Ray Tracing

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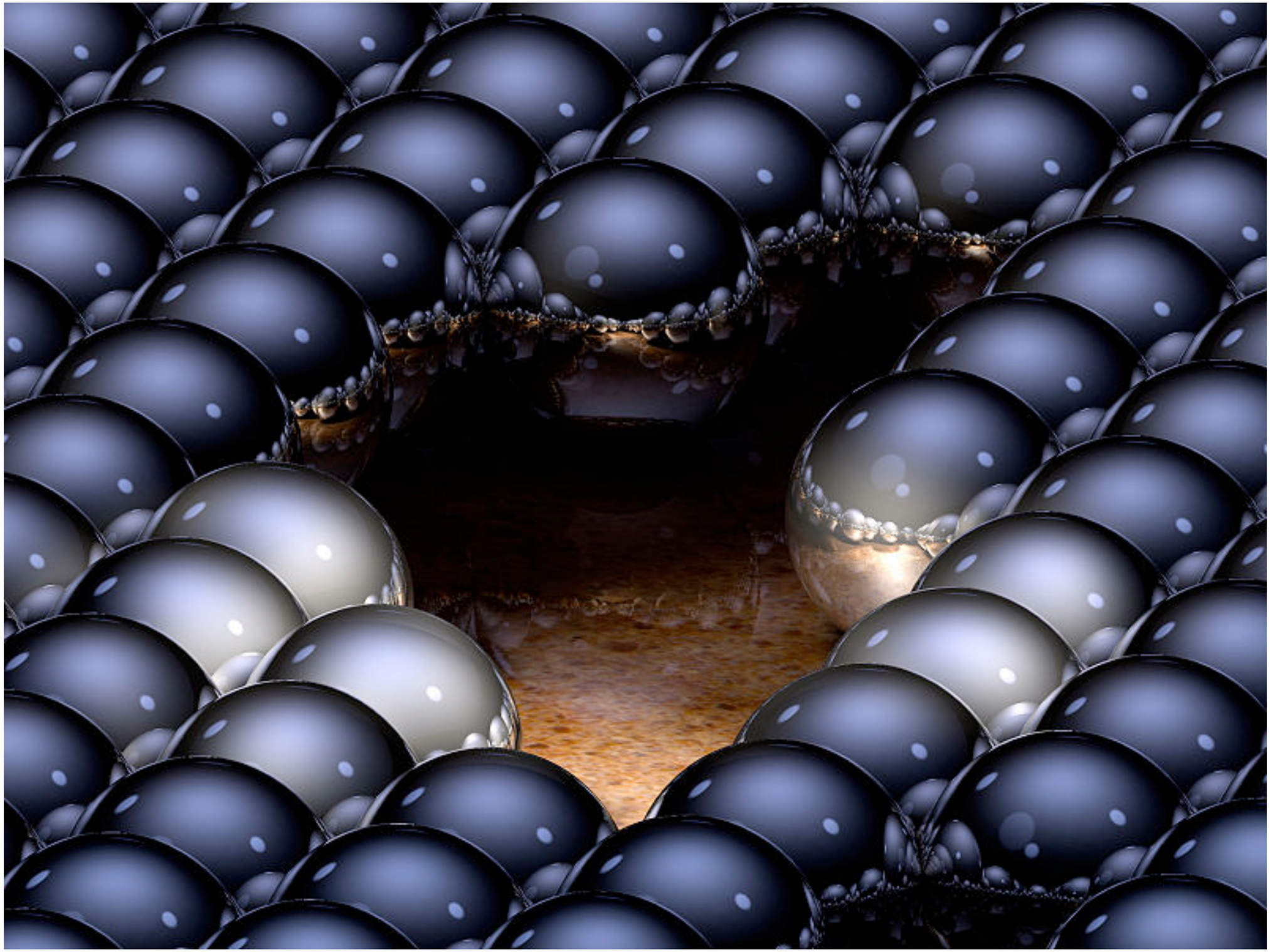
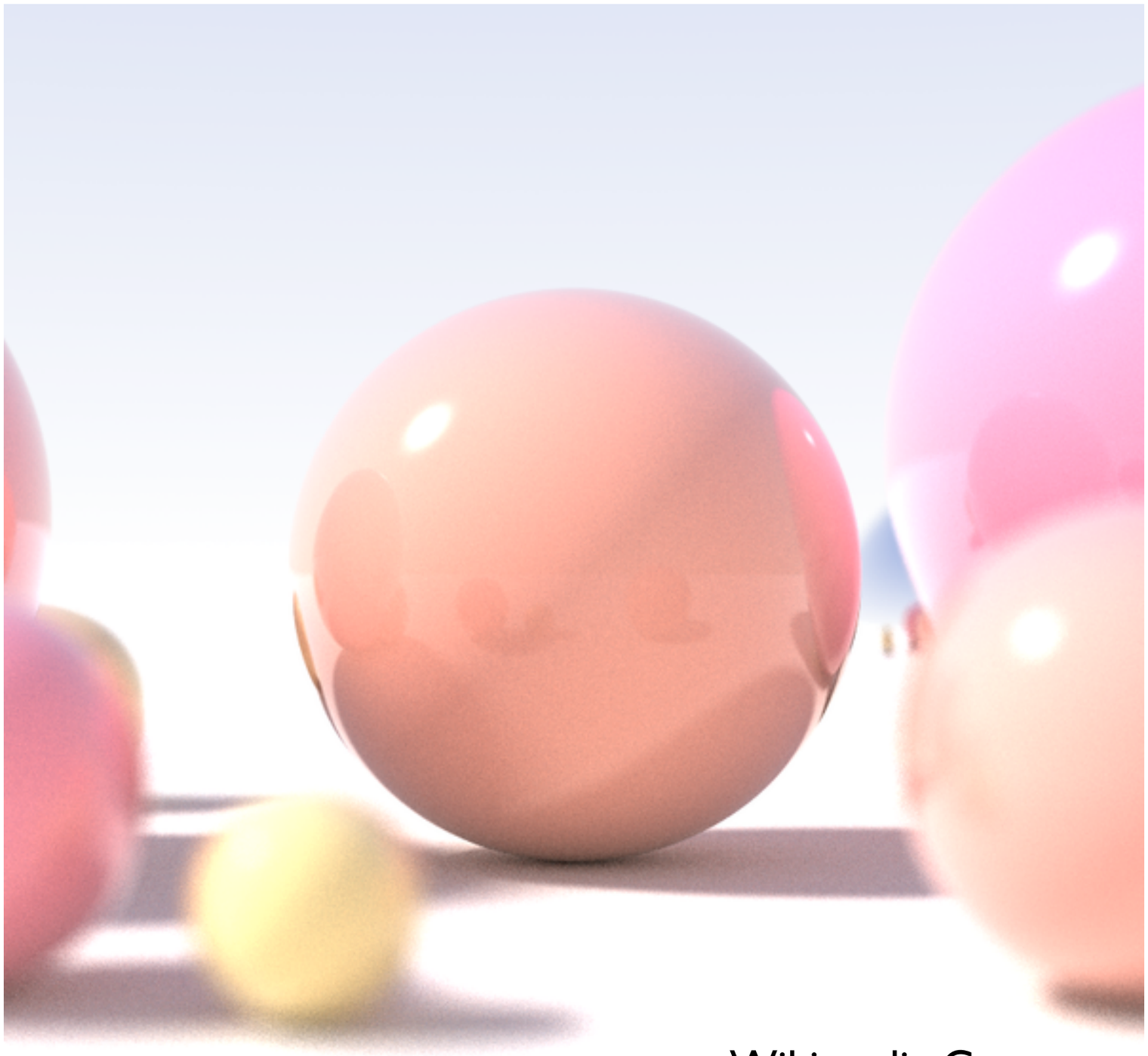


