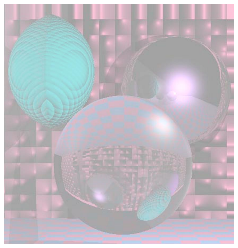
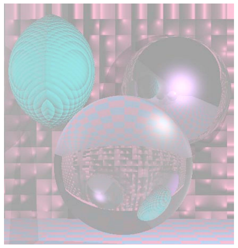


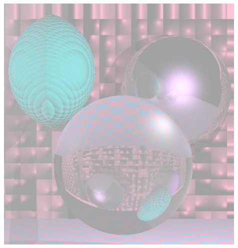
CS 4300
Computer Graphics

Prof. Harriet Fell
Fall 2011
Lecture 31 – November 16, 2011

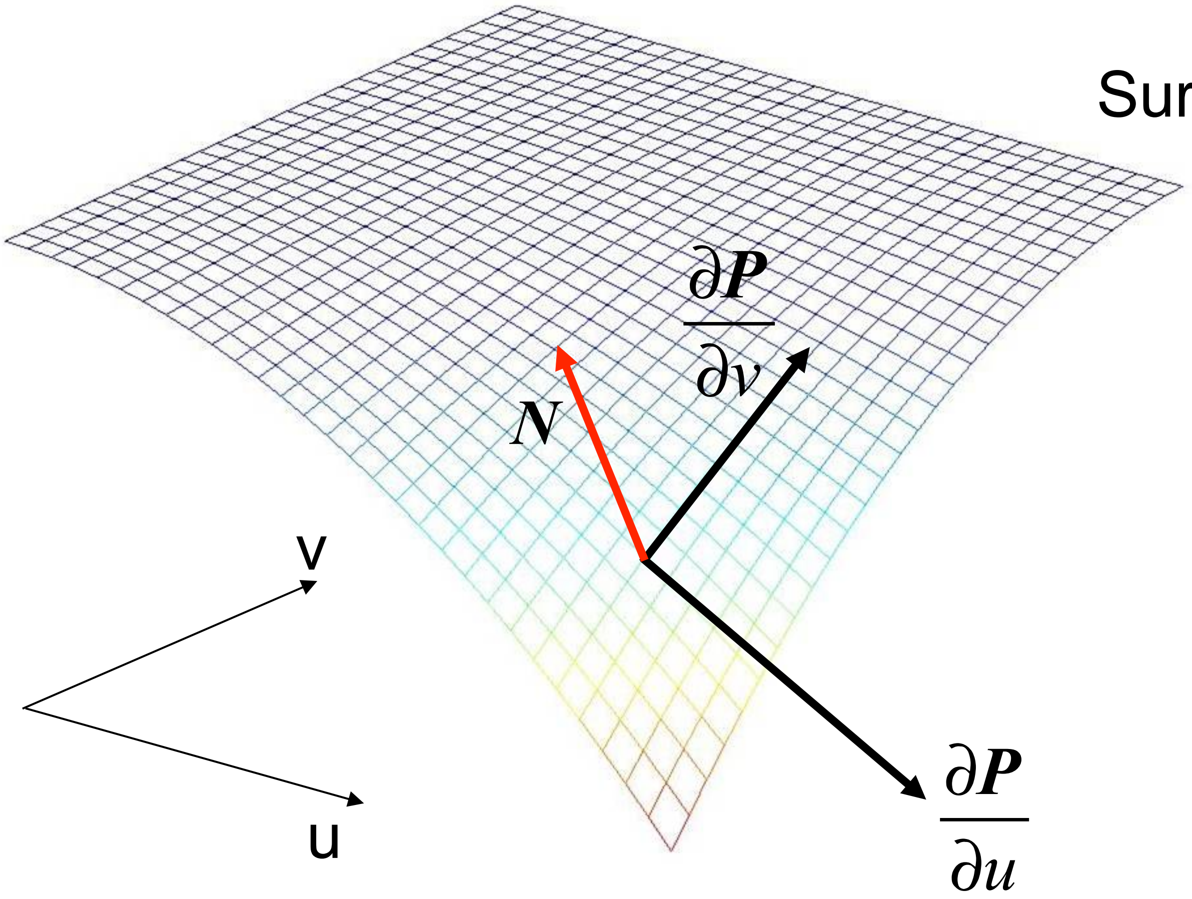


Today’s Topics

- Bump Maps
- Texture Maps



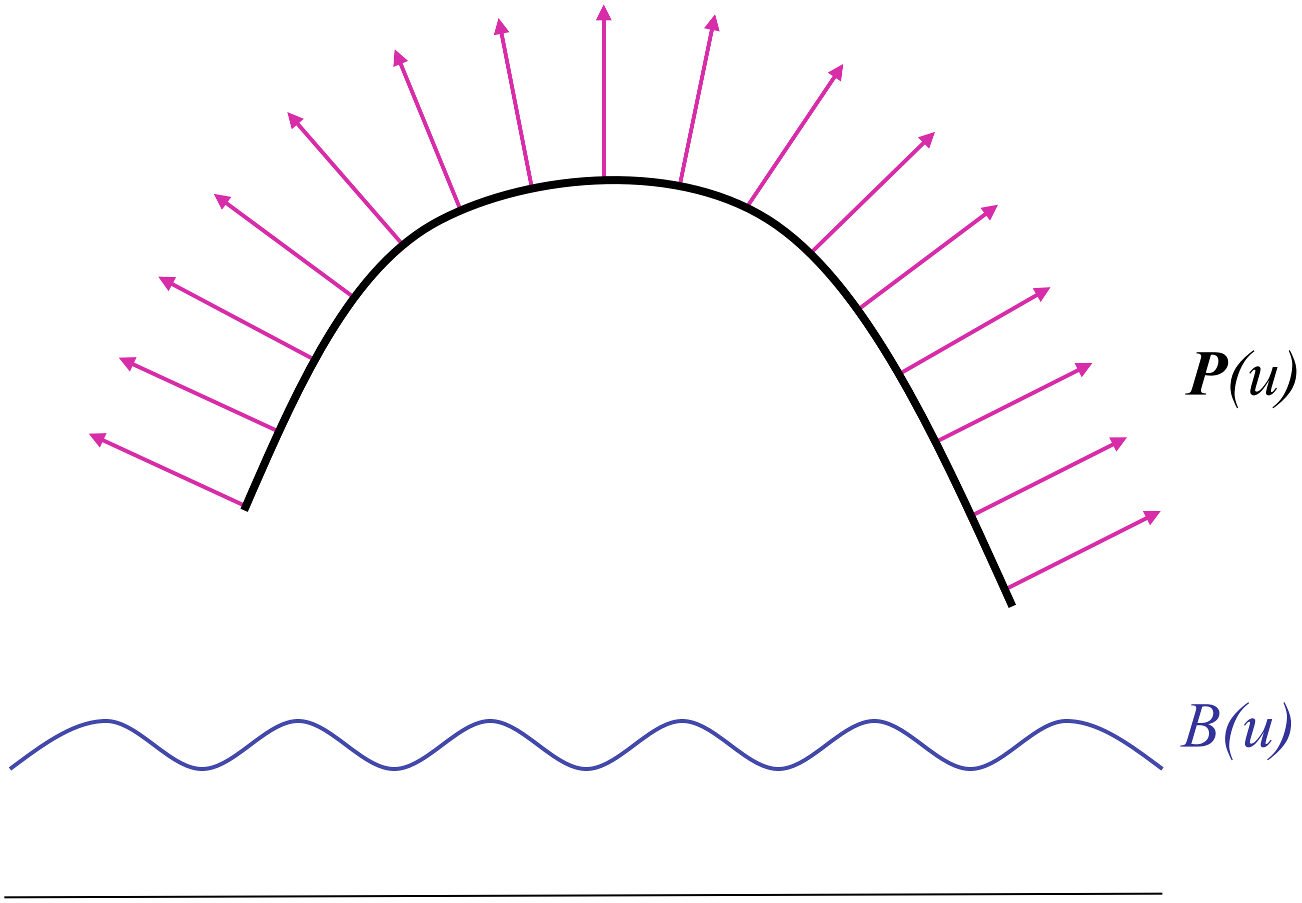
Bump Maps - Blinn 1978


$\frac{\partial \boldsymbol{P}}{\partial v}$
$\boldsymbol{N}$
v
u
$\frac{\partial \boldsymbol{P}}{\partial u}$

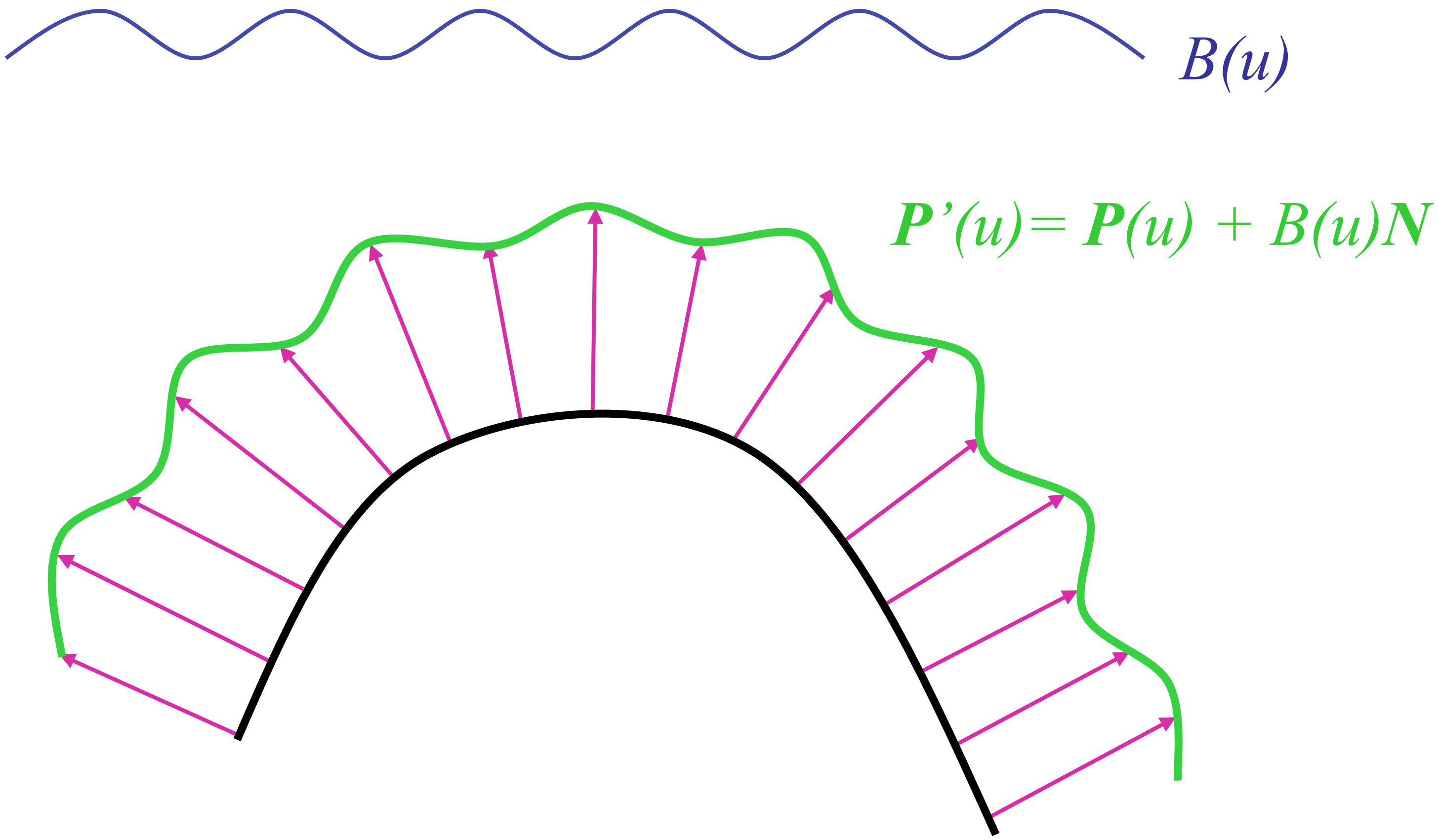
Surface $\boldsymbol{P}(u, v)$

$$\boldsymbol{N} = \frac{\partial \boldsymbol{P}}{\partial u} \times \frac{\partial \boldsymbol{P}}{\partial v}$$

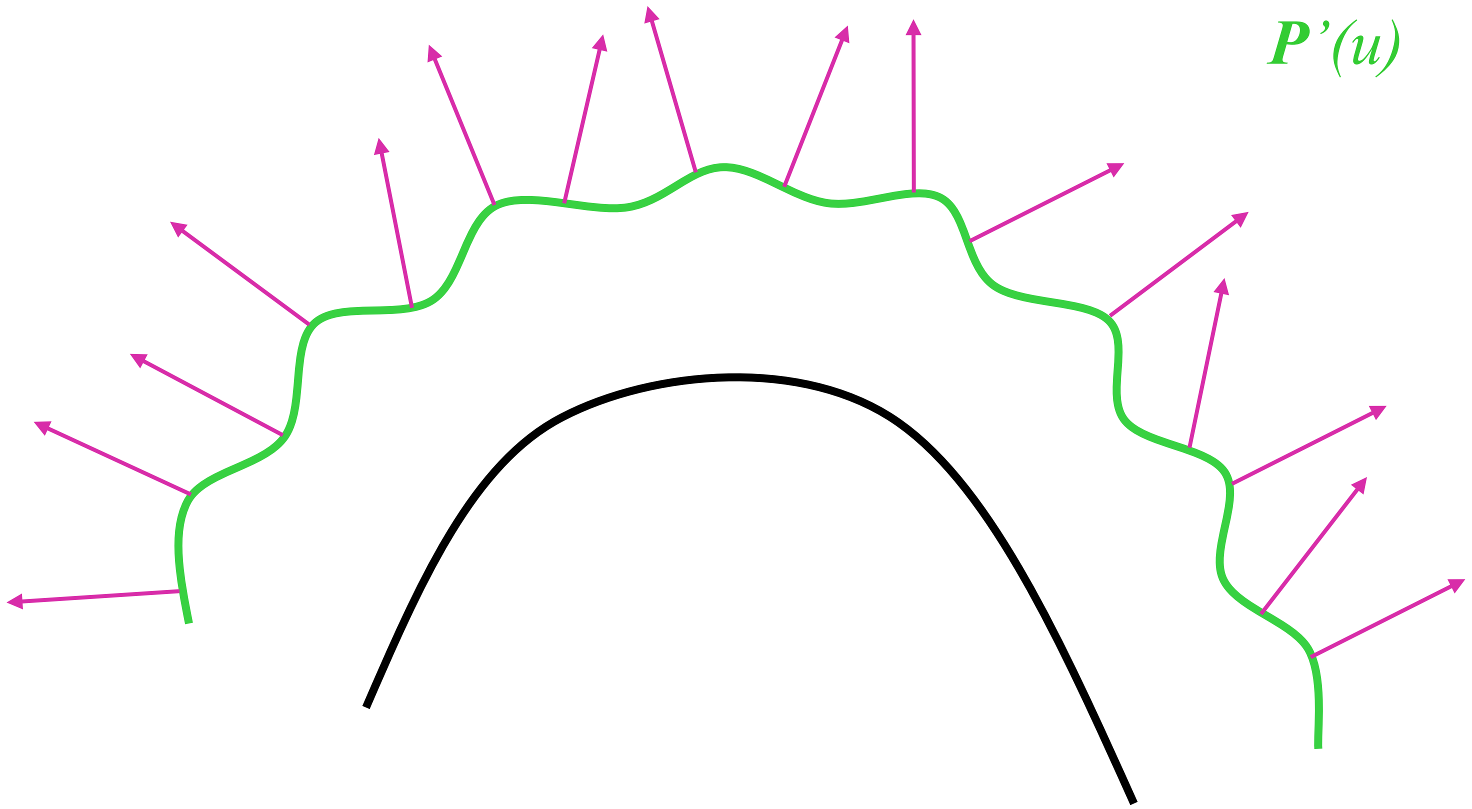
One dimensional Example

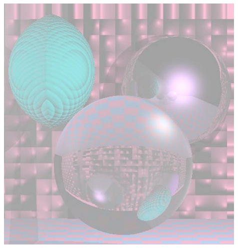


The New Surface



The New Surface Normals





Bump Maps - Formulas

A parametric Surface $\left(x(u,v), y(u,v), z(u,v)\right) = \boldsymbol{P}(u,v)$

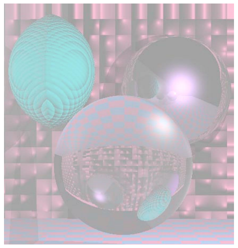
$$\boldsymbol{N} = \frac{\partial \boldsymbol{P}}{\partial u} \times \frac{\partial \boldsymbol{P}}{\partial v}$$

The new surface $\boldsymbol{P}'(u,v) = \boldsymbol{P}(u,v) + B(u,v)\boldsymbol{N}$

$$\boldsymbol{N}' = \boldsymbol{P}'_u \times \boldsymbol{P}'_v$$

$$\boldsymbol{P}'_u = \boldsymbol{P}_u + B_u \boldsymbol{N} + B(u,v)\boldsymbol{N}_u$$

$$\boldsymbol{P}'_v = \boldsymbol{P}_v + B_v \boldsymbol{N} + B(u,v)\boldsymbol{N}_v$$



The New Normal

$$\boldsymbol{N}' = \left(\boldsymbol{P}_u + B_u\boldsymbol{N} + B(u,v)\boldsymbol{N}_u\right)\times\left(\boldsymbol{P}_v + B_v\boldsymbol{N} + B(u,v)\boldsymbol{N}_v\right)$$

$$= \boldsymbol{P}_u\times\boldsymbol{P}_v + B_v\boldsymbol{P}_u\times\boldsymbol{N} + \xcancel{B(u,v)\boldsymbol{P}_u\times\boldsymbol{N}_v}$$

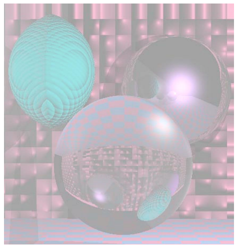
$$+B_u\boldsymbol{N}\times\boldsymbol{P}_v + \xcancel{B_uB_v\boldsymbol{N}\times\boldsymbol{N}} + \xcancel{B_uB(u,v)\boldsymbol{N}\times\boldsymbol{N}_v}$$

$$+\xcancel{B(u,v)\boldsymbol{N}_u\times\boldsymbol{P}_v} + \xcancel{B(u,v)B_v\boldsymbol{N}_u\times\boldsymbol{N}} + \xcancel{B(u,v)^2\boldsymbol{N}_u\times\boldsymbol{N}_v}$$

✗ This term is 0.

