $r=txu$

position:  $P_0$

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### how much of the world is seen?

the *view volume* is a pyramid that is axis-aligned with the toward, up, and right vectors

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### how much of the world is seen?

or a truncated pyramid, called a frustum

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### view volume

we can specify the view volume by its height and width at some distance  $d$  from the viewpoint

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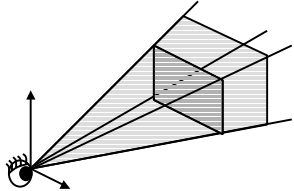
### view volume

or, we can specify the the view volume by its height angle  $\theta_h$  and width angle  $\theta_w$

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### view volume

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or ...

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### specification recap

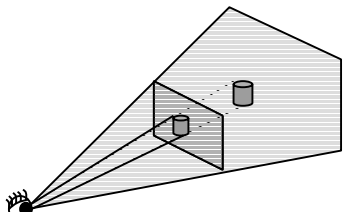
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- viewpoint
  - position
  - toward, up, right
- view volume
  - height and width angles

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### projection

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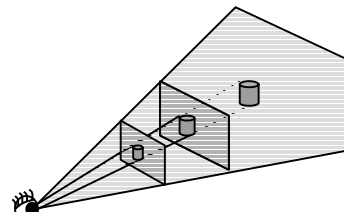


objects in the view volume are projected onto the *view plane*

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### where is the view plane?

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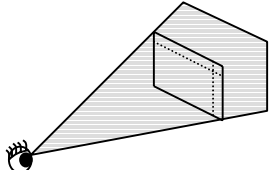


doesn't matter

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### image coordinates

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what matters is the sampling density:  
image size is specified by height and width in pixels

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### specification recap

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- viewpoint
  - position
  - toward, up, right
- view volume
  - height and width angles
- image size
  - height and width in pixels

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### objective

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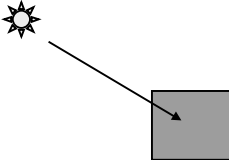
approximate the interaction of light and surface materials in a way that is

- consistent with our perception
- computationally efficient

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### light/material interaction

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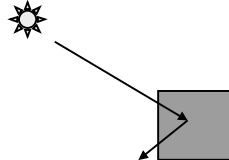


- light
  - incident angle
  - incident intensity

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### light/material interaction

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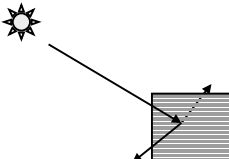


- light
  - incident angle
  - incident intensity
- material
  - angle of reflection
  - reflected intensity

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### light/material interaction

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- light
  - incident angle
  - incident intensity
- material
  - angle of reflection
  - reflected intensity
  - angle of refraction
  - transmitted intensity

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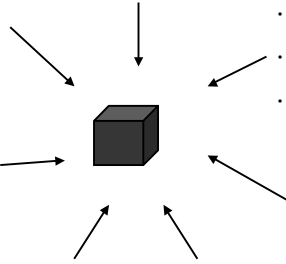
### light sources (in cs155)

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- ambient light
- directional light
- point light
- spot light

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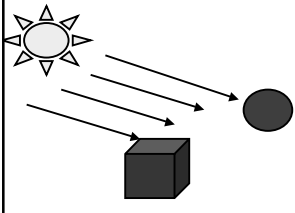
### ambient light



- "source-less" light
- incident angle: falls uniformly from every angle
- incident intensity: constant everywhere
- specification
  - red, green, and blue intensity

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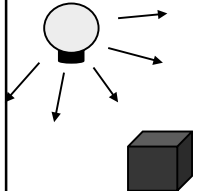
### directional light



- light positioned at "infinity"
- incident angle: constant everywhere
- incident intensity: constant everywhere subject to occlusion
- specification
  - incident angle (direction)
  - red, green, and blue intensity

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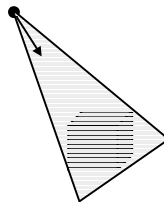
### point light



- local light
- incident angle: depends on position of light and surface point
- incident intensity: drops off with distance
- specification
  - location in world coordinates
  - red, green, and blue intensity
  - how the light drops off with distance

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### spot light



- local light
- incident angle: depends on position of light and surface point
- incident intensity: drops off with distance and angle
- specifications
  - location in world coordinates
  - direction
  - red, green, and blue intensity
  - how the light drops off with distance
  - how light drops off with angle from center