Greg L., Wikimedia Commons

up to 16 reflections per ray



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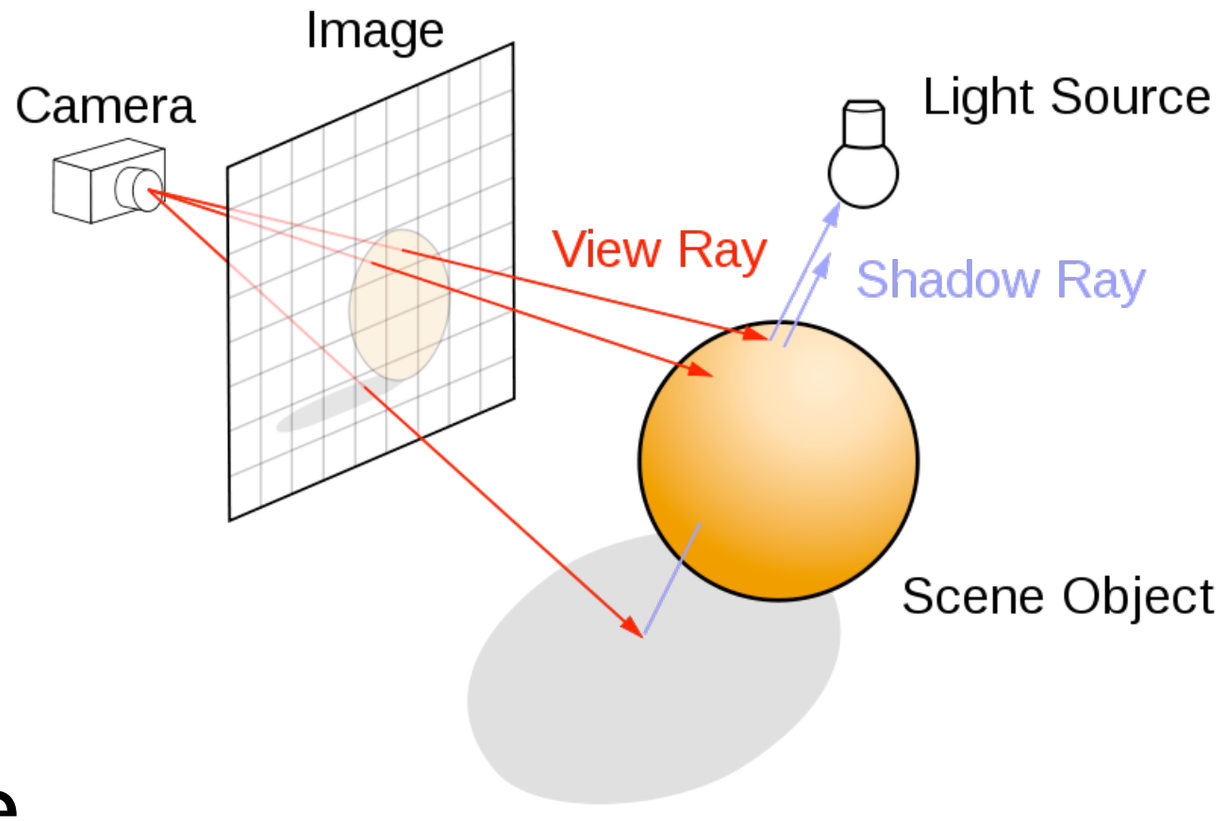
shallow depth of field, area light sources,
diffuse inter-reflection