✗ These terms are small if $B(u, v)$ *is small*.

We use $\boldsymbol{N}' = \boldsymbol{P}_u\times\boldsymbol{P}_v + B_v\boldsymbol{P}_u\times\boldsymbol{N} + B_u\boldsymbol{N}\times\boldsymbol{P}_v$



Tweaking the Normal Vector

$$N' = \boldsymbol{P}_u \times \boldsymbol{P}_v + B_v \boldsymbol{P}_u \times \boldsymbol{N} + B_u \boldsymbol{N} \times \boldsymbol{P}_v$$

$$= \boldsymbol{N} + B_v \boldsymbol{P}_u \times \boldsymbol{N} + B_u \boldsymbol{N} \times \boldsymbol{P}_v$$

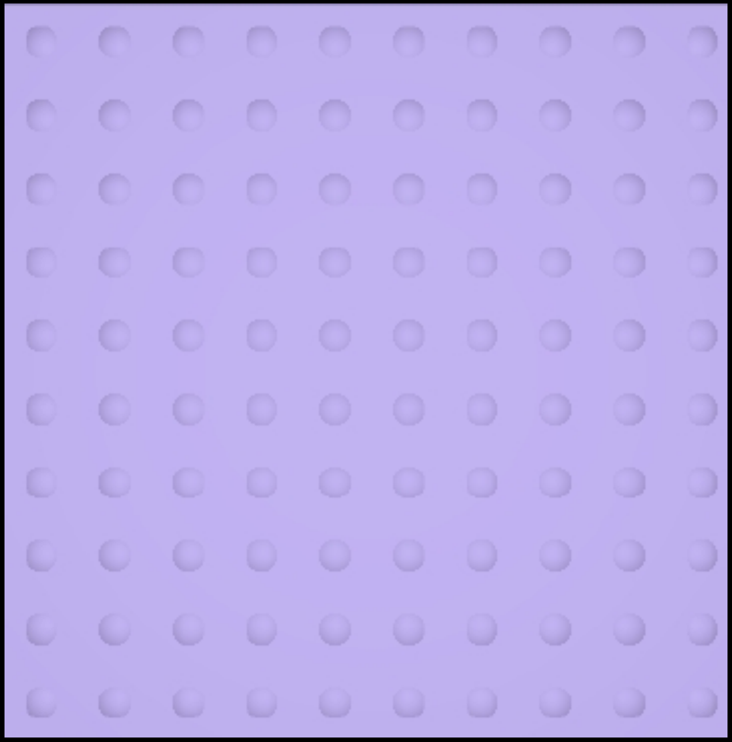
$\boldsymbol{A} = N \times \boldsymbol{P}_v$ $\qquad$ $\boldsymbol{B} = N \times \boldsymbol{P}_u$

$\boldsymbol{D} = B_u \boldsymbol{A} - B_v \boldsymbol{B}$ is the difference vector.

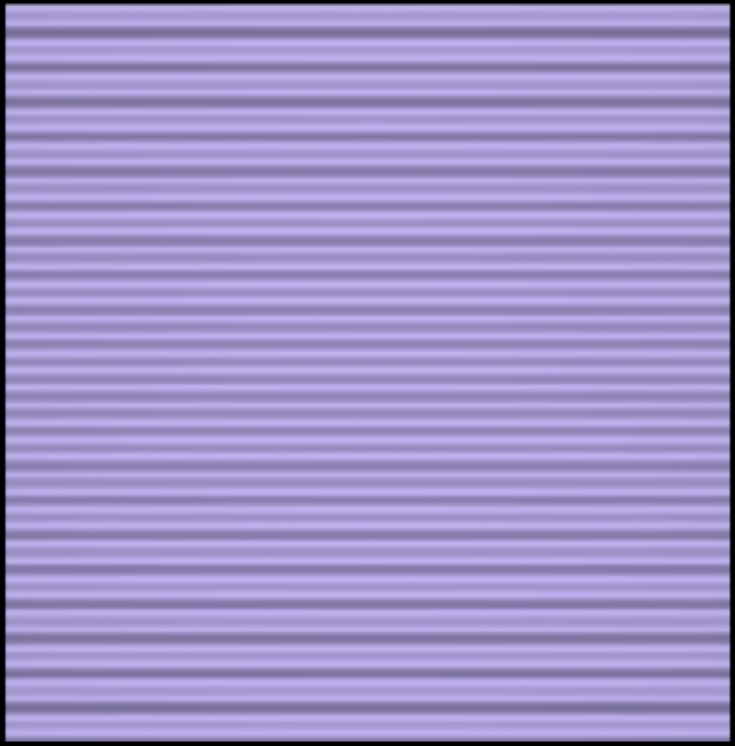
$$N' = \boldsymbol{N} + \boldsymbol{D}$$

D lies in the tangent plane to the surface.