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### material properties

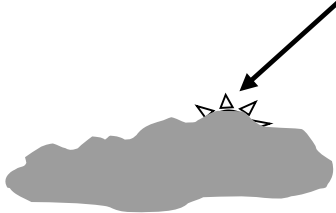
how does the surface material

- reflect light
- transmit light

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### diffuse reflection

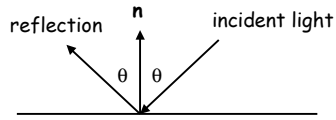
rough/matte surface: light reflects uniformly in all directions



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### specular reflection

smooth (mirror) surfaces: light reflects in one (primary) direction



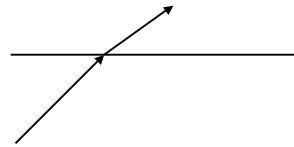
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### transparency

does surface transmit light?  
is transmitted light refracted?



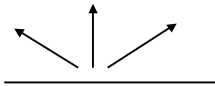
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### hybrid light/material

• surface emits light



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### material property specification

1. red, green, and blue emission
2. diffuse reflectivity coefficient for red, green, and blue light
3. specular reflectivity coefficient for red, green, and blue light
4. transparency and refractive index
5. cheap tricks
6. ambient response (!)

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### overview

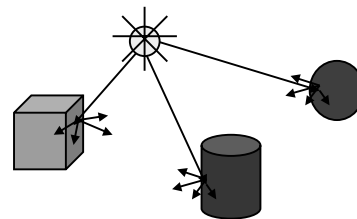
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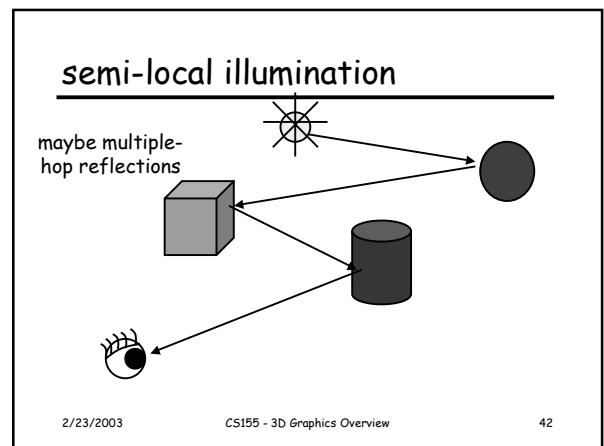
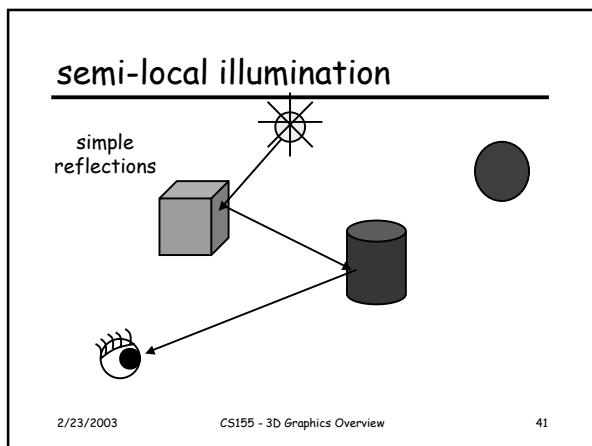
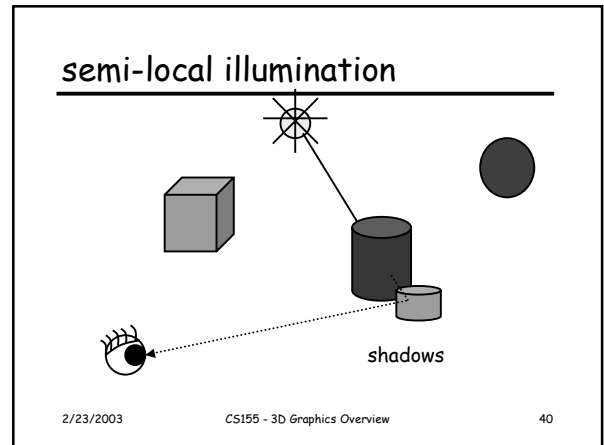
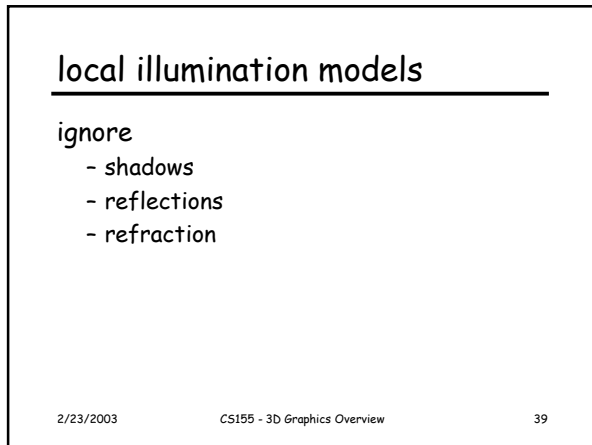
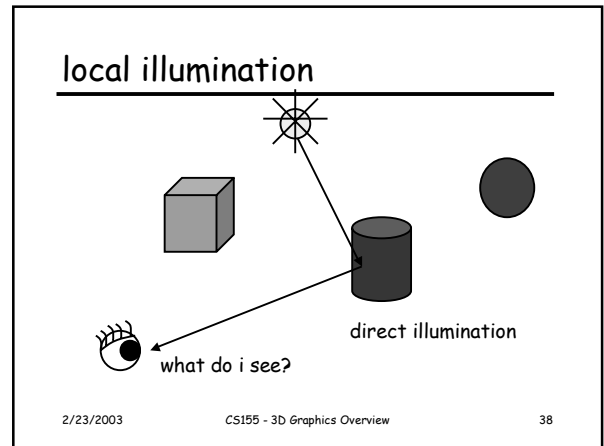
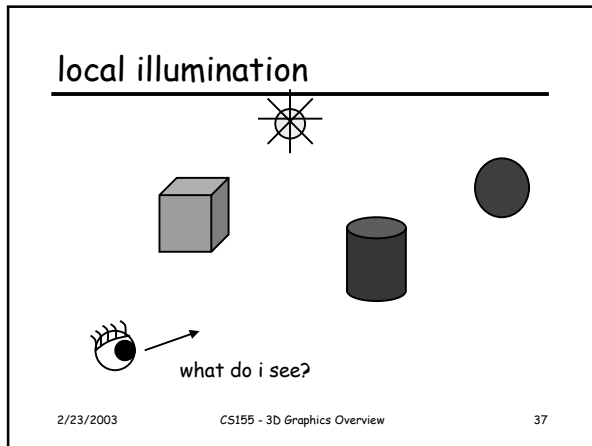
### global illumination