Basic Algorithm

for each pixel

1. **cast view ray**: compute view ray from camera through pixel into scene
2. **intersect**: find intersection of ray with closest object
3. **shade**: compute the color of the intersection point



Ray Tracing Program

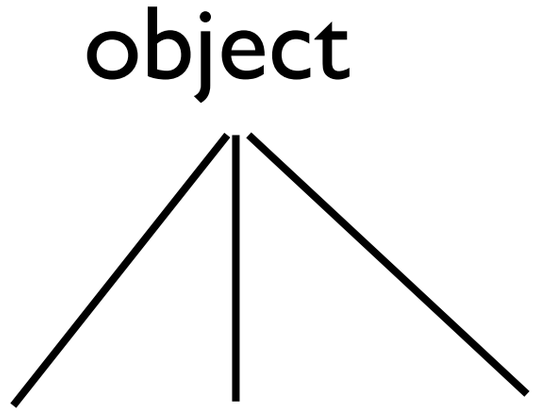
```
for each pixel do
    compute viewing ray
    find closest object that intersects ray
    if ( ray hits an object with t in [0, inf] ) then
        compute n
        evaluate shading model and set pixel to that color
    else
        set pixel color to the background color
```

Object-oriented design

```
class object
{
  public:

     . . .

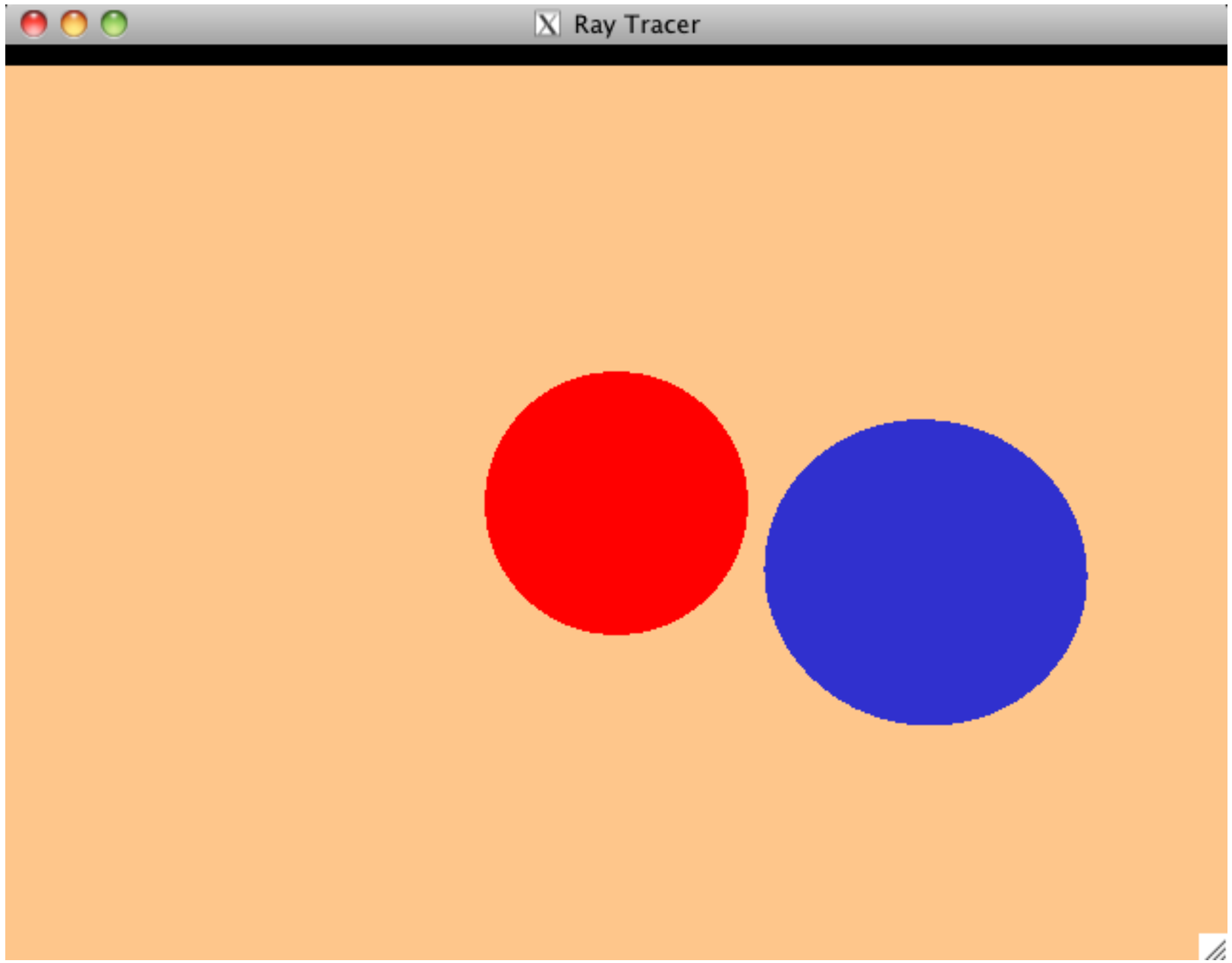
     bool Intersection(RAY& ray)=0;
     vec4 Normal(vec3& point)=0;
     Box Bounding_Box()=0;
}
```