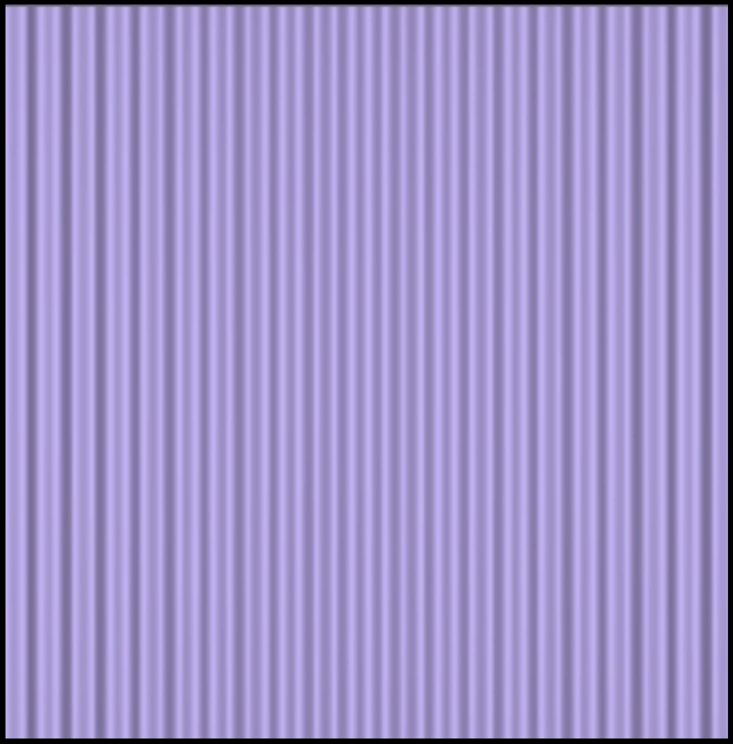
Plane with Spheres



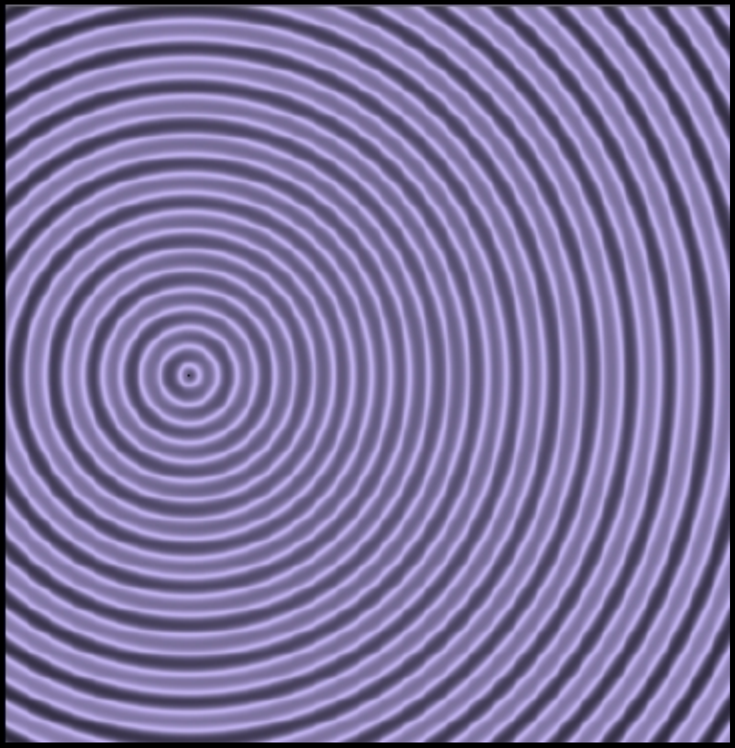
Plane with Horizontal Wave



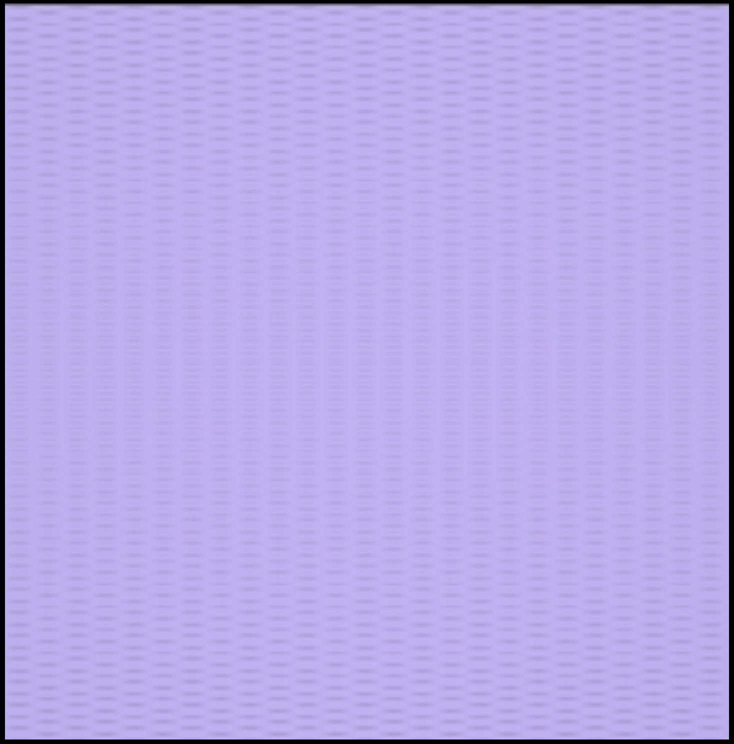
Plane with Vertical Wave



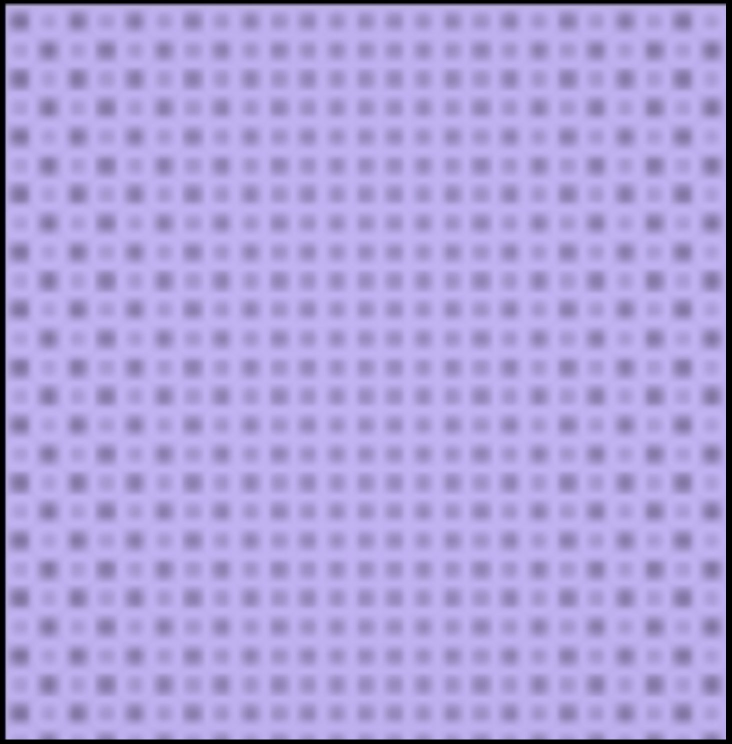
Plane with Ripple



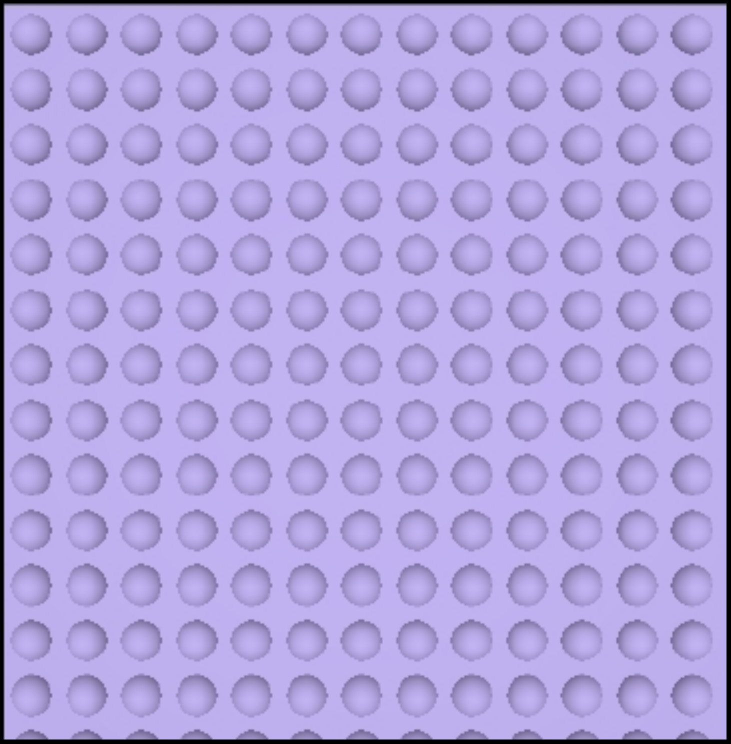
Plane with Mesh



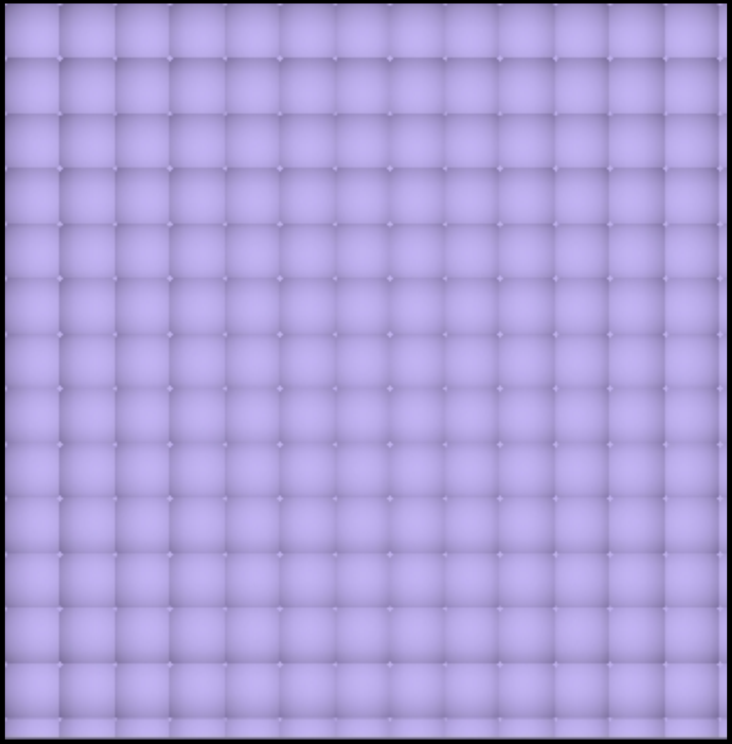
Plane with Waffle



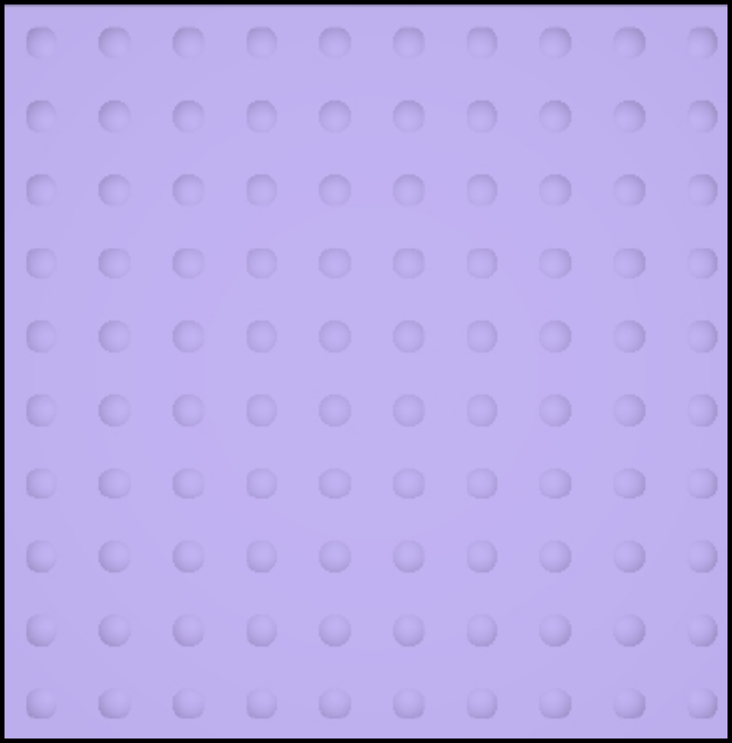
Plane with Dimples

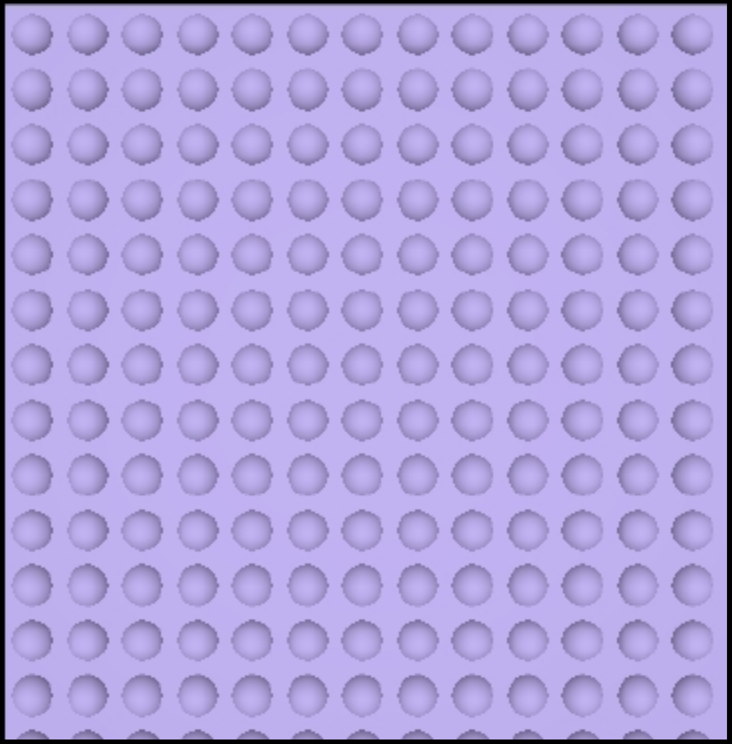


Plane with Squares

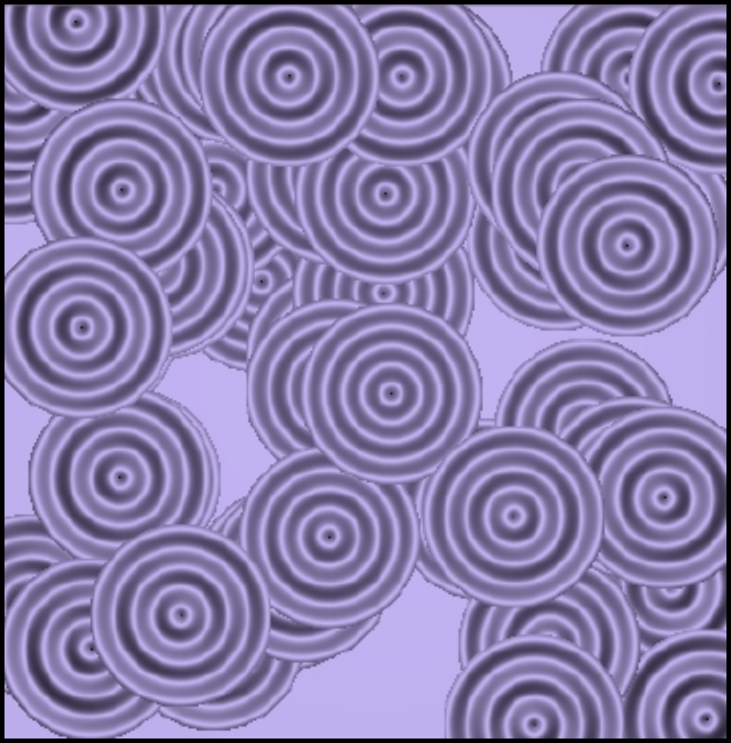


Dots and Dimples

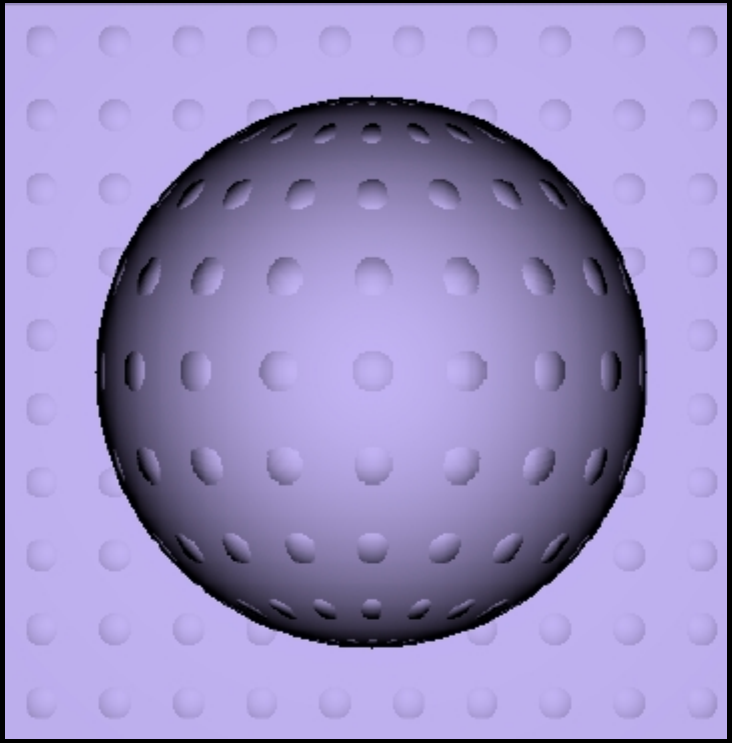




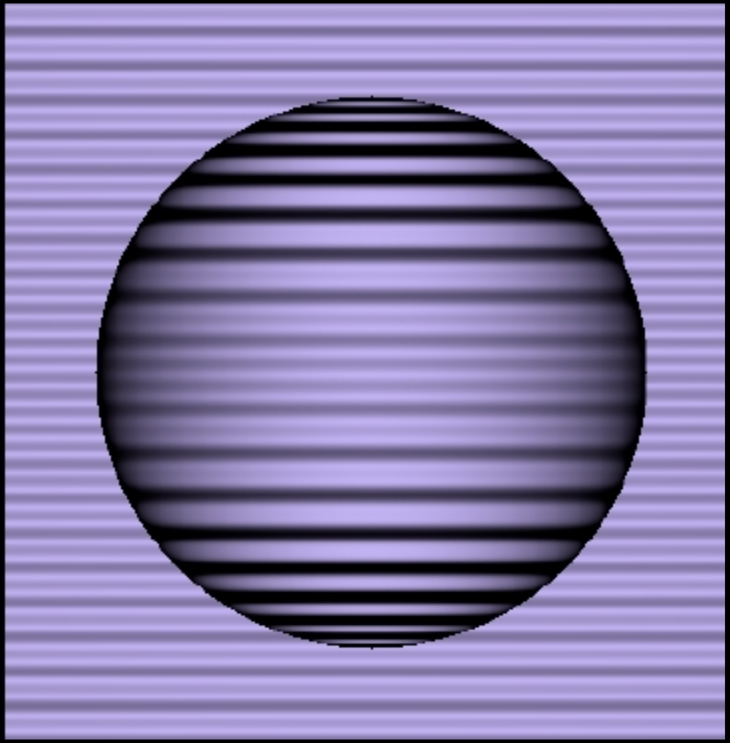
Plane with Ripples



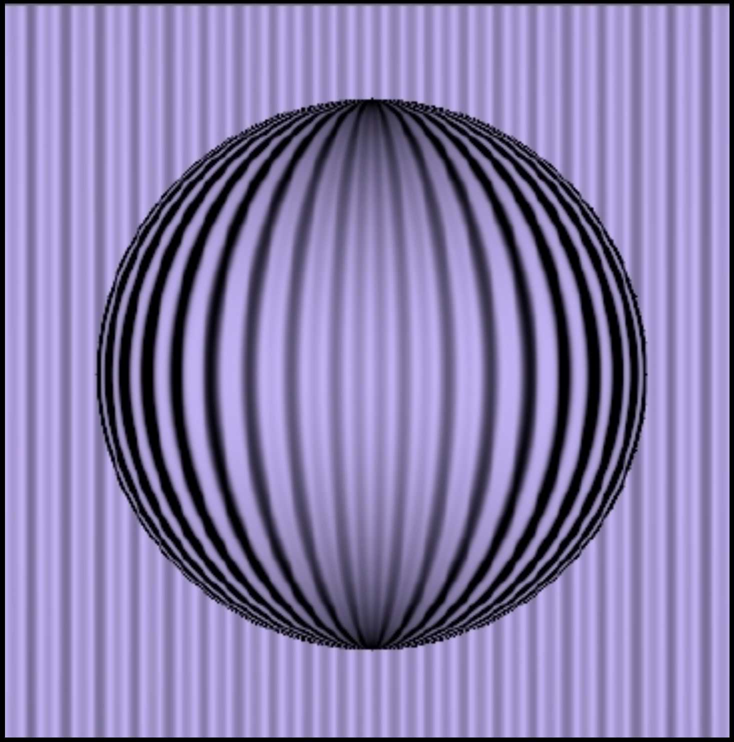
Sphere on Plane with Spheres



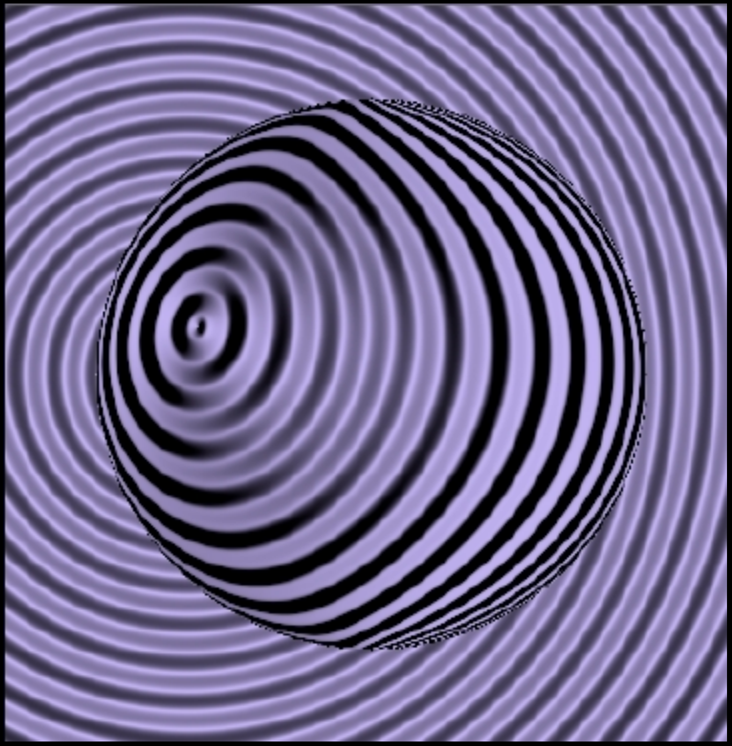
Sphere on Plane with Horizontal Wave



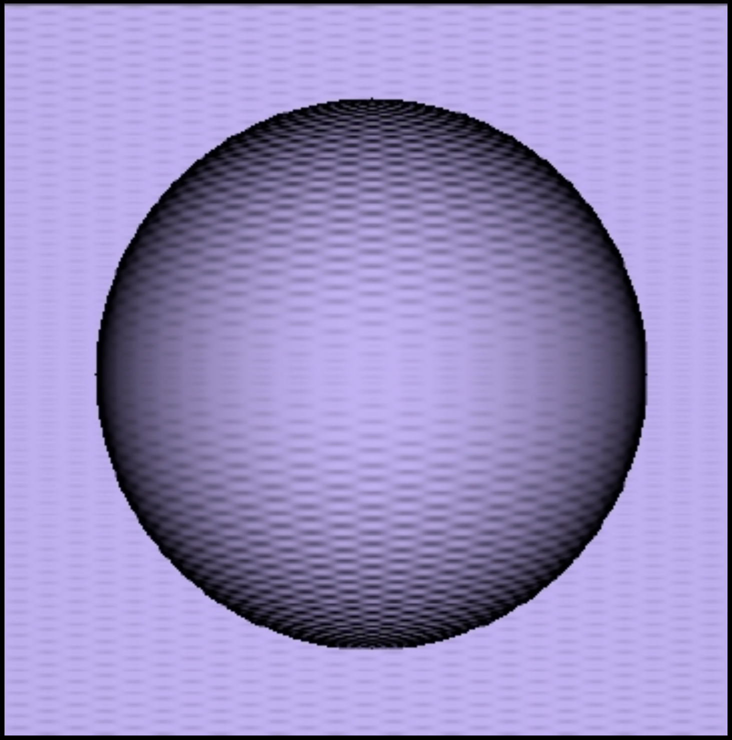
Sphere on Plane with Vertical Wave



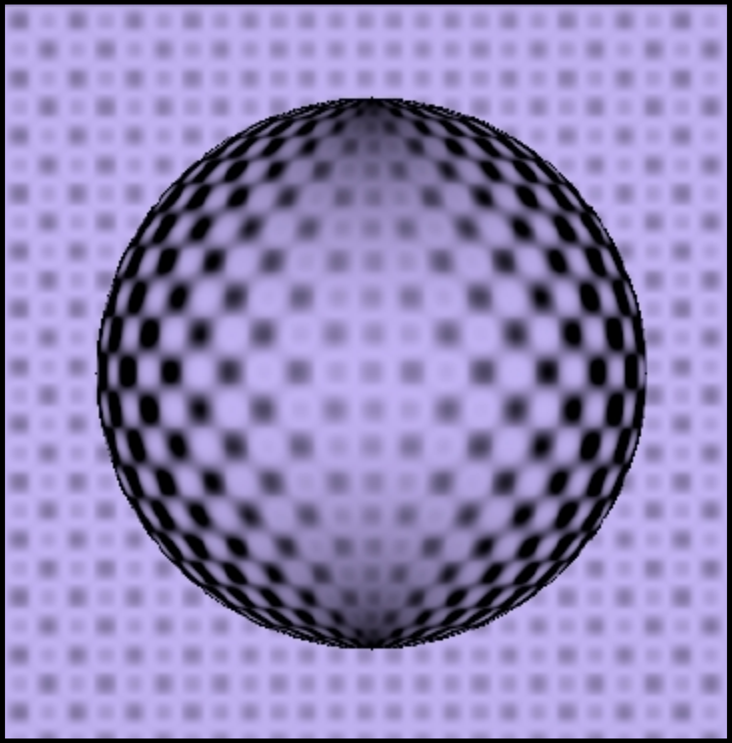
Sphere on Plane with Ripple



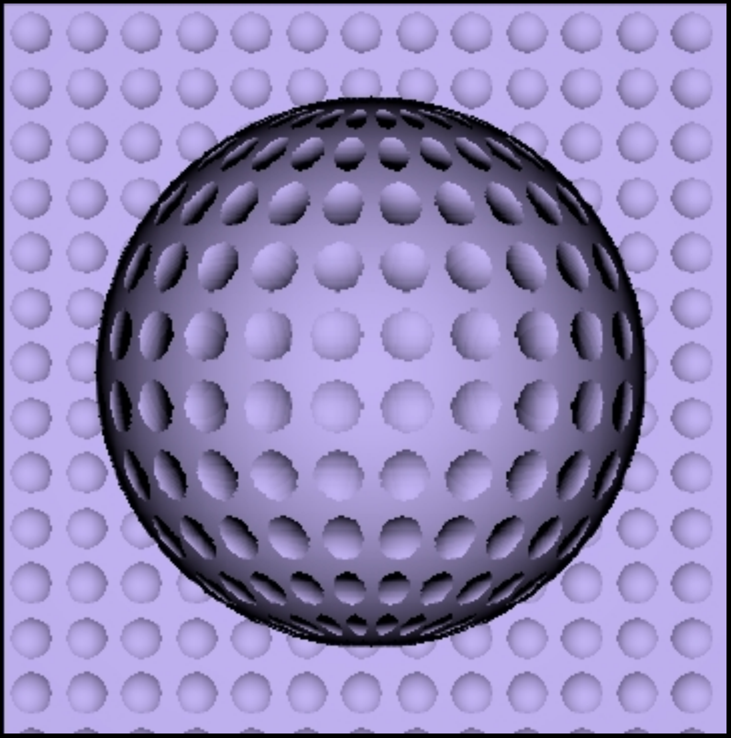
Sphere on Plane with Mesh



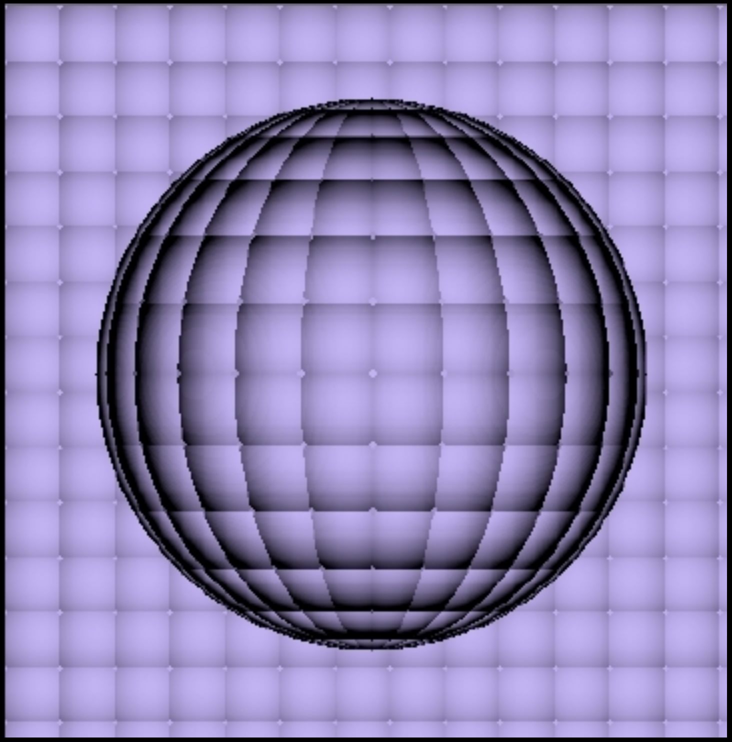
Sphere on Plane with Waffle



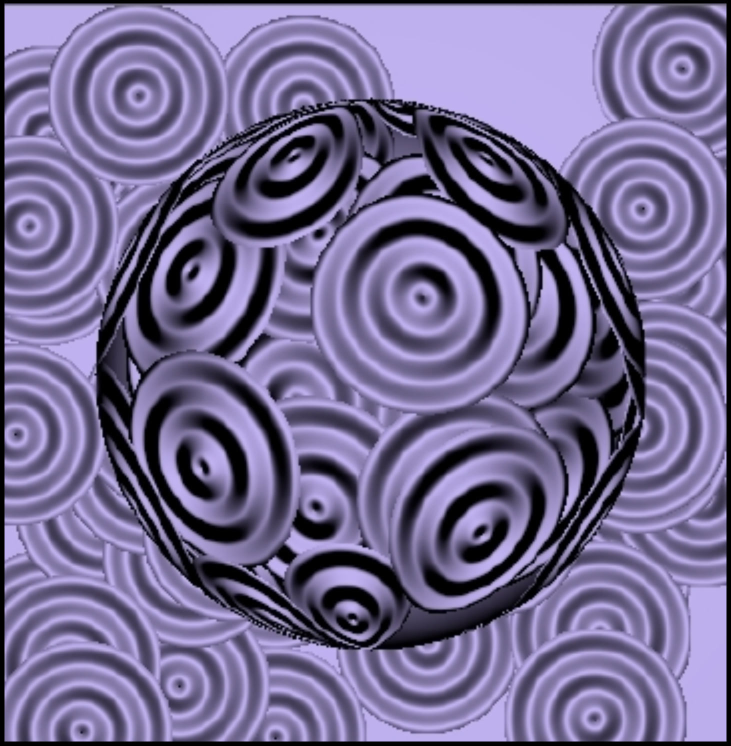