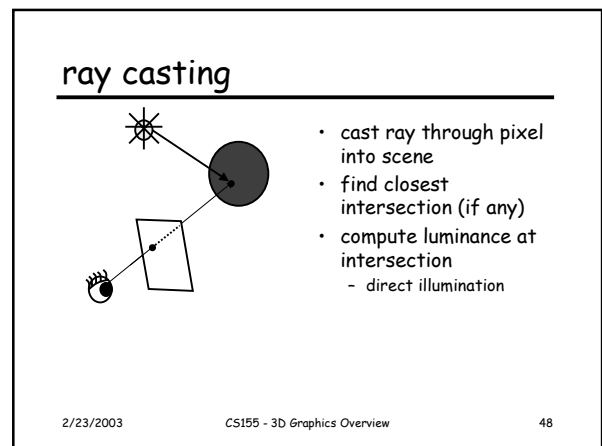
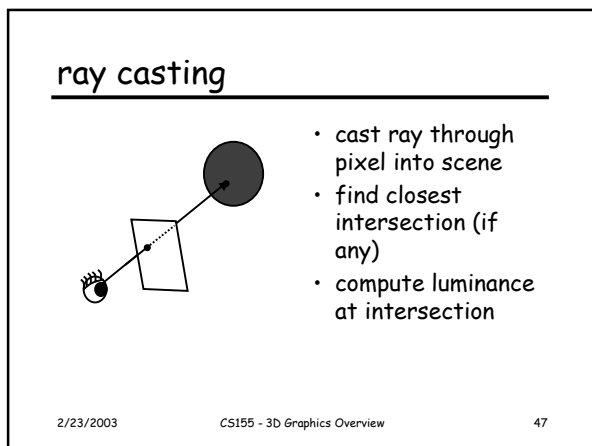
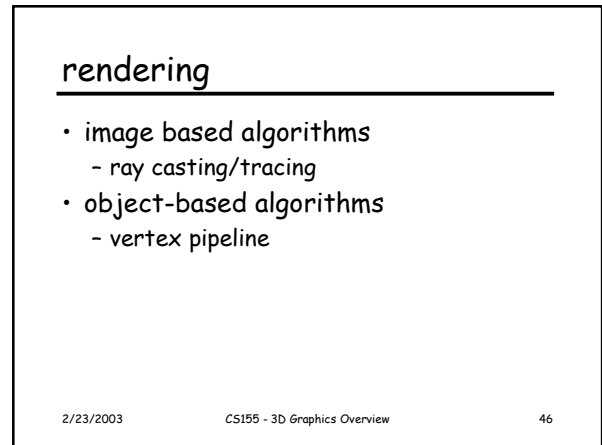
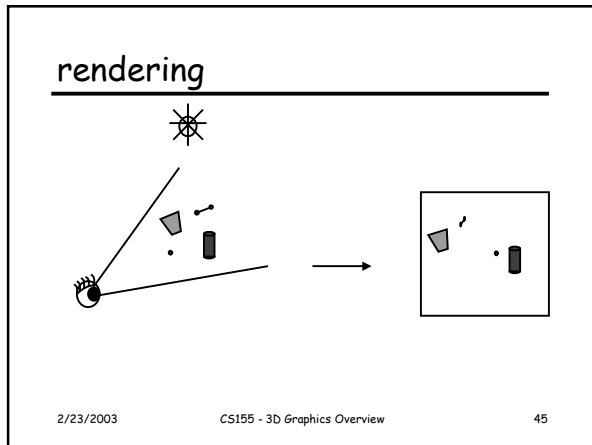
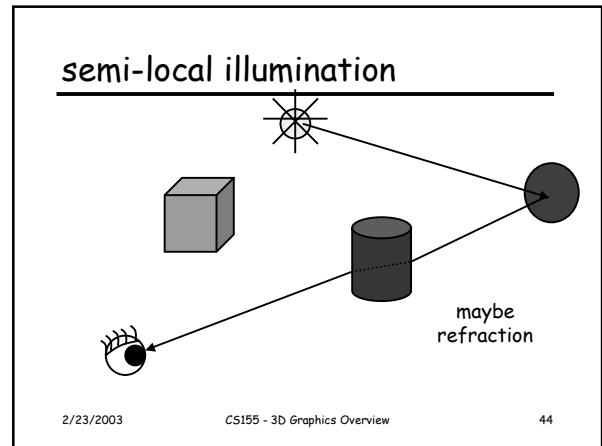
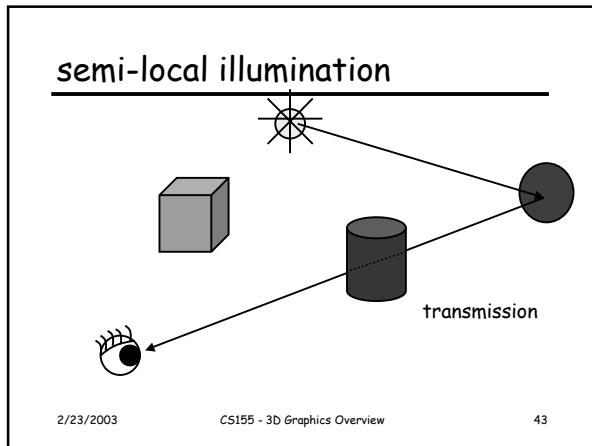


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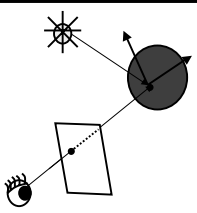
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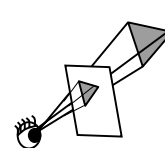
### ray tracing



- cast ray through pixel into scene
- find closest intersection (if any)
- compute luminance at intersection
  - direct illumination
  - reflections
  - transmission

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### object-based



- project each object
- hidden surface removal

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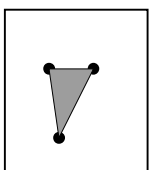
### vertex pipeline



- project vertices each polygon

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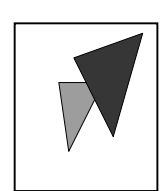
### vertex pipeline



- project vertices of each polygon
- turn on "inside" pixels

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### vertex pipeline



- project vertices of each polygon
- turn on inside pixels
- use hidden surface removal to resolve conflicts

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