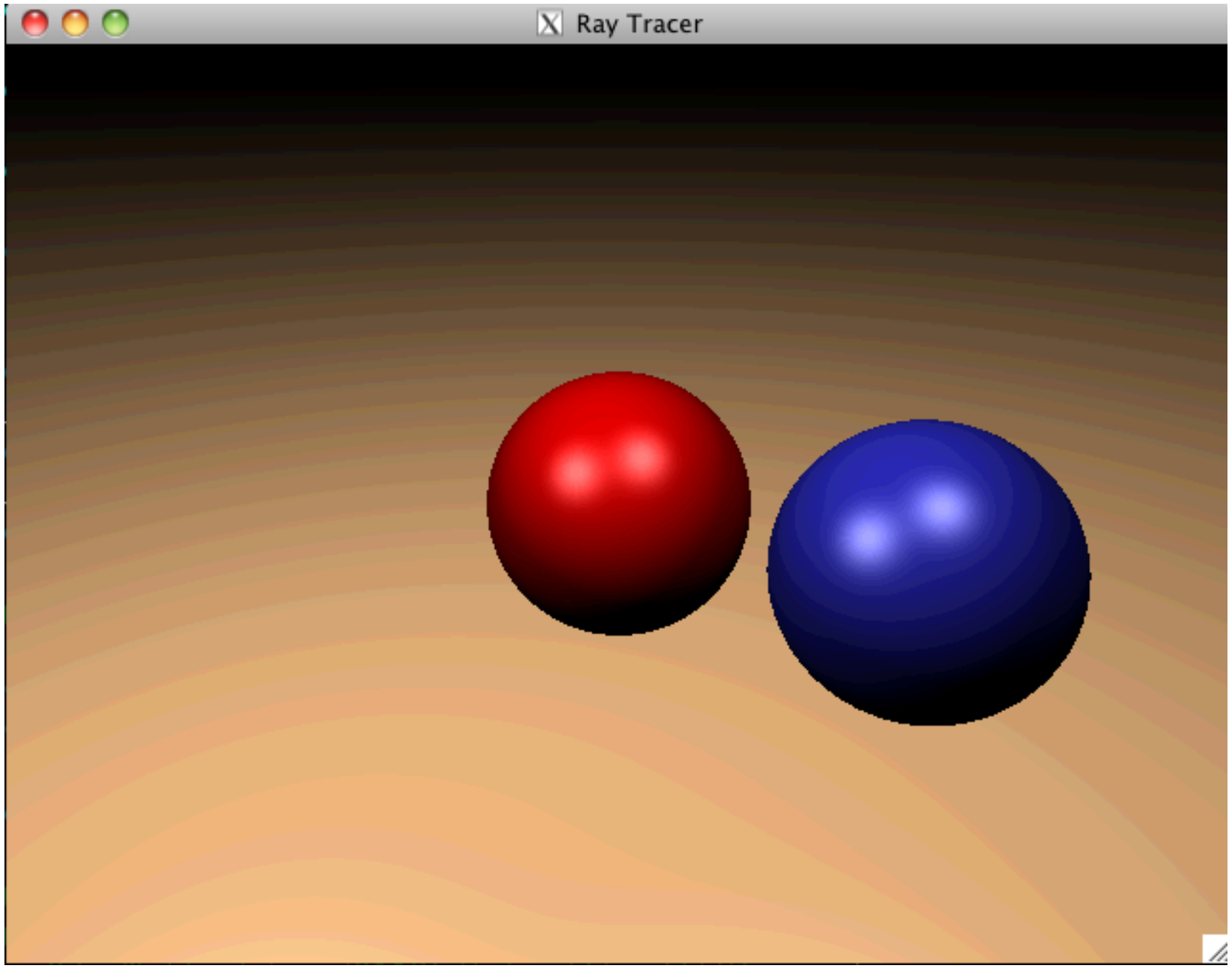
sphere plane triangle

Other classes: ray, light, shader, camera, world

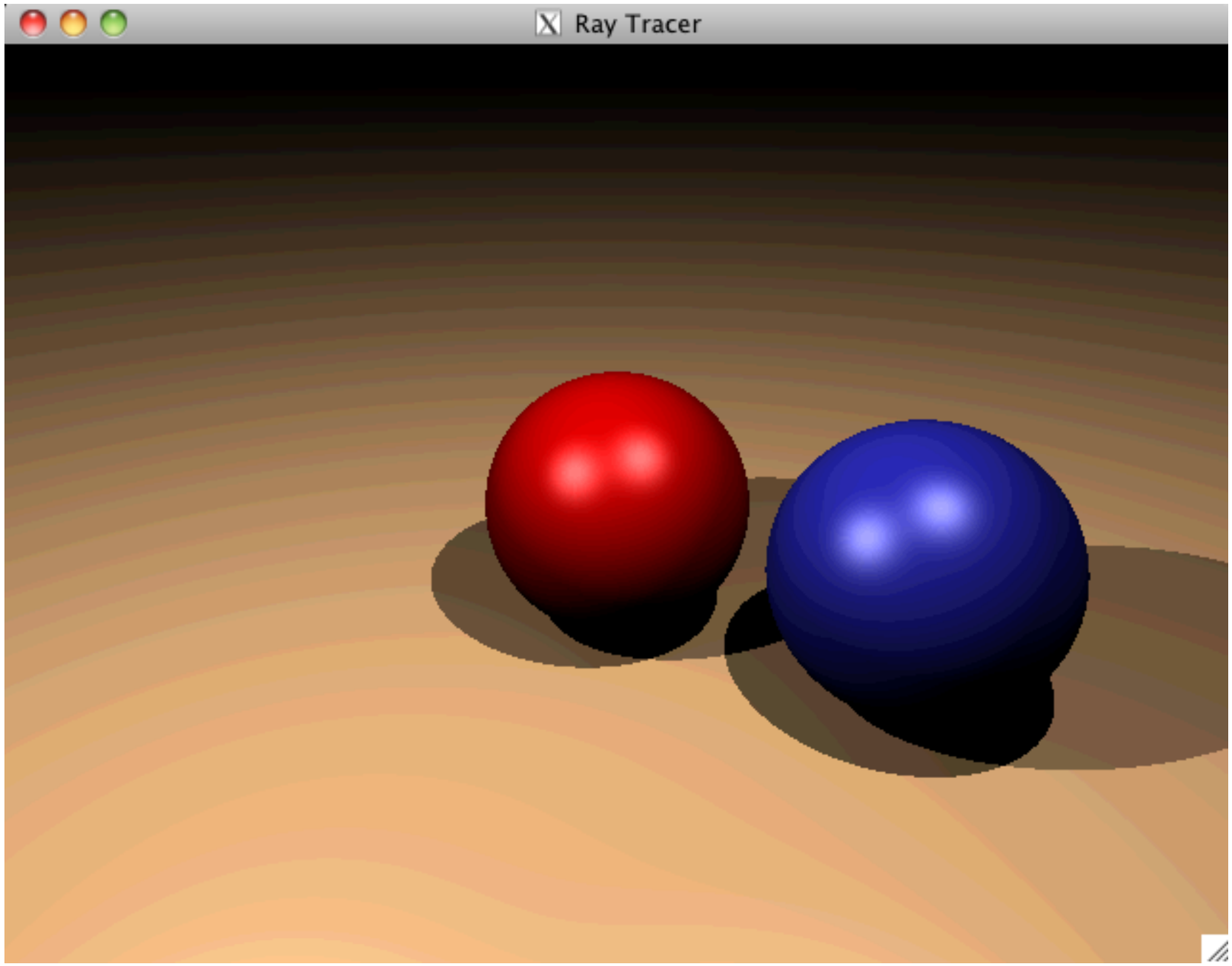
Simple Ray Tracer



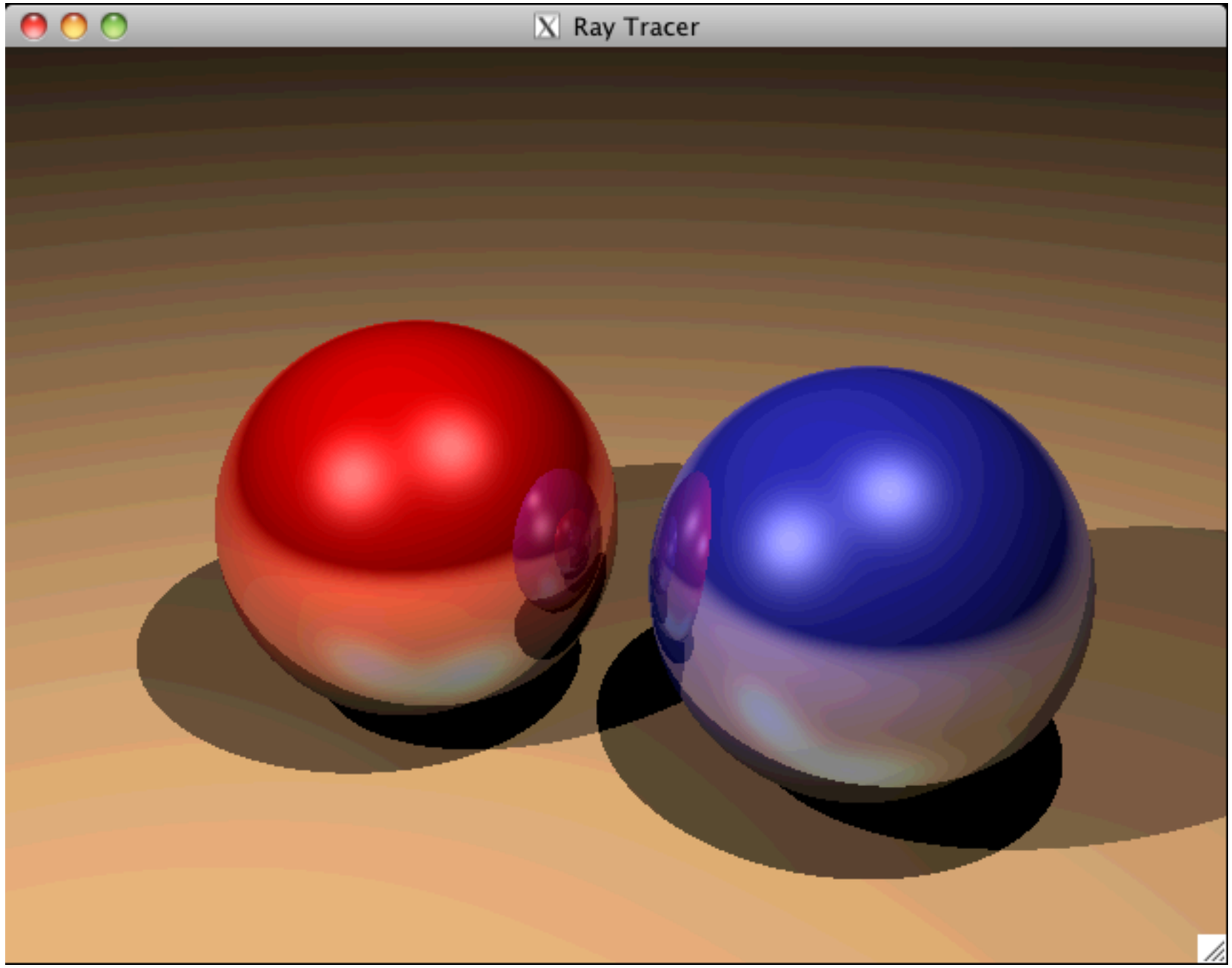