Sphere on Plane with Dimples



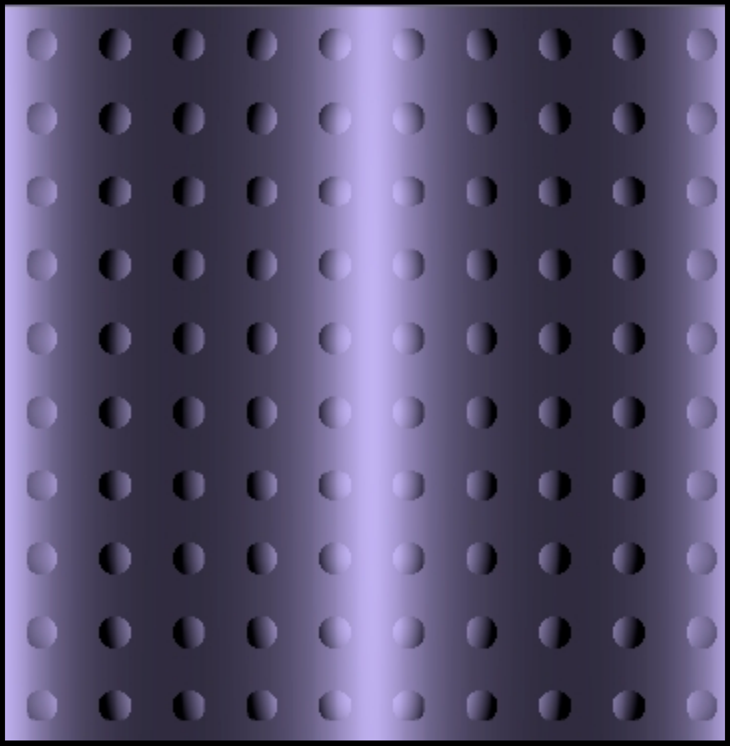
Sphere on Plane with Squares



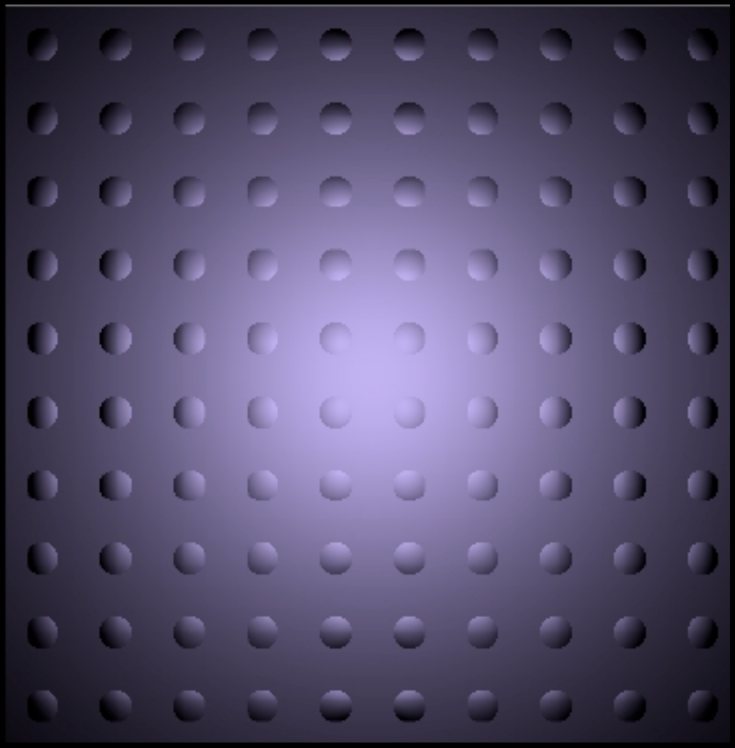
Sphere on Plane with Ripples



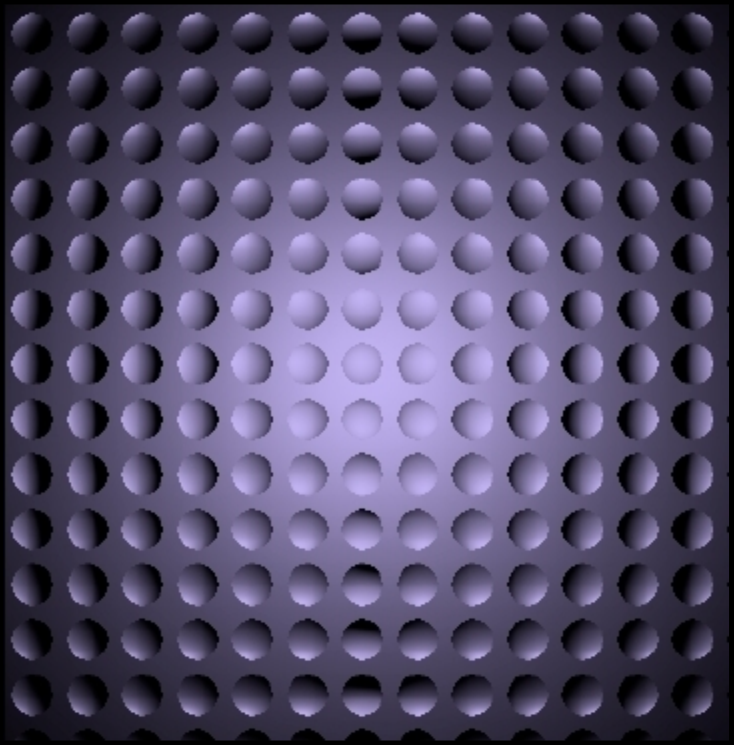
Wave with Spheres



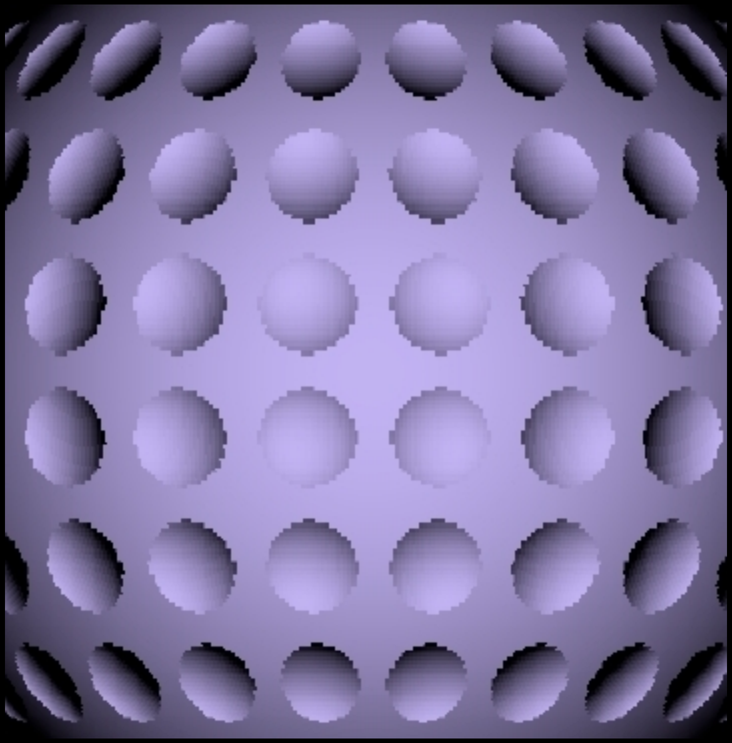
Parabola with Spheres



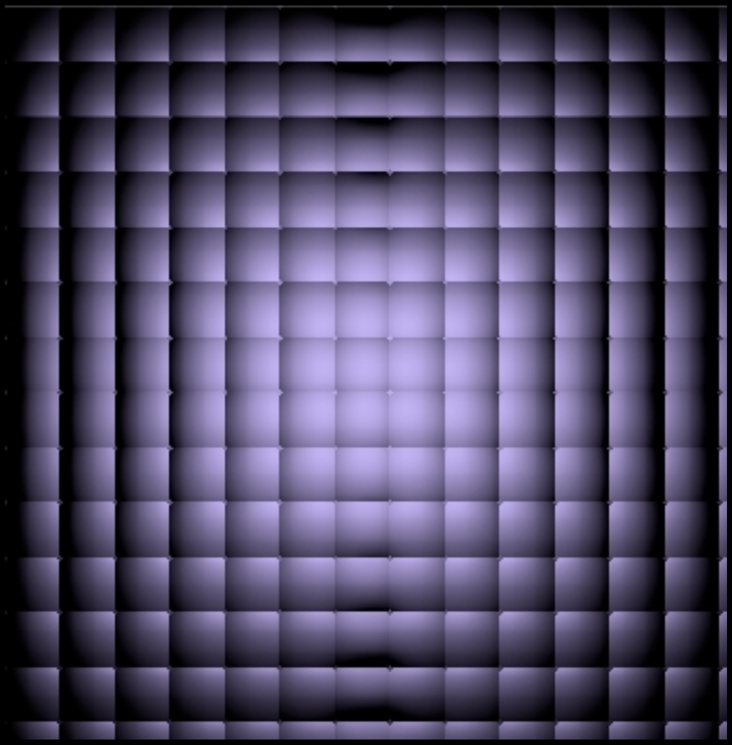
Parabola with Dimples



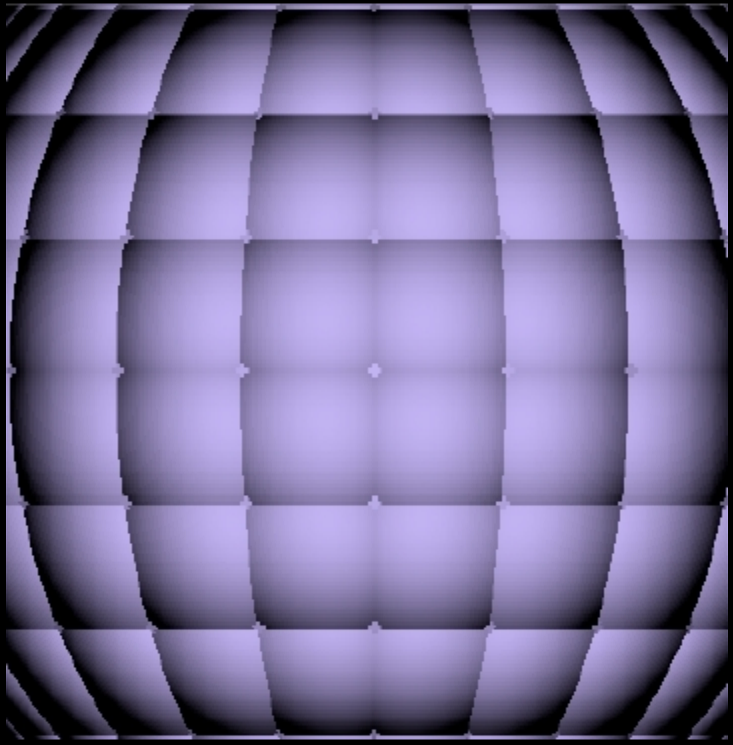
Big Sphere with Dimples



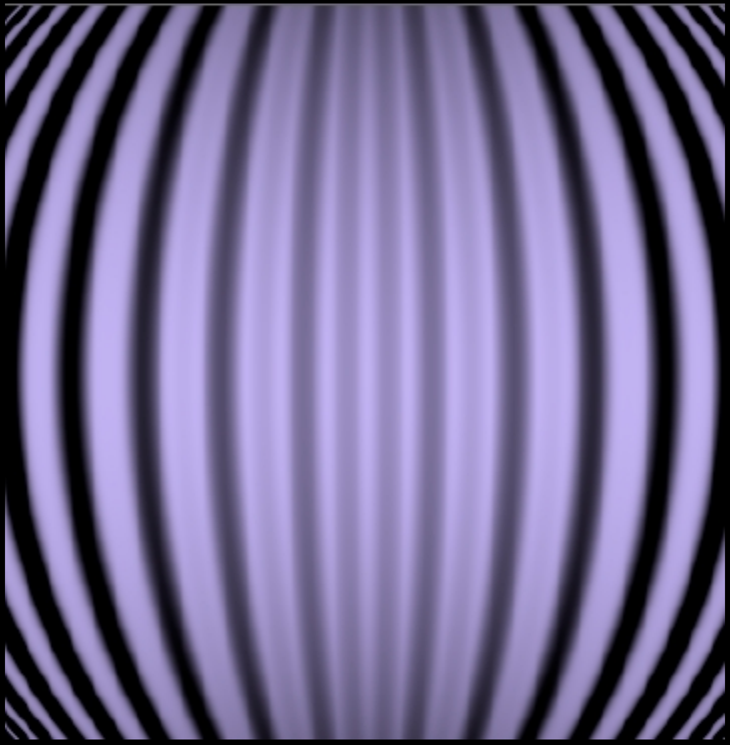
Parabola with Squares



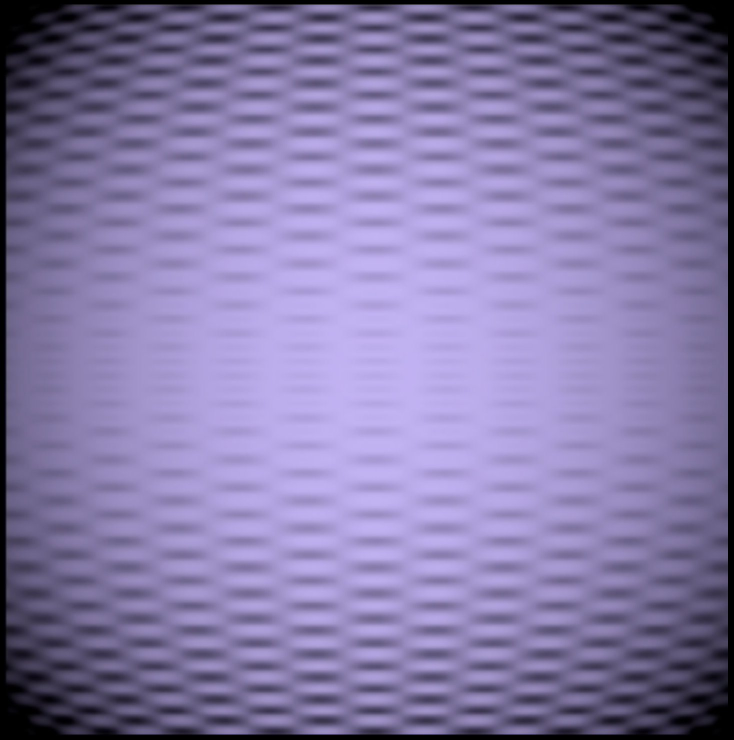
Big Sphere with Squares



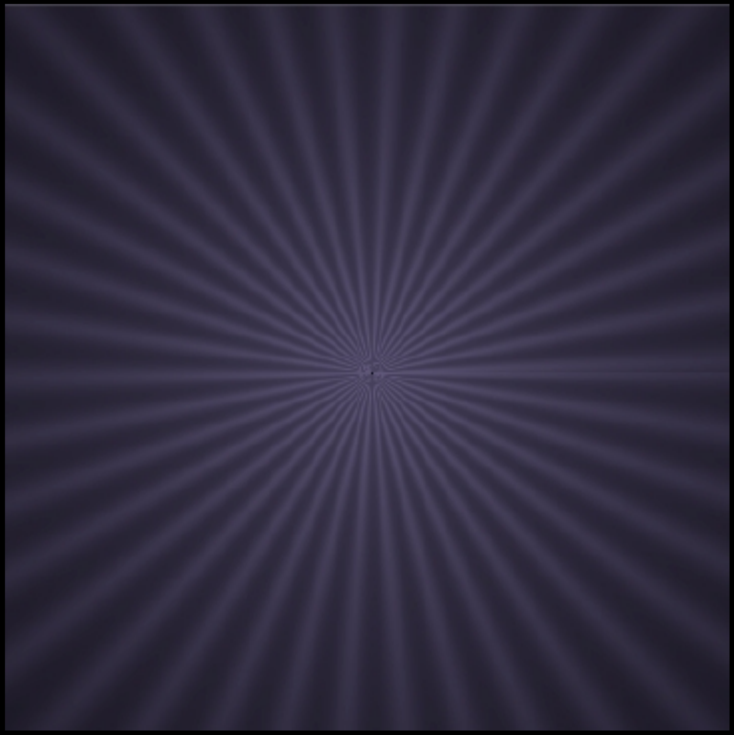
Big Sphere with Vertical Wave



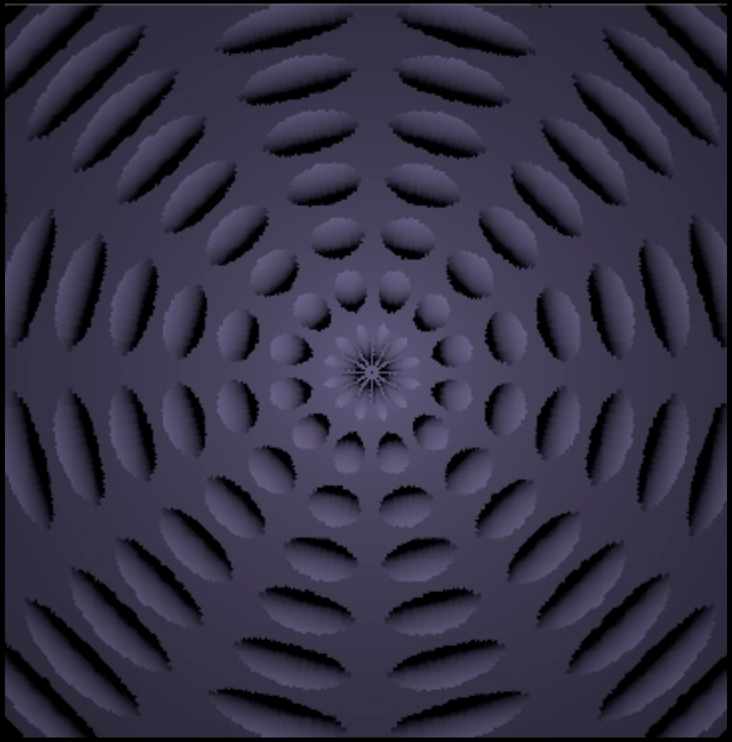
Big Sphere with Mesh



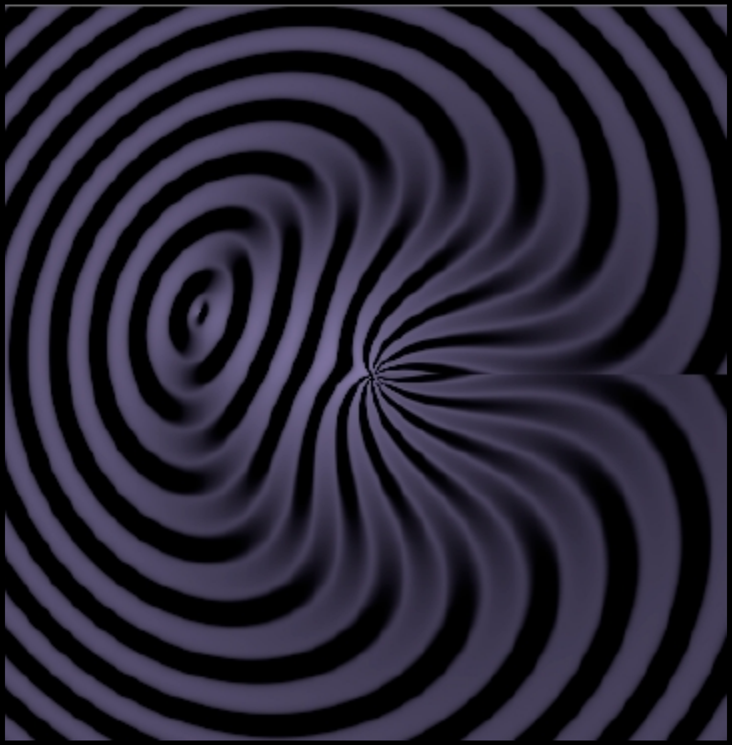
Cone Vertical with Wave



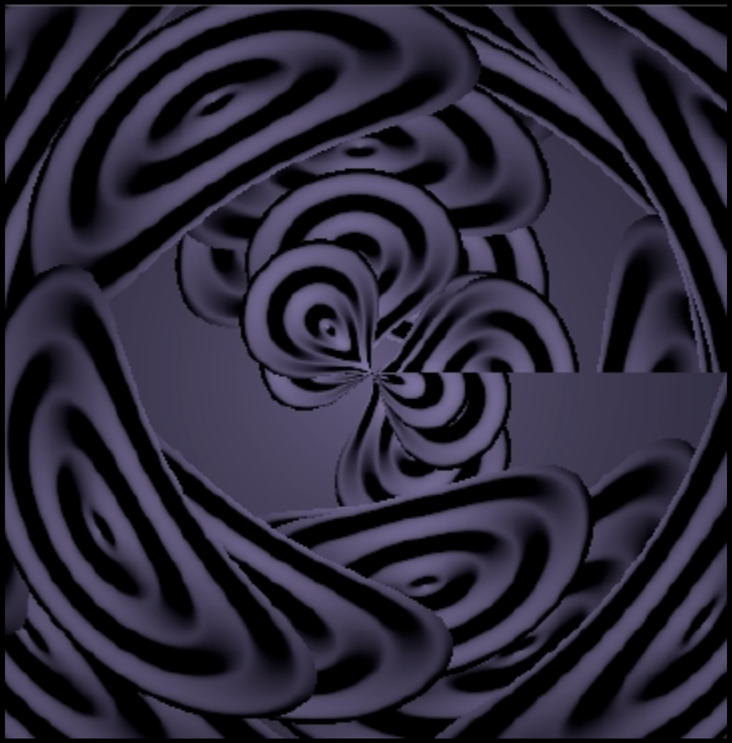
Cone with Dimples

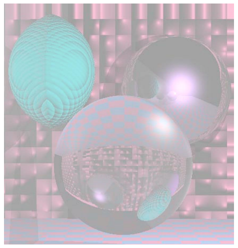


Cone with Ripple

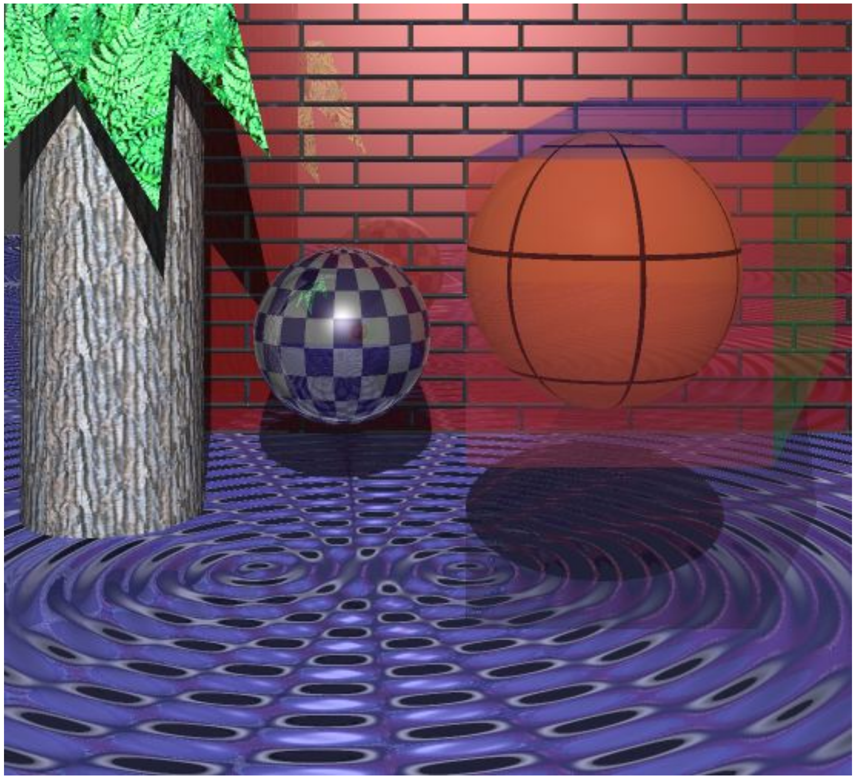


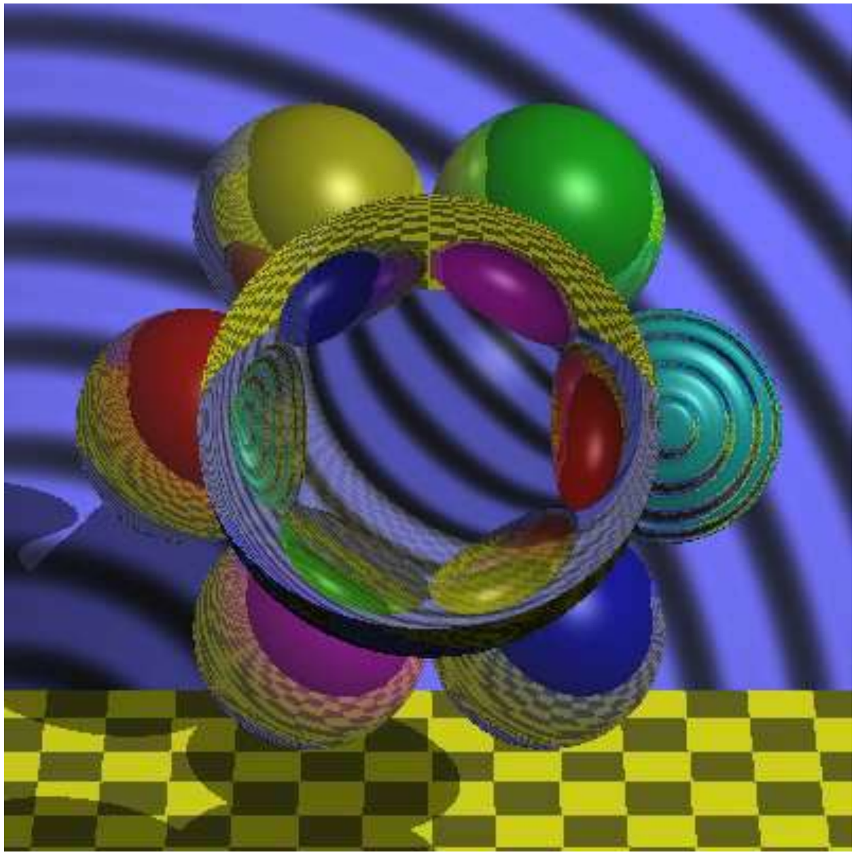
Cone with Ripples

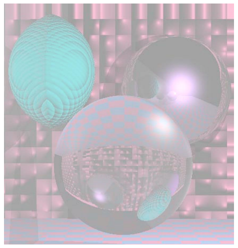




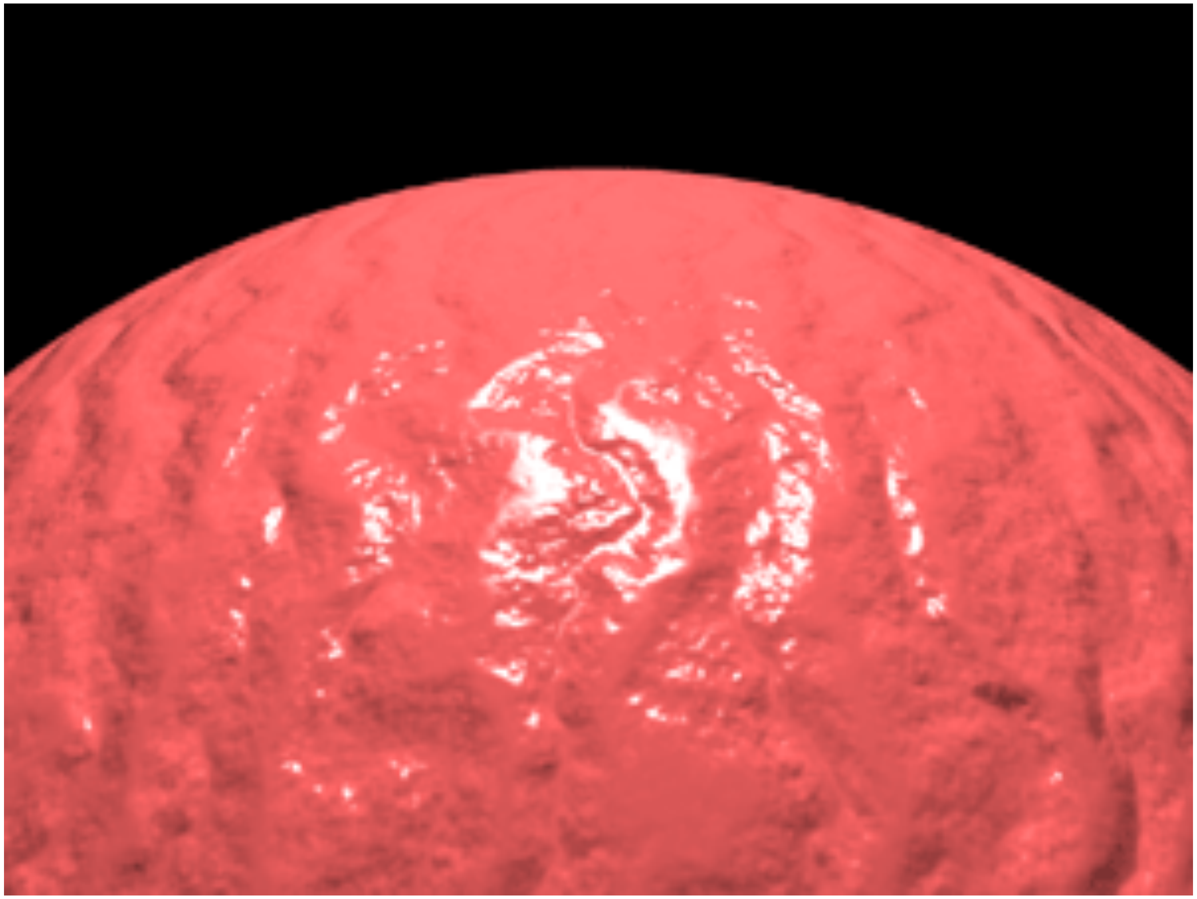
Student Images



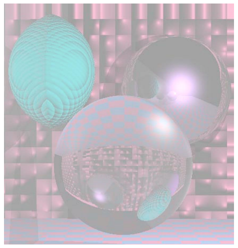




