Using Shaders for Lighting

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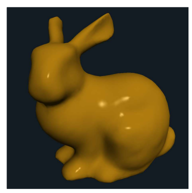
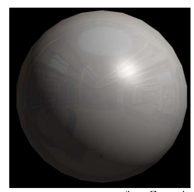
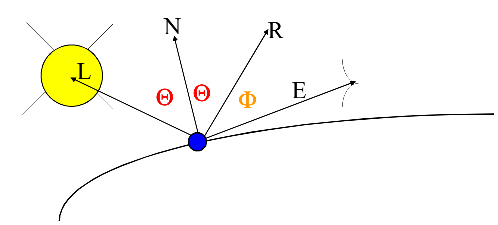




Lighting Definitions

N = Normal vector
L = Vector from Point to the Light
R = Light reflection vector
E = Vector from the Point to the eye

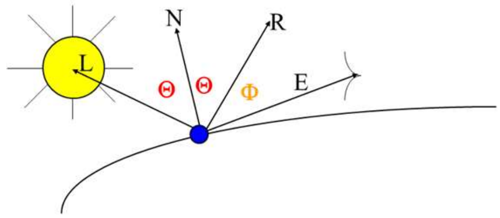


Ambient = Light intensity that is "everywhere"
Diffuse = Light intensity proportional to cos(Θ)
Specular = Light intensity proportional to $\cos^S(\Phi)$
A-D-S = Lighting model that includes Ambient, Diffuse, and Specular

Flat Interpolation = Use a single polygon normal to compute one A-D-S for the entire polygon
Smooth Interpolation = Use a normal at each vertex to compute one A-D-S at each vertex

Per-fragment lighting = Interpolate the vectors across the entire polygon and then compute A-D-S at each fragment

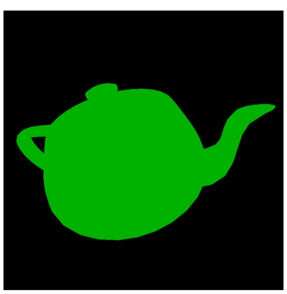
A-D-S Lighting



Ambient: K_a

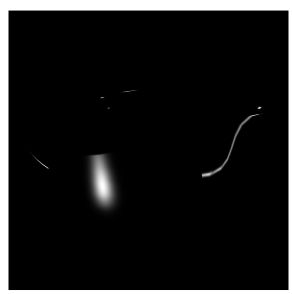
Diffuse: K_d*cosθ

Specular: K_s*$\cos^s\varphi$



Ambient-only

Diffuse-only



Specular-only

ADS – Shininess=50

ADS – Shininess=1000

ADS – Shininess=1000 -- Flat

The Difference Between Per-Vertex Lighting and Per-Fragment Lighting

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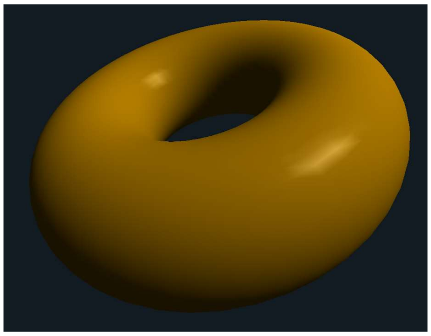
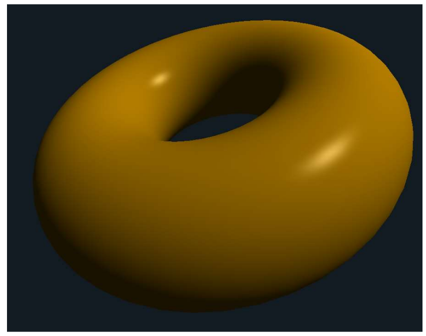


Per-vertex



Per-fragment

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The Difference Between Per-Vertex Lighting and Per-Fragment Lighting

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Per-vertex

Per-fragment

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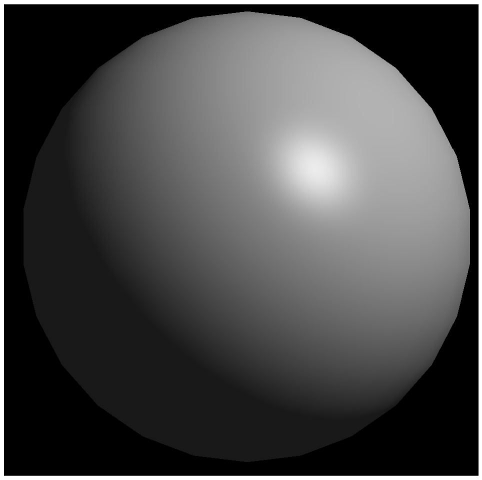
Per-fragment A-D-S Lighting