Add Phong Shading



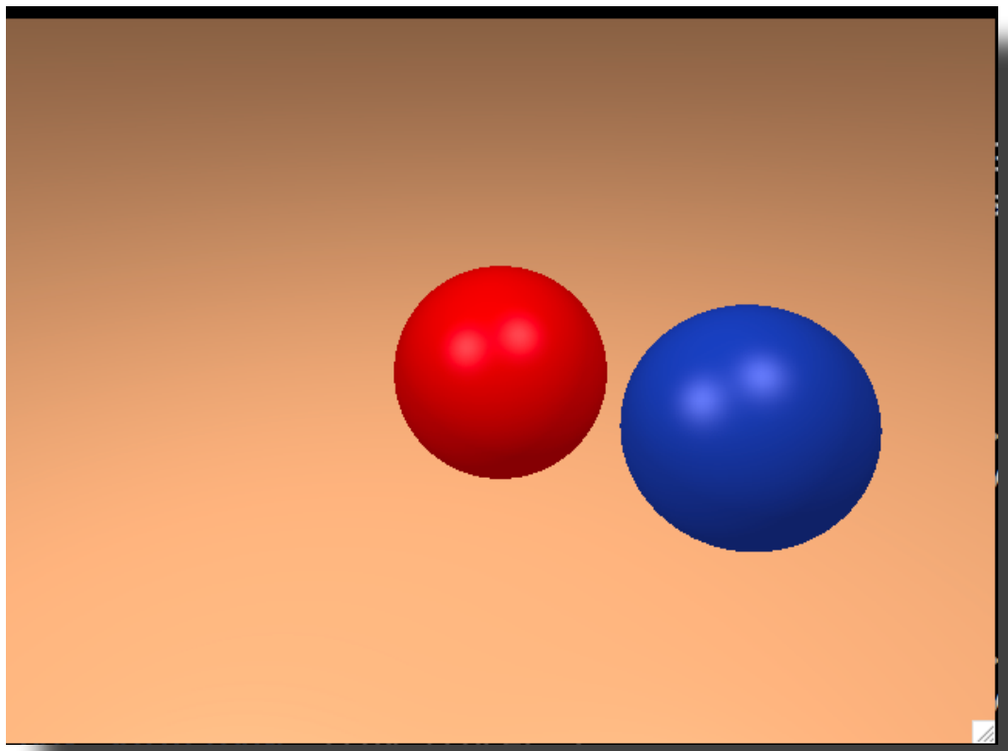
Add Shadows

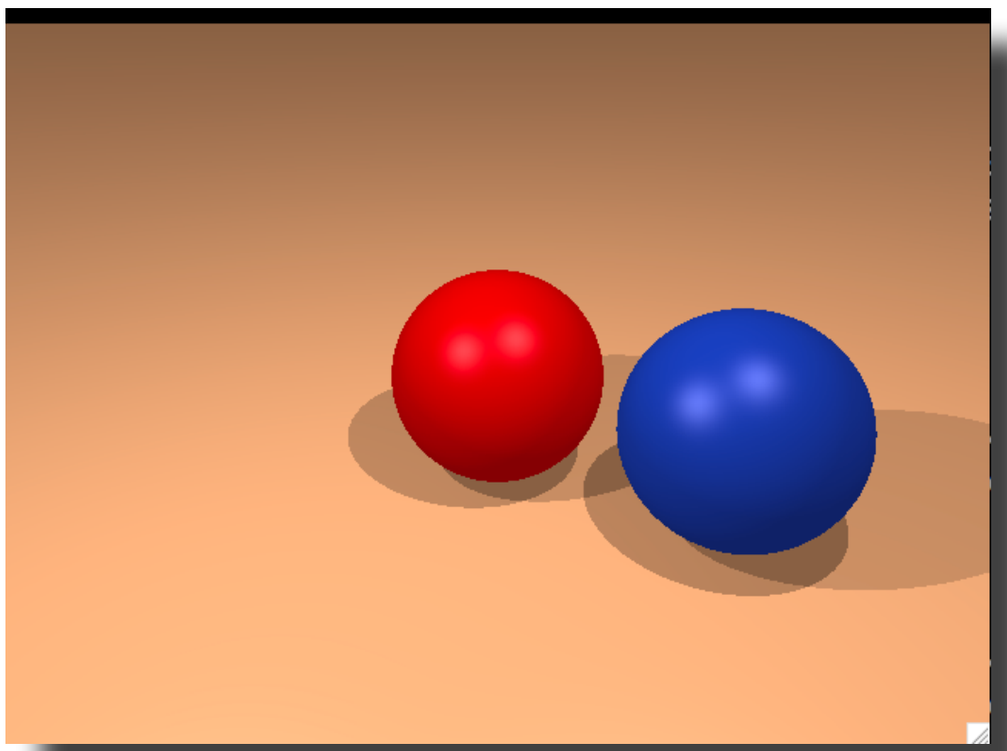


Add Reflections



Shadows





Shadows

```
for each pixel do
    compute viewing ray
    find closest object that intersects ray
    if ( ray hits an object with t in [0, inf] ) then
        compute n
        evaluate shading model and set pixel to that color
    else
        set pixel color to the background color
```