Bump Map



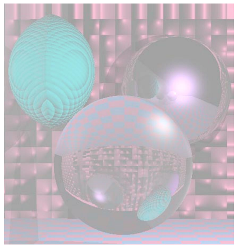
Bump Maps in PovRay



Bump Map - Plane

```
x = h - 200;
y = v - 200;
z = 0;

        N.Set(0, 0, 1);
        Du.Set(-1, 0, 0);
        Dv.Set(0, 1, 0);
        uu = h;
        vv = v;
        zz = z;
```

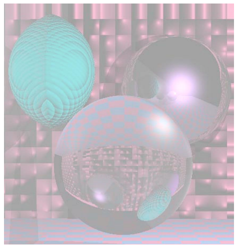


Bump Map Code – Big Sphere

```
radius = 280.0;
z = sqrt(radius*radius - y*y - x*x);
N.Set(x, y, z);
N = Norm(N);

Du.Set(z, 0, -x);
Du = -1*Norm(Du);
Dv.Set(-x*y, x*x +z*z, -y*z);
Dv = -1*Norm(Dv);

vv = acos(y/radius)*360/pi;
uu = (pi/2 +atan(x/z))*360/pi;
zz = z;
```



Bump Map Code – Dimples

```
Bu = 0; Bv = 0;
iu = (int)uu % 30 - 15;
iv = (int)vv % 30 - 15;
r2 = 225.0 - (double)iu*iu - (double)iv*iv;
if (r2 > 100) {
        if (iu == 0) Bu = 0;
        else Bu = (iu)/sqrt(r2);
        if (iv == 0) Bv = 0;
        else Bv = (iv)/sqrt(r2);
}
```

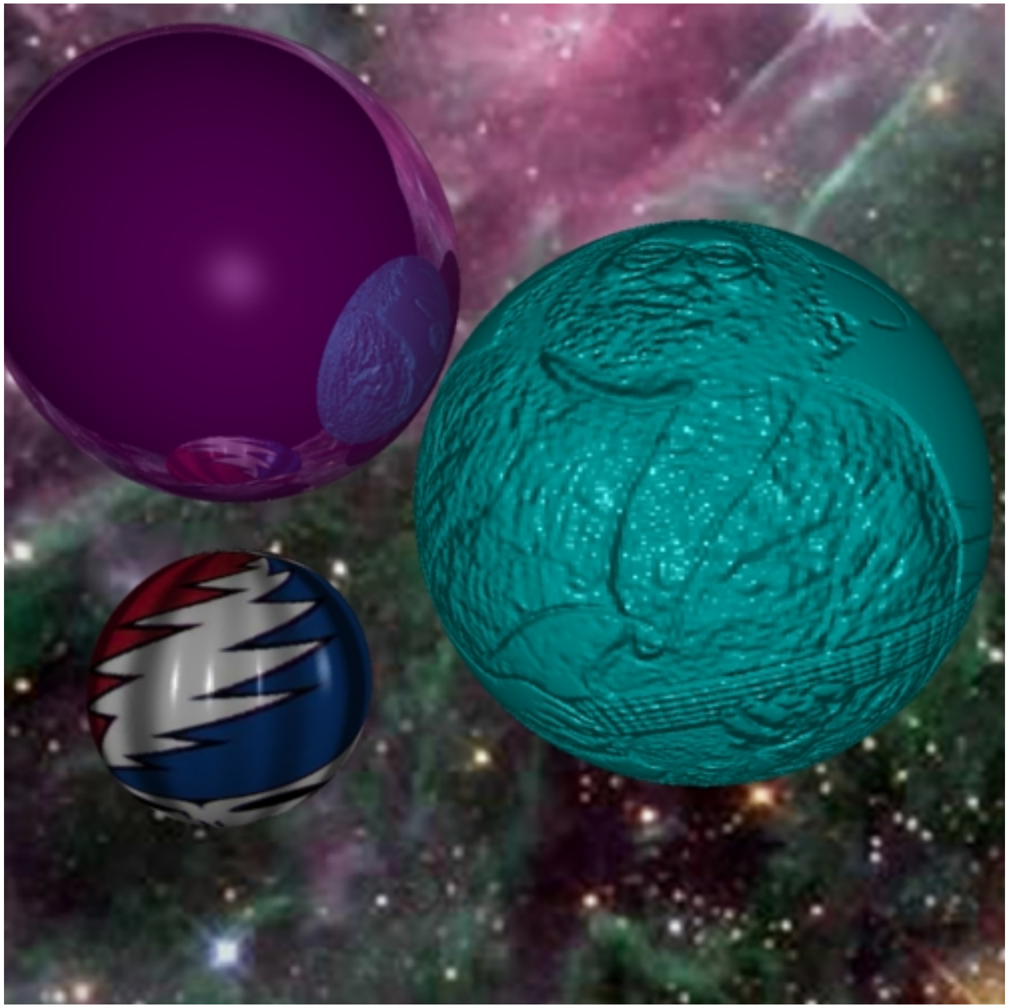
Image as a Bump Map

A bump map is a gray scale image; any image will do. The lighter areas are rendered as raised portions of the surface and darker areas are rendered as depressions. The bumping is sensitive to the direction of light sources.

