Lighting & Materials

OpenGL

Learning Outcomes

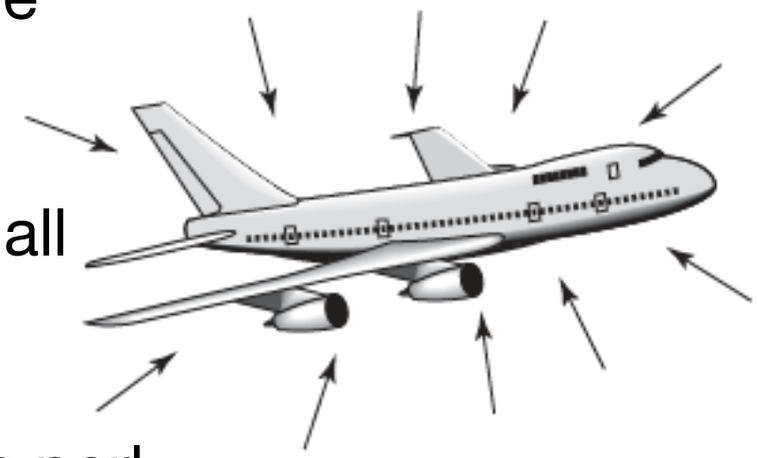
- Understand the basic principles behind the OpenGL Lighting Model
- Be able to distinguish between ambient, diffuse & specular lighting
- Be able to specify the components of these lighting types
- Have an appreciation of how the lighting characteristics are combined with the material properties in the rendering of a scene

OpenGL Lighting Principles

- In the real world, objects don’t appear in a solid or shaded color based solely on their RGB values.
- OpenGL attempts to approximate the real world in by providing a “lighting model”:
    - A simple and intuitive, but not necessarily based on the physics of real world light.
- An object is considered to be illuminated by three kinds of light:
    - Ambient
    - Diffuse
    - Specular.

Ambient

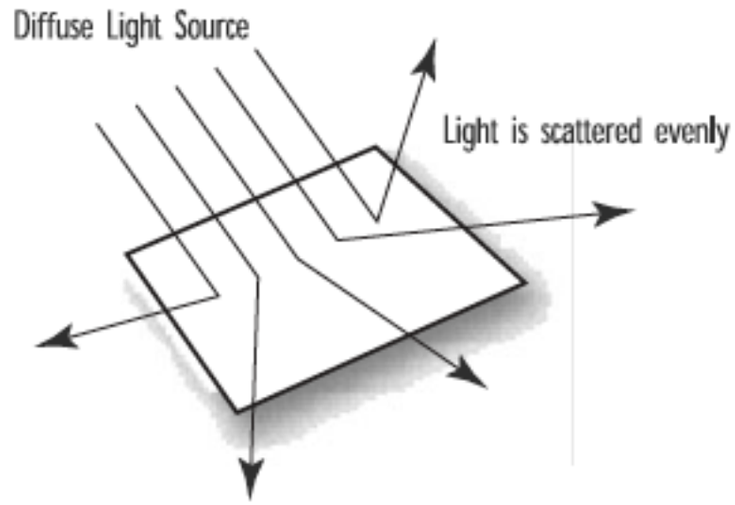
- Ambient light doesn’t come from any particular direction.
- It has an original source somewhere, but the rays of light have bounced around the room or scene and become directionless.



- Objects illuminated by ambient light are evenly lit on all surfaces in all directions.
- Considered as a global “brightening” factor applied a perl light source.
- Approximates scattered light in the environment that originates from the light source.

Diffuse

- The component that appears to come from a particular direction and is reflected off a surface with an intensity proportional to the angle at which the light rays strike the surface.



- The object surface is brighter if the light is pointed directly at the surface than if the light grazes the surface from a greater angle. E.g a lamp, candle, or sunlight stream-ing in a side window.

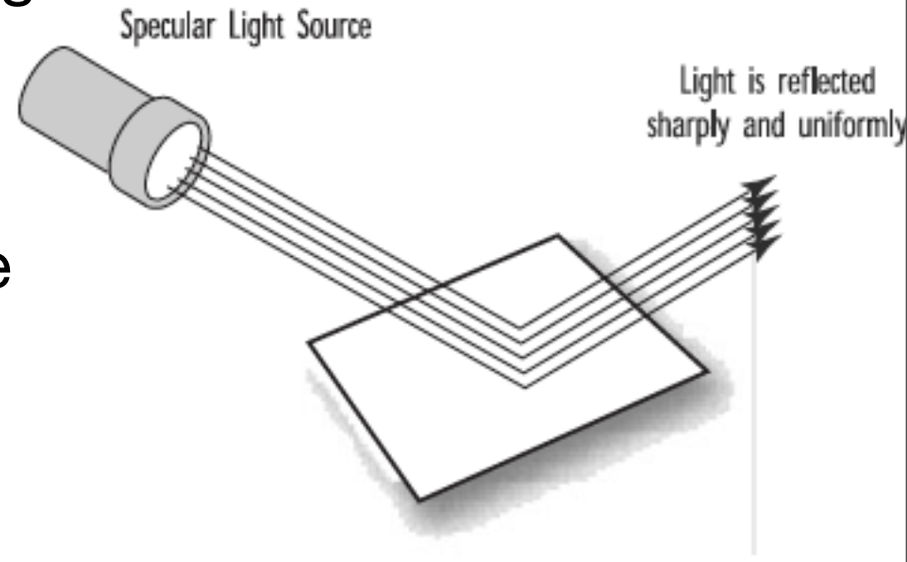
- Produces the shading (or change in color) across a lit object’s surface.

Specular

- Highly directional property, interacts more sharply with the surface and in a particular direction.