Shadows

```
for each pixel do
    compute viewing ray
    find closest object that intersects ray
    if ( ray hits an object with t in [0, inf] ) then
        compute n
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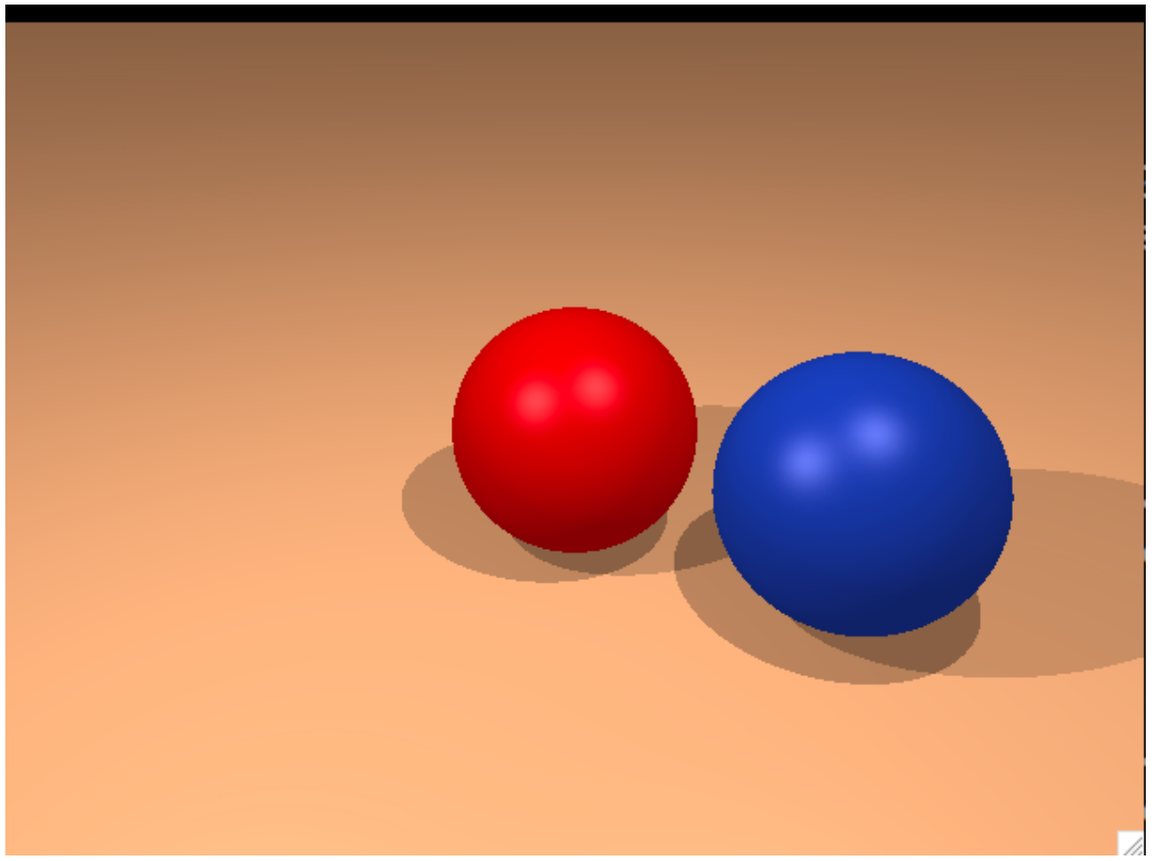
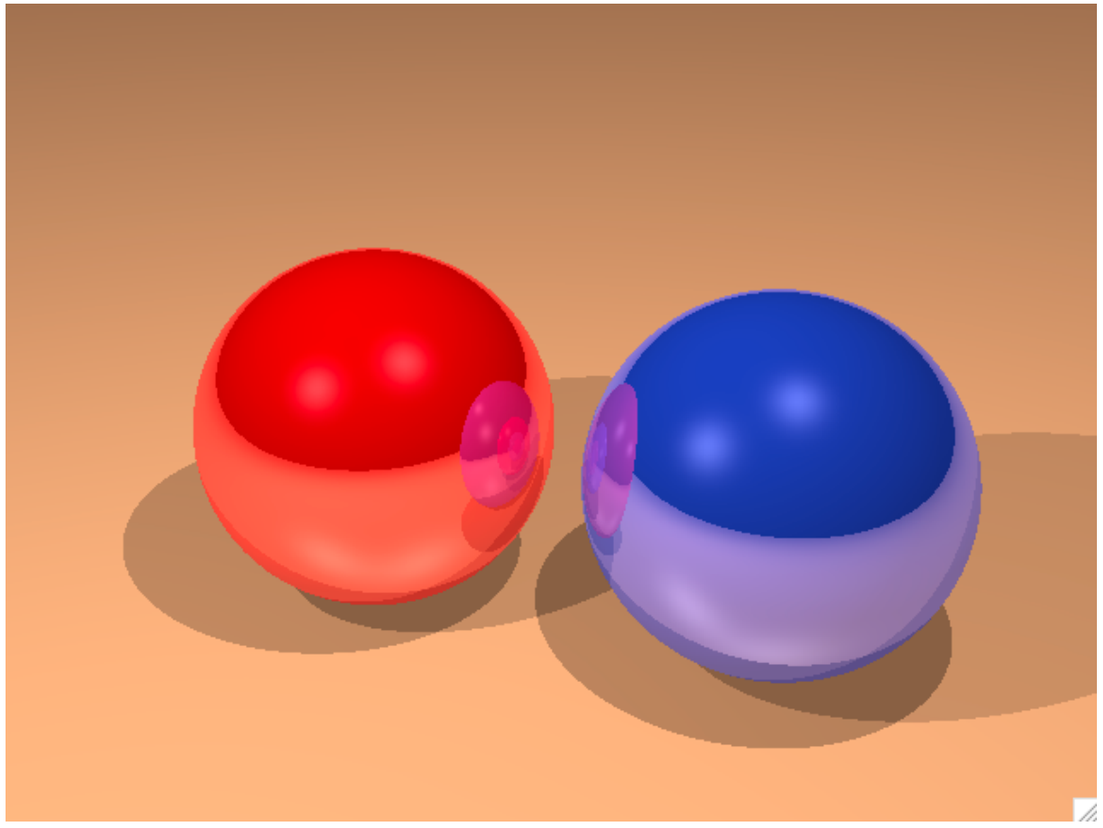
```

Shadows

```
for each pixel do
    compute viewing ray
    find closest object that intersects ray
    if ( ray hits an object with t in [0, inf] ) then
        compute n
        // e.g., phong shading
        add ambient component
        for each light
          compute shadow ray
          if ( ! shadow ray hits an object )
            add light's diffuse and specular components
    else
        set pixel color to the background color
```

Reflections





Reflections

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for each pixel do
    compute viewing ray
    find closest object that intersects ray
    if ( ray hits an object with t in [0, inf] ) then
        compute n
        evaluate shading model and set pixel to that color
    else
        set pixel color to the background color
```

Reflections

```
for each pixel do
    compute viewing ray
    pixel color = cast_ray(viewing ray)

cast_ray:
    find closest object that intersects ray
    if ( ray hits an object with t in [0, inf] ) then
        compute n
        return color = shade_surface
    else
        return color = to the background color

shade_surface:
    color = ...
    compute reflected ray
    return color = (1-k) * color + k * cast_ray(reflected ray)
```