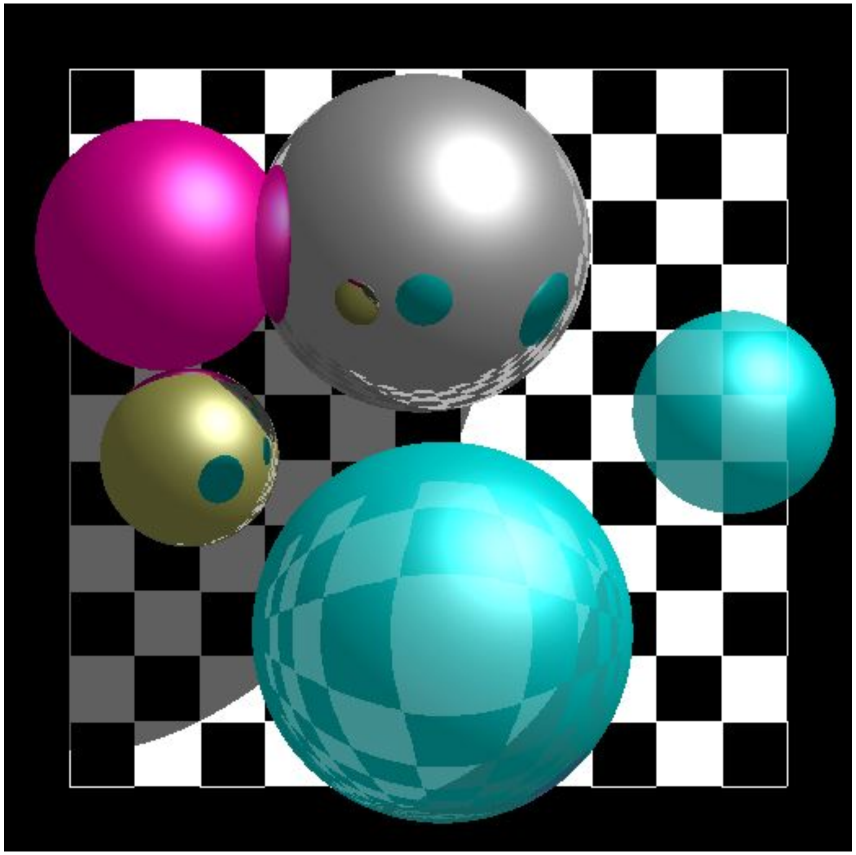
http://www.cadcourse.com/winston/BumpMaps.html

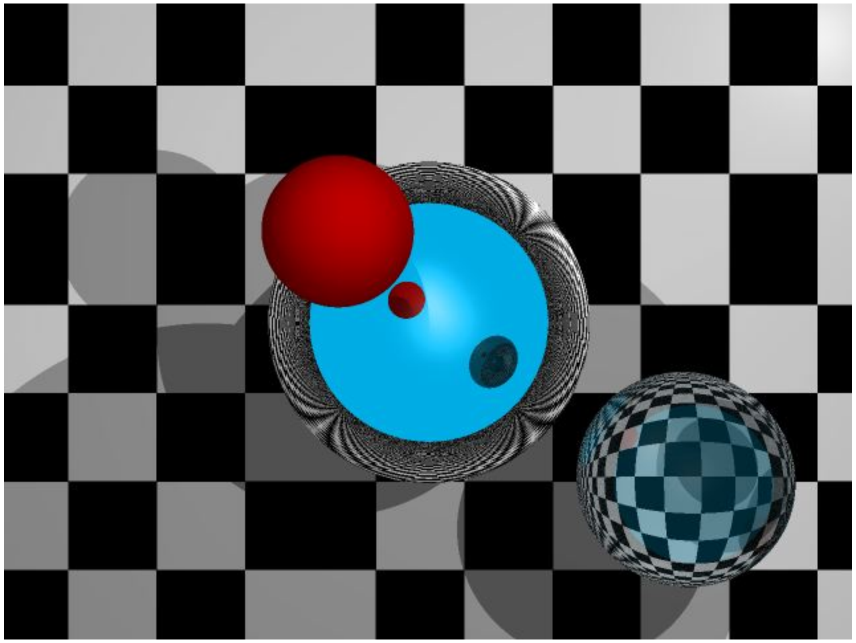
Bump Map from an Image

Victor Ortenberg

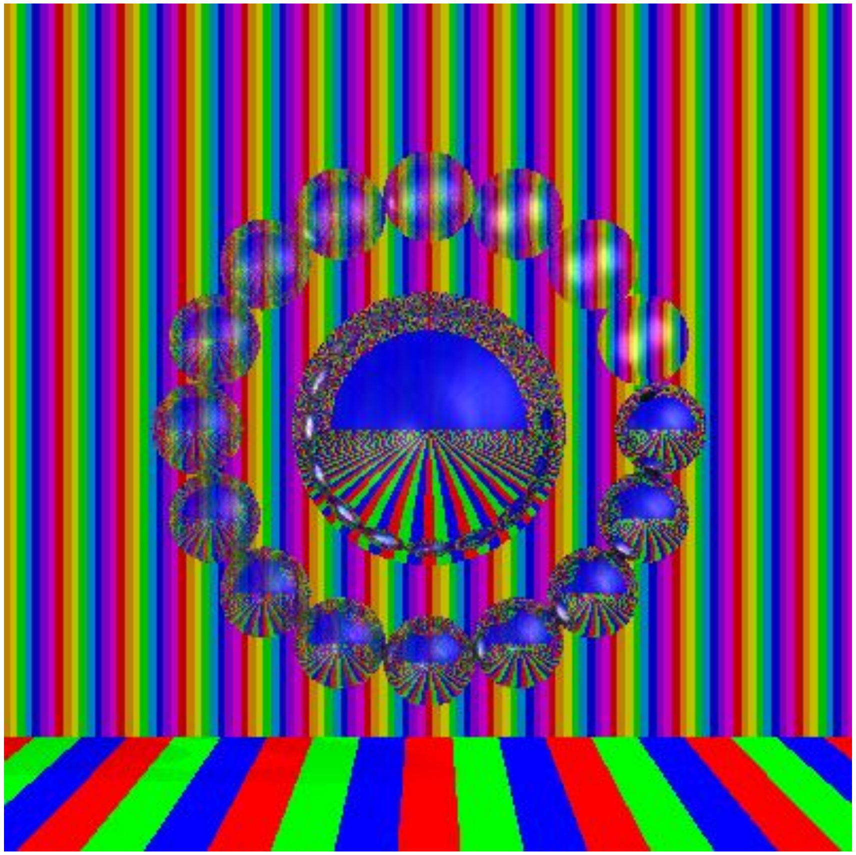


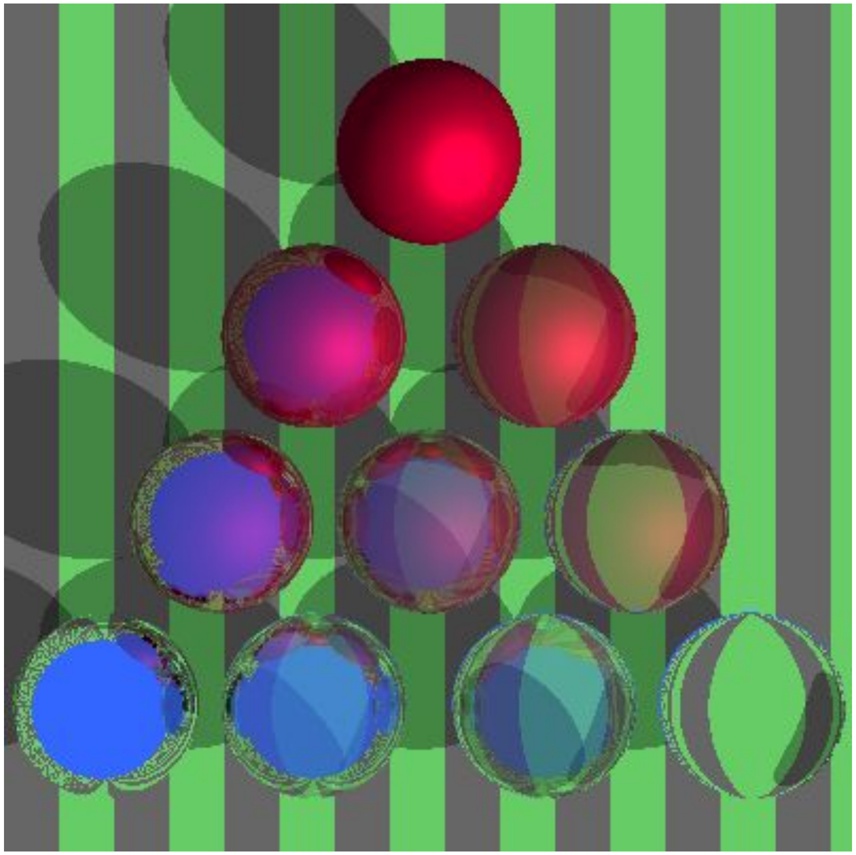
Simple Textures on Planes Parallel to Coordinate Planes



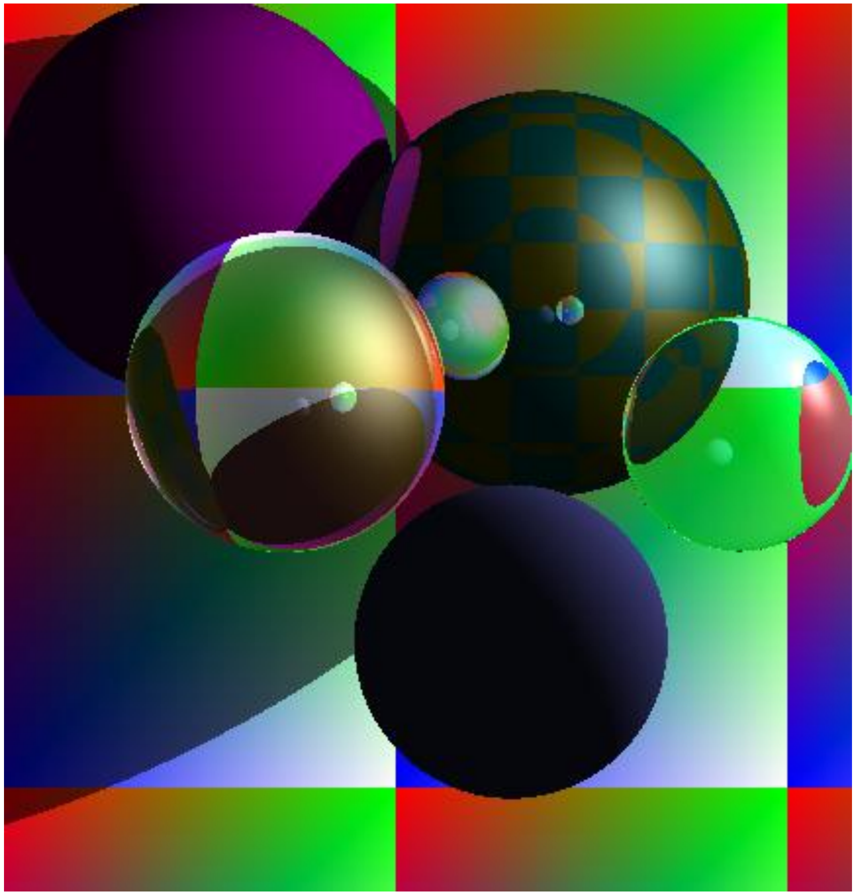


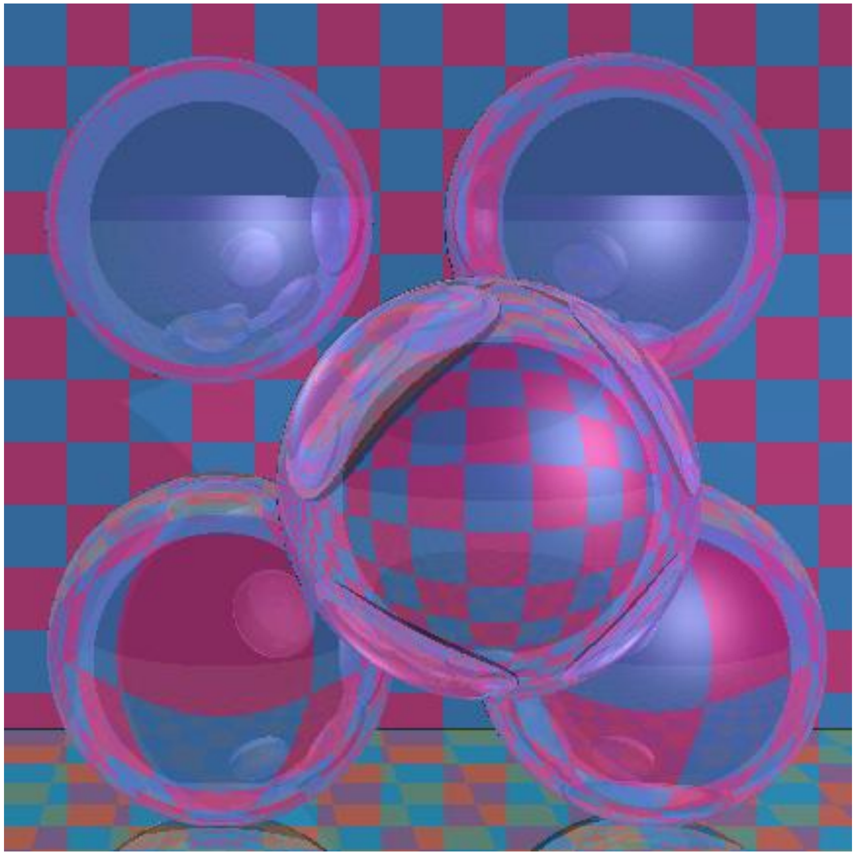
Stripes

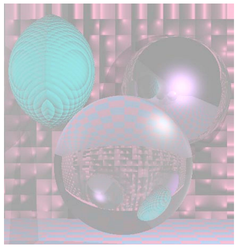




Checks



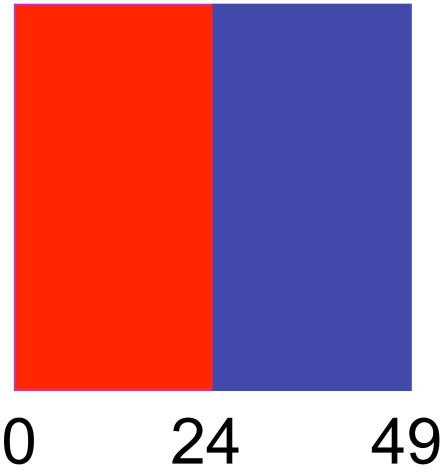




Stripes and Checks

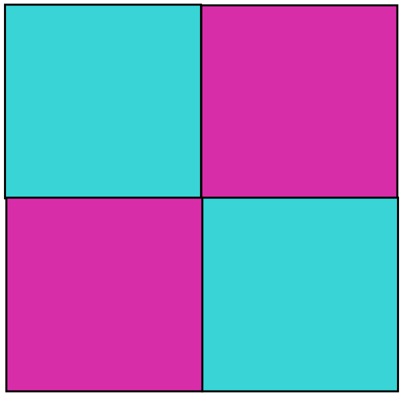
Red and Blue Stripes

```
    if ((x % 50) < 25) color = red
    else color = blue
```