Smooth-rasterize N, L, E

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Applying Per-Fragment Lighting

Vertex shader:

```
#version 330 compatibility

uniform vec3 uLightPosition;

out vec2   vST;                    // texture coords
out  vec3  vN;                     // normal vector
out  vec3  vL;                     // vector from point to light
out  vec3  vE;                     // vector from point to eye

void
main( )
{
        vST = gl_MultiTexCoord0.st;

        vec4 ECposition = gl_ModelViewMatrix * gl_Vertex;         // eye coordinate position
        vN = normalize( gl_NormalMatrix * gl_Normal );            // normal vector
        vL = uLightPosition - ECposition.xyz;                     // vector from the point to the light position
        vE = vec3( 0., 0., 0. ) - ECposition.xyz;                 // vector from the point to the eye position
        gl_Position = gl_ModelViewProjectionMatrix * gl_Vertex;
}
```

Rasterizer

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Applying Per-Fragment Lighting

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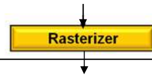

Fragment shader:

```
#version 330 compatibility
uniform vec3  uColor;
uniform vec3  uSpecularColor;
uniform float   uKa, uKd, uKs;          // coefficients of each type of lighting
uniform float   uShininess;             // specular exponent
in vec2   vST;                          // texture cords
in  vec3  vN;                                   // normal vector
in  vec3  vL;                                   // vector from point to light
in  vec3  vE;                                   // vector from point to eye
void main( )
{
        vec3 Normal = normalize(vN);
        vec3 Light     = normalize(vL);
        vec3 Eye       = normalize(vE);

         vec3 myColor = uColor;                 // default color

        << possibly change myColor >>

        vec3 ambient = uKa * myColor;
        float d = 0.;
        float s = 0.
        if( dot(Normal,Light) > 0. )        // only do specular if the light can see the point
        {
                d = dot(Normal,Light);
                vec3 R = normalize(  reflect( -Light, Normal )  );          // reflection vector
                s = pow(  max( dot(Eye,R), 0. ),  uShininess );
        }
        vec3 diffuse    = uKd * d * myColor;
        vec3 specular = uKs * s * uSpecularColor;
        gl_FragColor = vec4( ambient + diffuse + specular,  1. );
}
```

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Per-fragment A-D-S Lighting with Flat Interpolation

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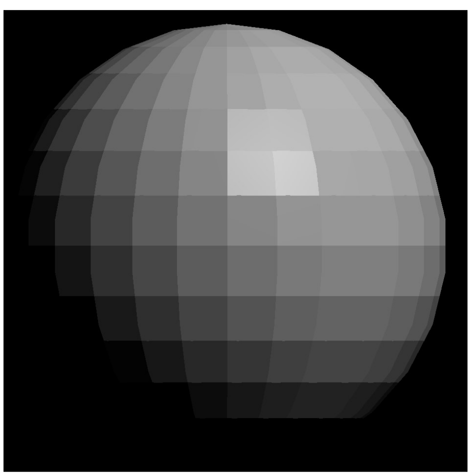

Each polygon has a single lighting value applied to every pixel within it.

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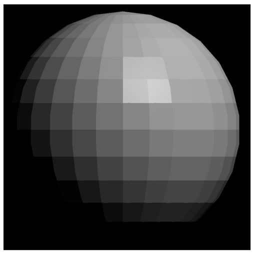
Per-fragment A-D-S Lighting with Flat Interpolation



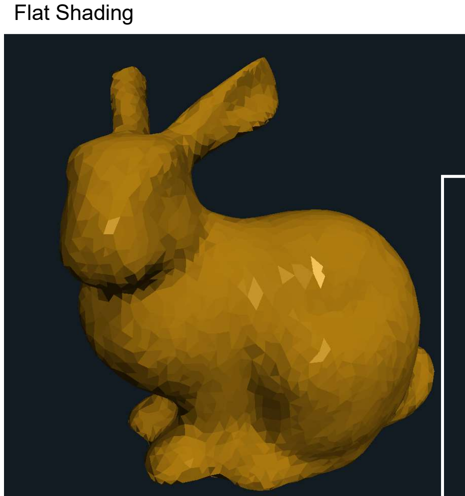
Vertex shader:

```
. . .

flat out vec2   vST;           // texture coords
flat out  vec3  vN;            // normal vector
flat out  vec3  vL;            // vector from point to light
flat out  vec3  vE;            // vector from point to eye

. . .
```