- Tends to cause a bright spot on the surface it shines on - the specular highlight.

- Possible, depending on a viewer's position, that the specular highlight may not even be visible.



Combining Lighting Types

- Light generally not composed entirely of just one of the three types of light, but is usually made up of varying intensities of each. E,g:
  - A red laser beam in a lab is composed of almost a pure-red specular component producing a very bright spot where it strikes any object.
  - Smoke or dust particles scatter the beam all over the room, giving it a very small ambient component. This would produce a slight red hue on other objects in the room.
- Thus, a light source in a scene is said to be composed of three lighting components: ambient, diffuse, and specular.
- Each lighting component is defined with an RGBA value that describes the relative intensities of red, green,and blue light that make up that component

Example: Red Laser Beam

	Red	Green	Blue	Alpha
Specular	0.99	0.0	0.0	1.0
Diffuse	0.10	0.0	0.0	1.0
Ambient	0.05	0.0	0.0	1.0

- The light described in this table has a very high specular component, a small diffuse component, and a very small ambient component.

- Wherever it shines, there will be a reddish spot.

- Because of conditions in the room, the ambient component—likely due to smoke or dust particles in the air—scatters a tiny bit of light all about the room.

Colour in a Lighted Scene : Material Properties

- When using lighting, do not describe polygons as having a particular color, but rather as consisting of materials that have certain reflective properties.
- Instead of saying that a polygon is red, we say that the polygon is made of a material that reflects mostly red light.
- The surface is still red, but must also specify the material's reflective properties for ambient, diffuse, and specular light sources.
- A material might be shiny and reflect specular light very well, while absorbing most of the ambient or diffuse light.
- Conversely, a flat colored object might absorb all specular light and not look shiny under any circumstances.

Adding Light to Materials

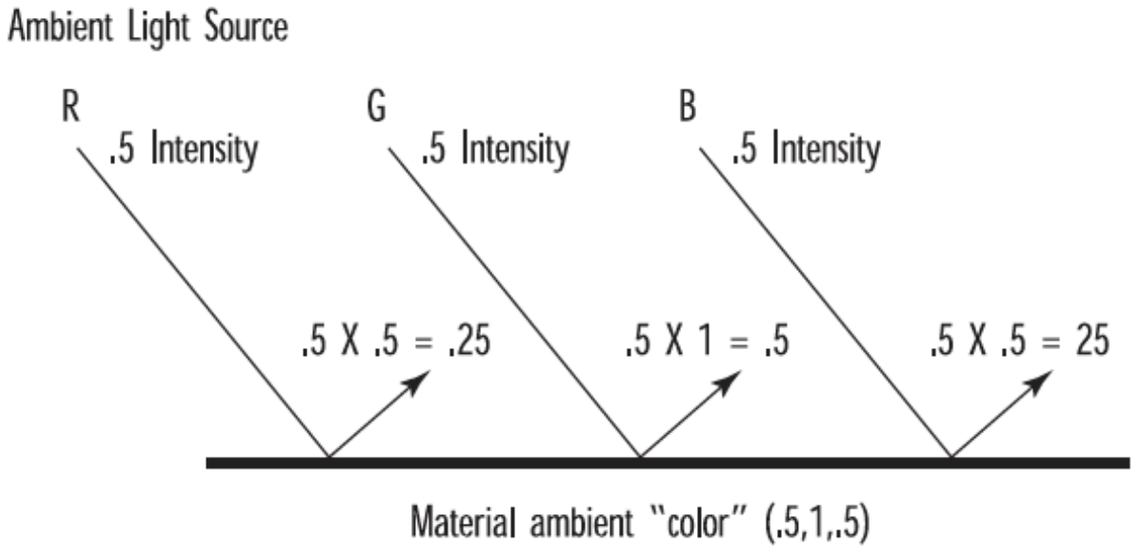
- When drawing an object, OpenGL decides which color to use for each pixel in the object.

- That object has reflective “colors,” and the light source has “colors” of its own

- Each vertex is assigned an RGB color value based on the net effect of the ambient, diffuse, and specular lighting characteristics in the scene, multiplied by the ambient, diffuse, and specular reflectance of the material properties specified for the vertex.

Calculating Ambient Light Effects

- To calculate ambient light effects, think in terms of red, green, and blue intensities.
- For an ambient light source of half-intensity red, green, and blue components, you have an RGB value for that source of (0.5, 0.5, 0.5).
- If this ambient light illuminates an object with ambient reflective properties specified in RGB terms of (0.5, 1.0, 0.5), the net “color” component from the ambient light is
  - (0.5 * 0.5, 0.5 * 1.0, 0.5 * 0.5) = (0.25, 0.5, 0.25)
- This is the result of multiplying each of the ambient light source terms by each of the ambient material property terms
- Thus, the material color components actually determine the percentage of incident light that is reflected



Calculating Diffuse & Specular Light Effects

- Diffuse & Specular light also have RGB intensities that interact in the same way with material properties.

- Diffuse & Specular light are directional, and the intensity at the surface of the object varies depending on the angle between the surface and the light source, the distance to the light source, any attenuation factors (whether it is foggy between the light and the surface), etc.

- The net effect in terms of RGB values is figured the same way as for ambient light, with the intensity of the light source (adjusted for the angle of incidence) being multiplied by the material reflectance.

- Finally, all three RGB terms are added to yield a final color for the object

Ambient, Diffuse & Specular Characteristics

- If any single color component is greater than 1.0, it is clamped to that value.
- The ambient and diffuse components of light sources have the greatest effect in determining the color of the object.
- Specular light and material properties tend to be light gray or white.
- The specular component depends significantly on the angle of incidence, and specular highlights on an object are usually set to white.