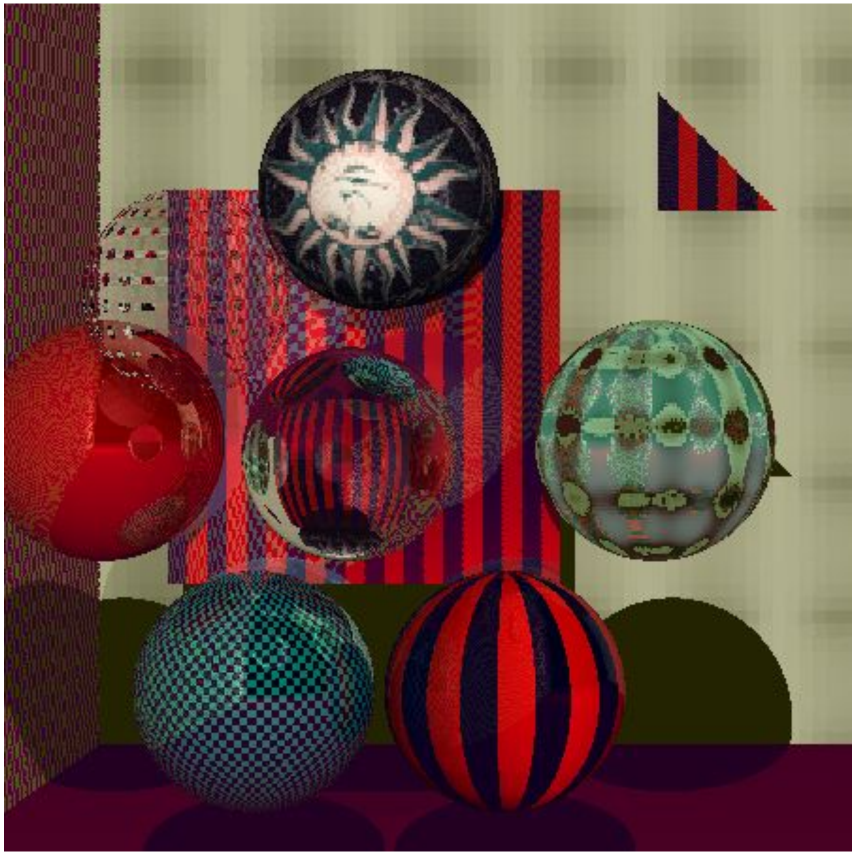
Cyan and Magenta Checks

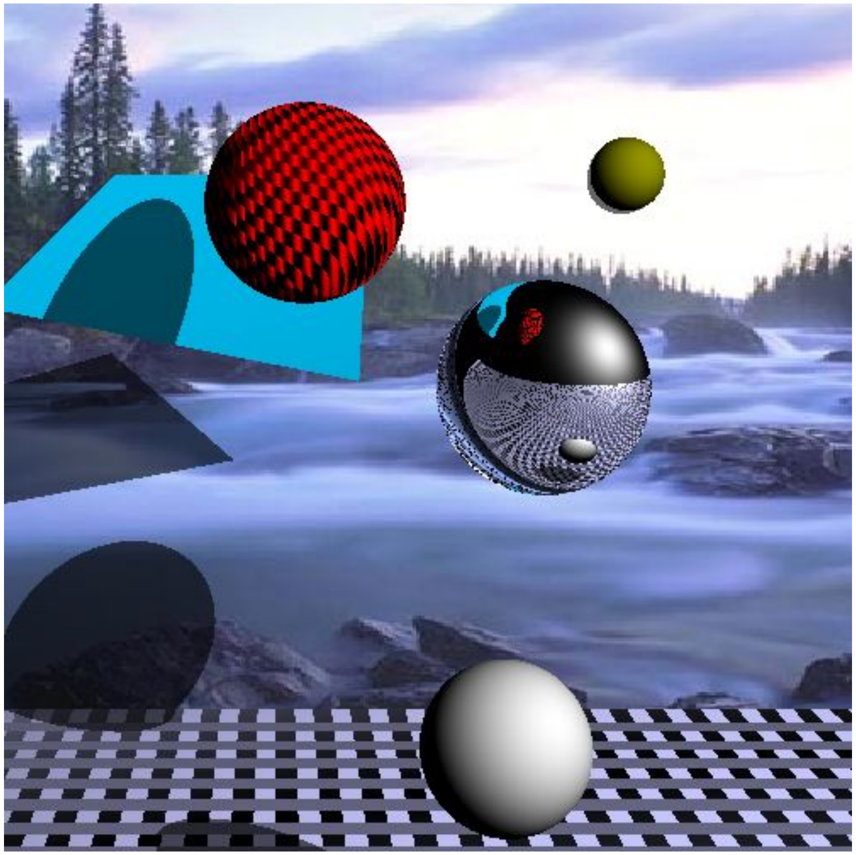
```
if (((x % 50) < 25 && (y % 50) < 25)) ||
          (((x % 50) >= 25 && (y % 50) >= 25)))
                    color = cyan
          else color = magenta
```



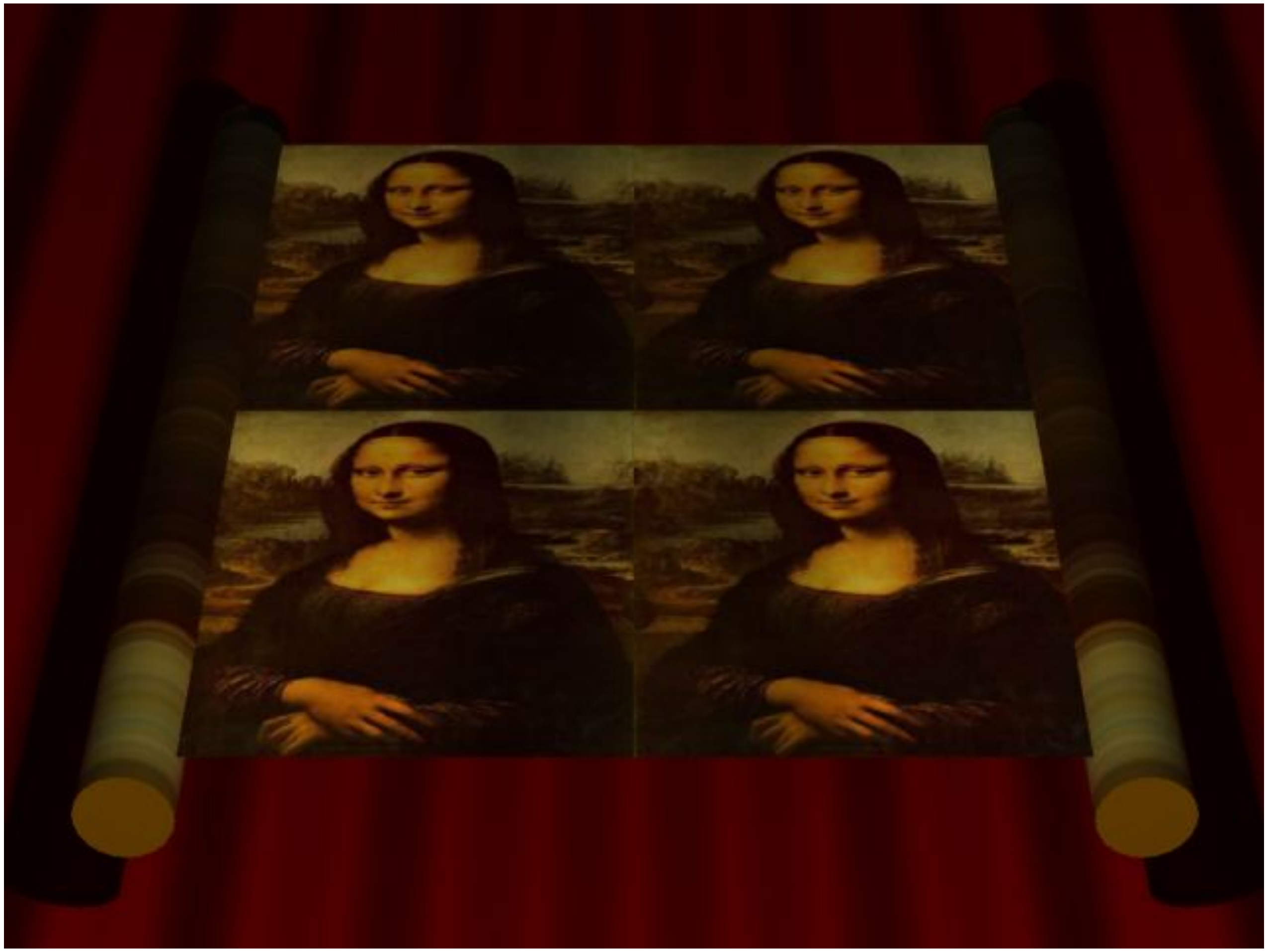
What happens when you cross x = 0 or y = 0?

Stripes, Checks, Image

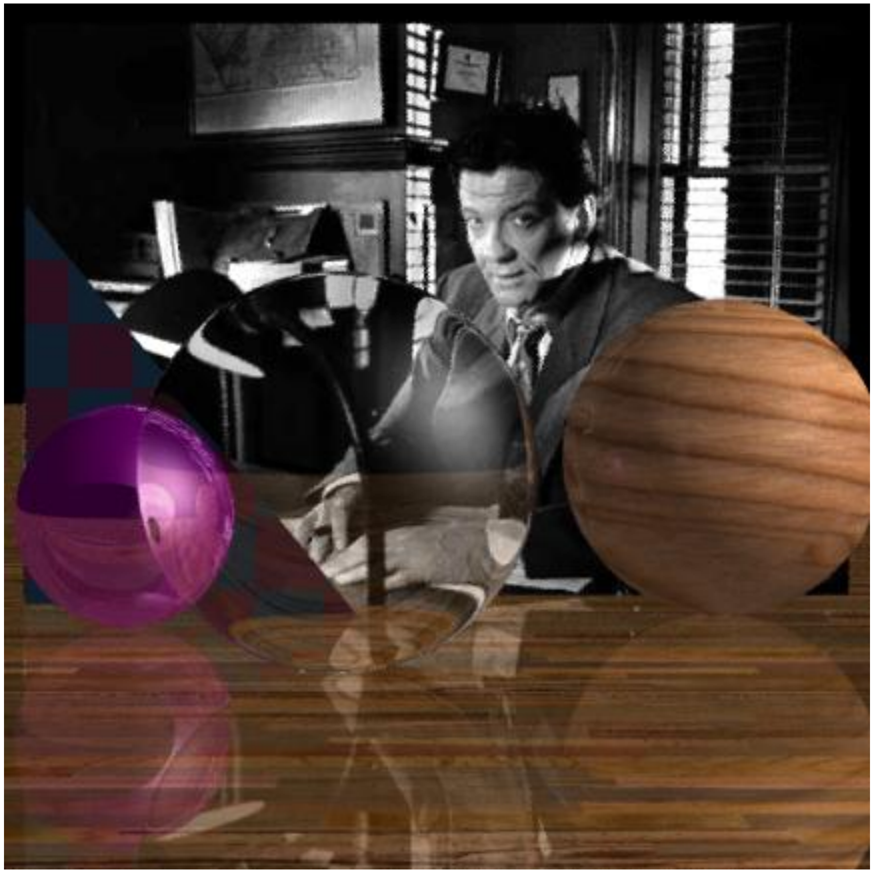




Mona Scroll



Textures on 2 Planes



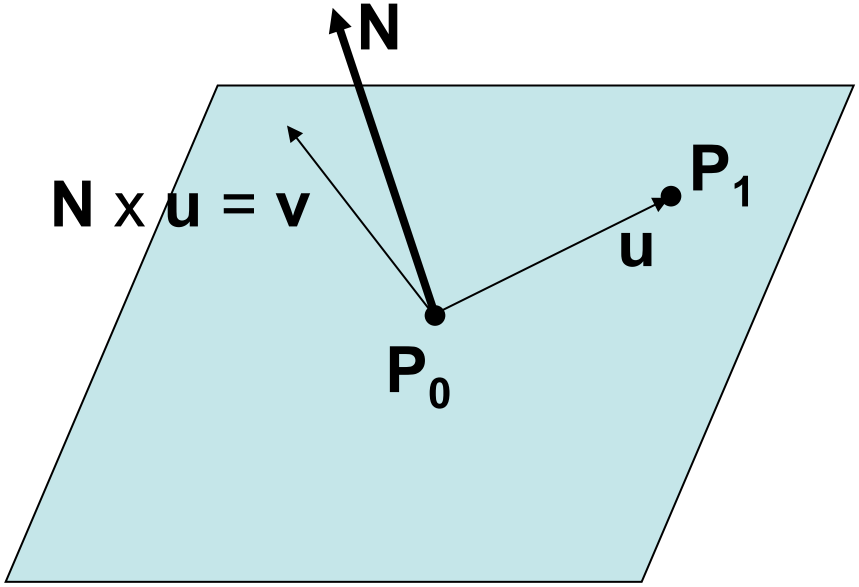
Mapping a Picture to a Plane

- Use an image in a ppm file.
- Read the image into an array of RGB values.

  Color myImage[width][height]
- For a point on the plane (x, y, d)

  theColor(x, y, d) = myImage(x % width, y % height)
- How do you stretch a small image onto a large planar area?

Other planes and Triangles



Given a normal and 2 points on the plane:

Make **u** from the two points.