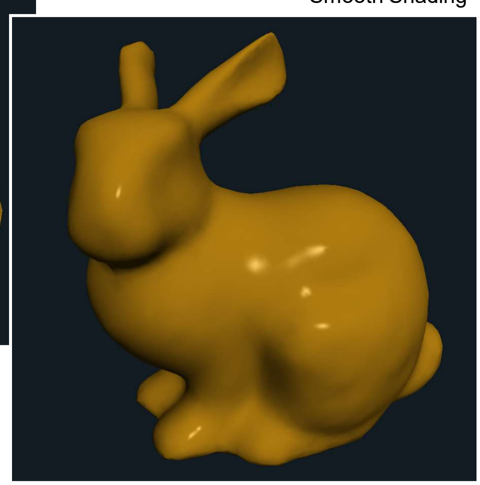
Fragment shader:

```
. . .

flat in vec2   vST;            // texture coords
flat in  vec3  vN;             // normal vector
flat in  vec3  vL;             // vector from point to light
flat in  vec3  vE;             // vector from point to eye
. . .
```


Flat Shading



Smooth Shading



What you see depends on the light color and the material color

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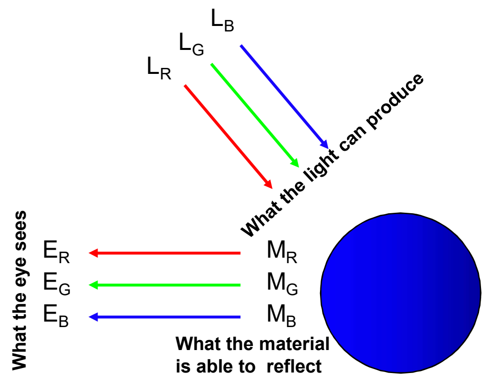
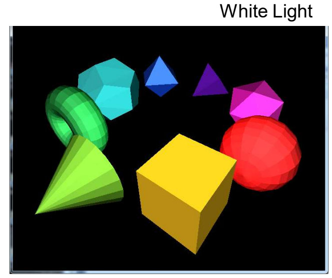
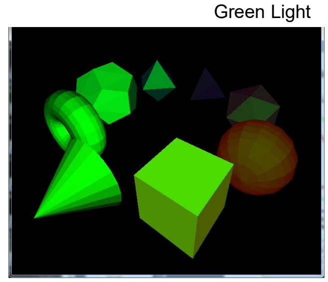


White Light



Green Light



$$E_R = L_R * M_R$$
$$E_G = L_G * M_G$$
$$E_B = L_B * M_B$$

This is how you implement subtractive coloring.

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A-D-S Anisotropic Lighting with Normal Interpolation

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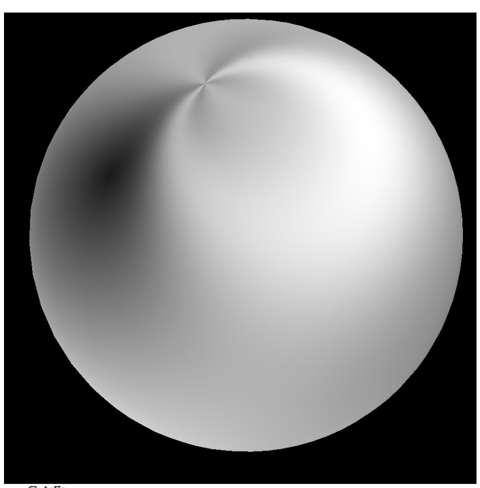

Note: The bright spot is not circular because the material has different properties in different directions. Materials such as fur, hair, and brushed metal behave this way.

James Kajiya and Timothy Kay, “Rendering Fur with Three Dimensional Textures”, *Proceedings of SIGGRAPH 1989*, Volume 23, Number 3, July 1989, pp. 271-280.

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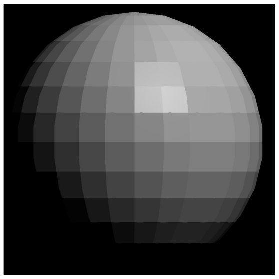
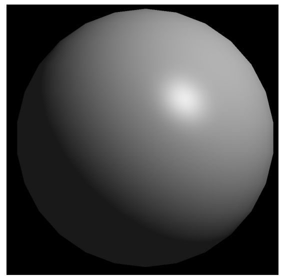
Summary

Flat



Smooth



Anisotropic