v = **N** x **u**

Express **P** on the plane as

P = $\mathbf{P}_0$ + a**u** + b**v.**

Image to Triangle - 1

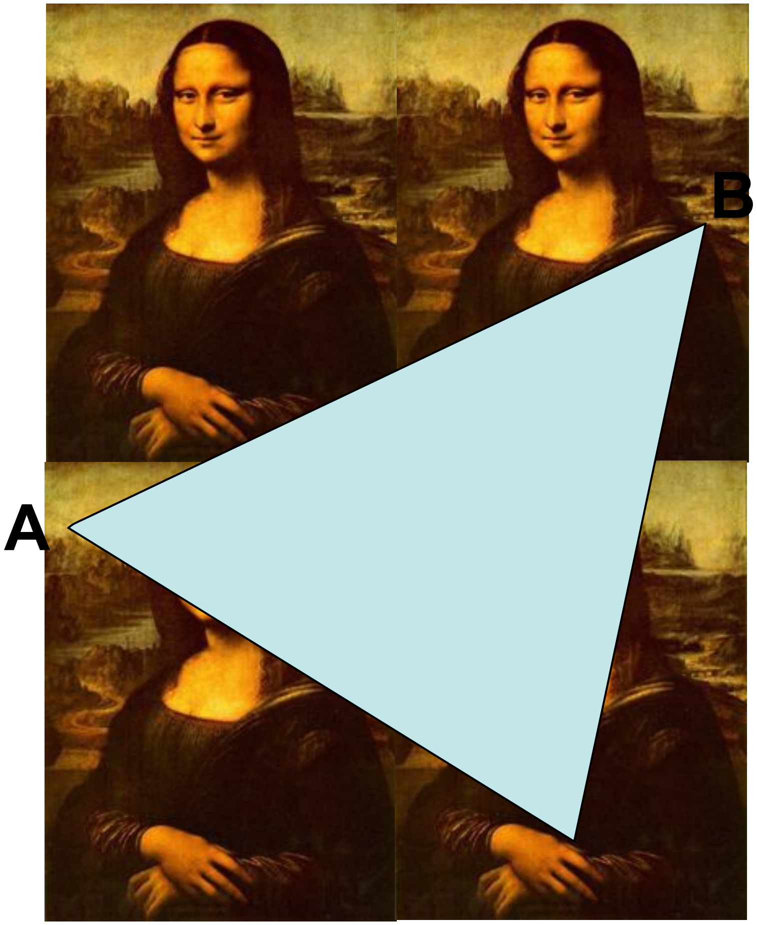


Image to Triangle - 2

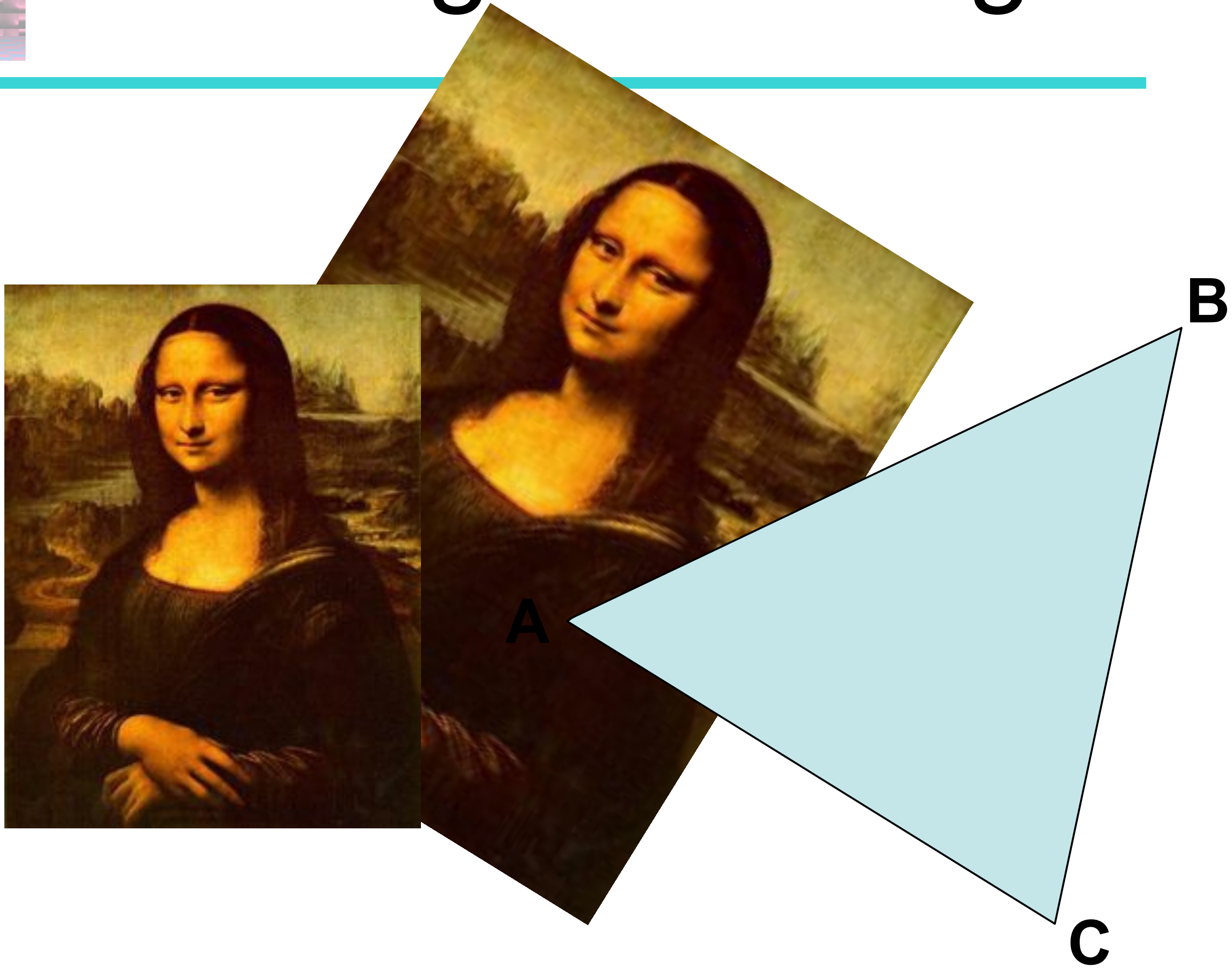
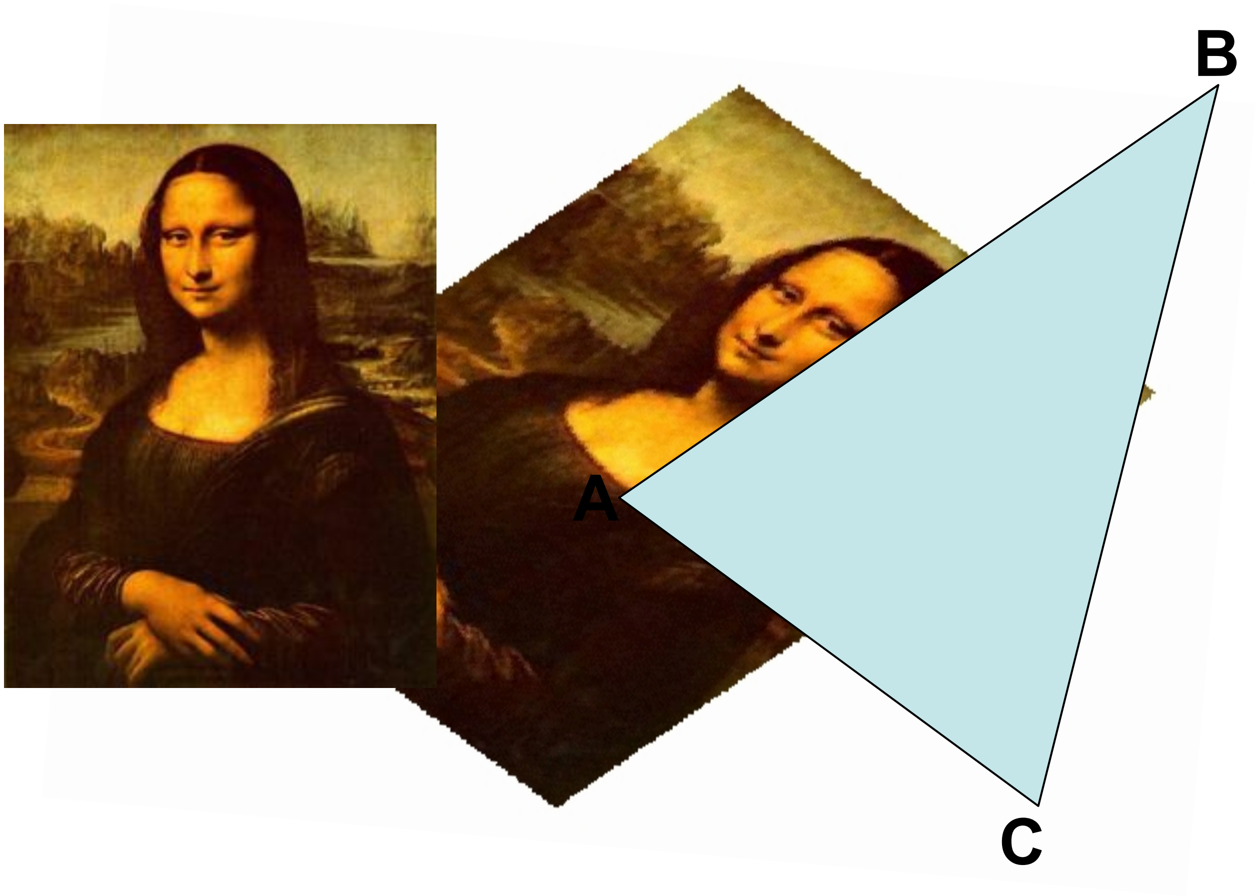
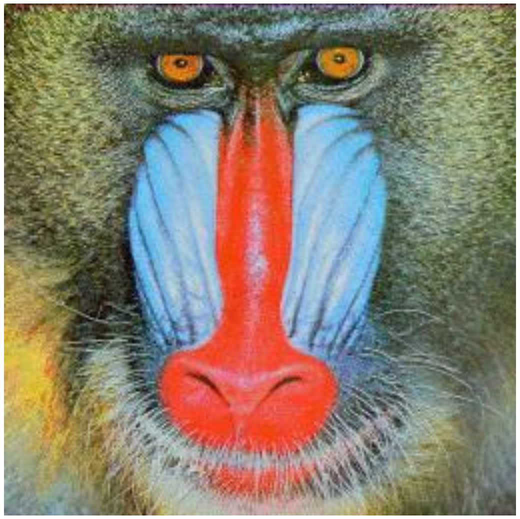
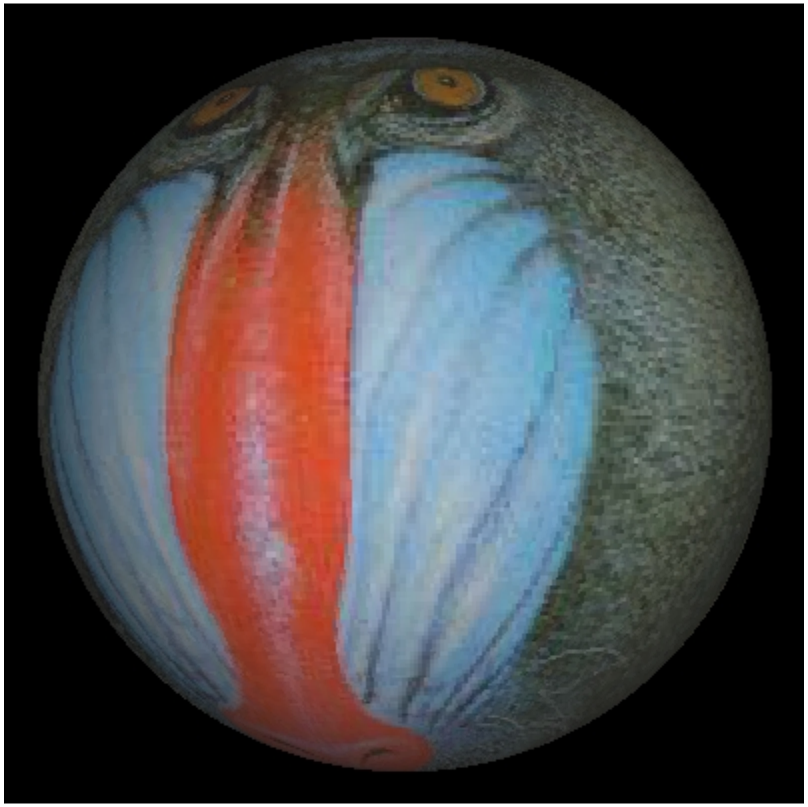


Image to Triangle - 3

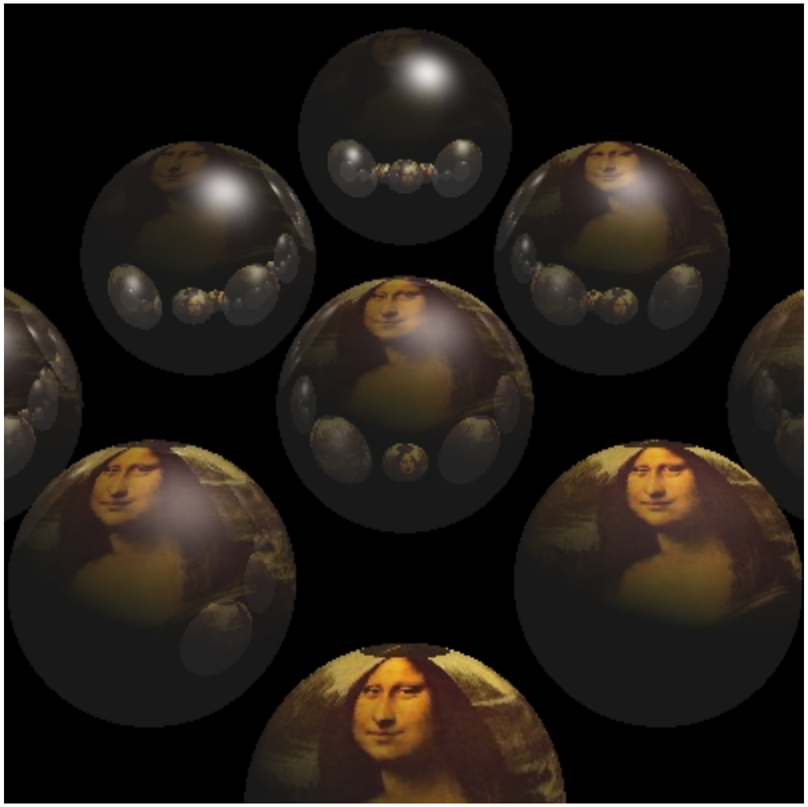


Mandrill Sphere

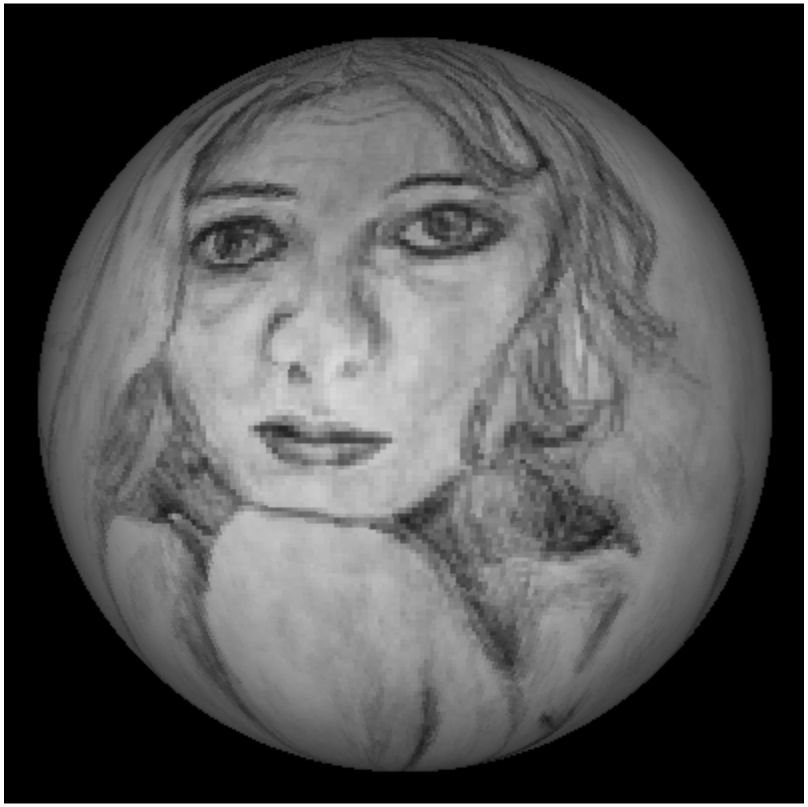




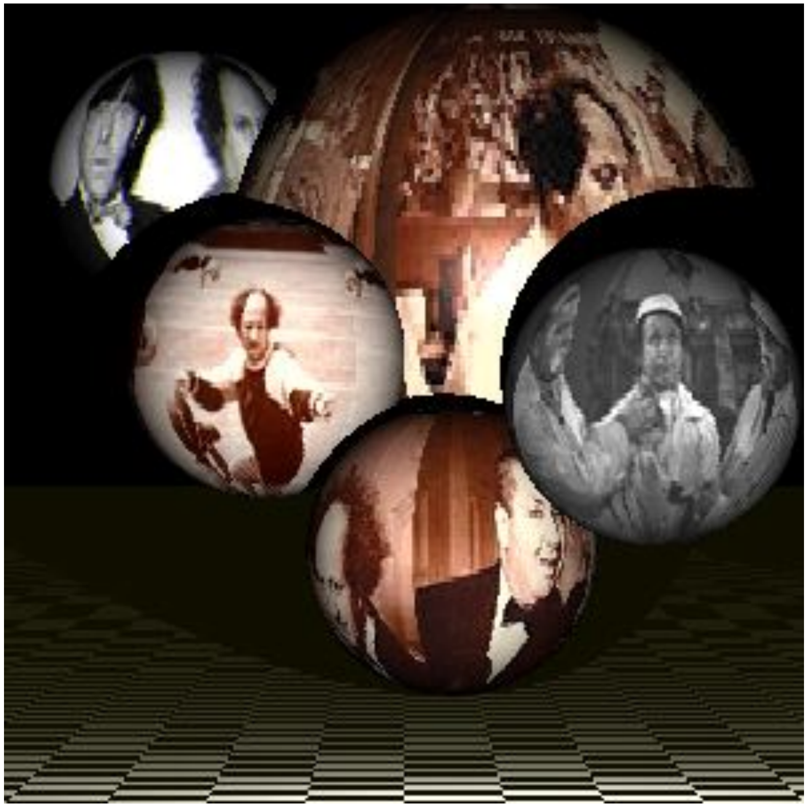
Mona Spheres

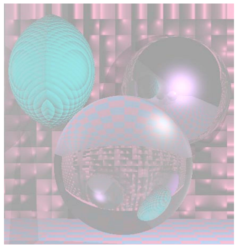


Tova Sphere

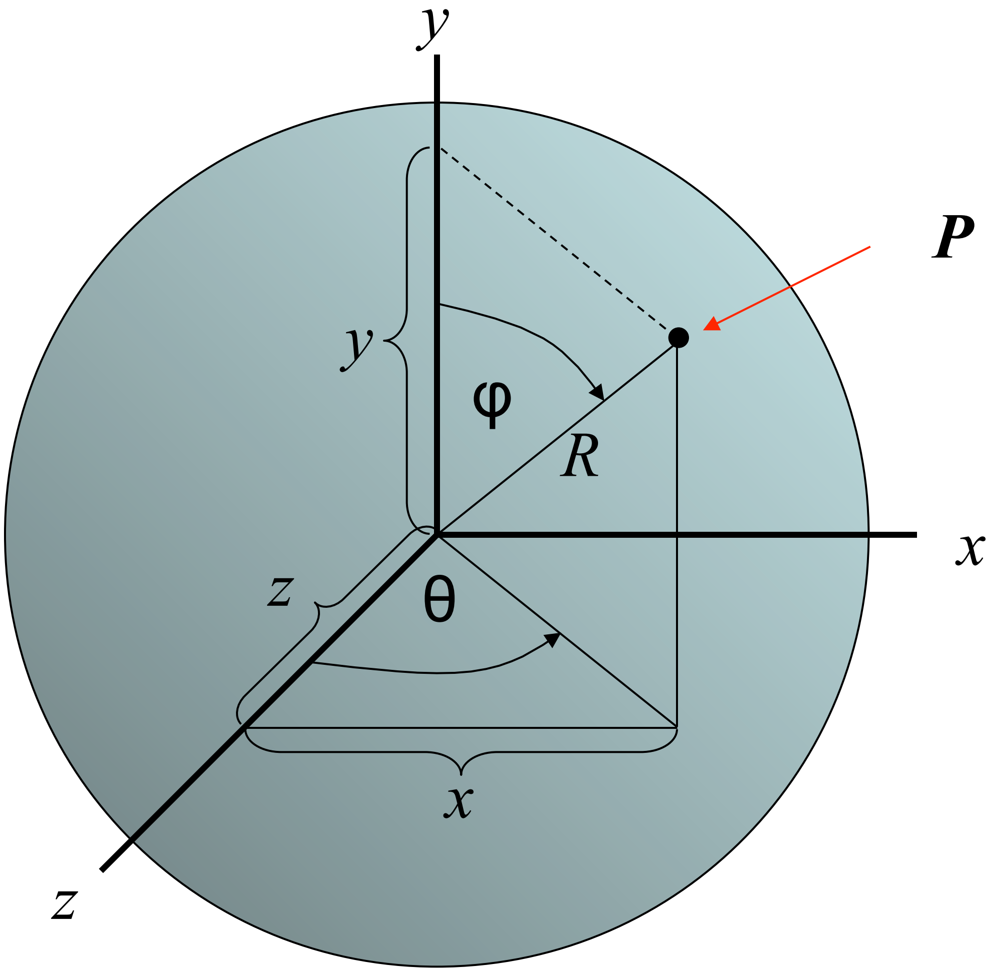


More Textured Spheres





Spherical Geometry



$\boldsymbol{P} = (x, y, z)$

$\varphi = \arccos(y/R)$

$\theta = \arctan(x/z)$

```
// for texture map – in lieu of using sphere color
double phi, theta;          // for spherical coordinates
double x, y, z;    // sphere vector coordinates
int h, v;          // ppm buffer coordinates
Vector3D V;

    V = SP - theSpheres[hitObject].center;
    V.Get(x, y, z);
    phi = acos(y/theSpheres[hitObject].radius);
    if (z != 0) theta = atan(x/z); else phi = 0;   // ???
    v = (phi)*ppmH/pi;
    h = (theta + pi/2)*ppmW/pi;

    if (v < 0) v = 0; else if (v >= ppmH) v = ppmH - 1;
    v = ppmH -v -1; //v = (v + 85*ppmH/100)%ppmH;//9
    if (h < 0) h = 0; else if (h >= ppmW) h = ppmW - 1;
    h = ppmW -h -1;      //h = (h + 1*ppmW/10)%ppmW;

    rd  = fullFactor*((double)(byte)myImage[h][v][0]/255); clip(rd);
    gd  = fullFactor*((double)(byte)myImage[h][v][1]/255); clip(gd);
    bd  = fullFactor*((double)(byte) myImage[h][v][2]/255); clip(bd);
```