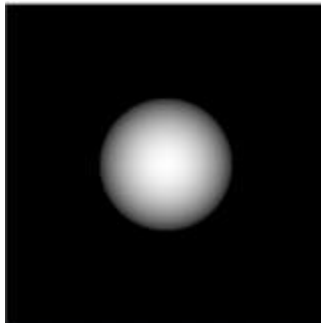$$z(x,y) = z_0 + \sqrt{r^2 - (x^2 + y^2)} \quad , \quad (x^2 + y^2) \leq r^2$$

for $\vec{N}(x,y)$, we need to find p and q.

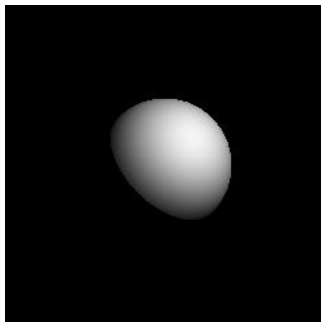$$p = \frac{\partial z}{\partial x} = \frac{-x}{\sqrt{r^2 - x^2 - y^2}}$$

$$q = \frac{\partial z}{\partial y} = \frac{-y}{\sqrt{r^2 - x^2 - y^2}}$$

$$\therefore \vec{N}(x,y) = (-p, -q, 1) = \left(\frac{x}{\sqrt{r^2 - x^2 - y^2}}, \frac{y}{\sqrt{r^2 - x^2 - y^2}}, 1 \right)$$
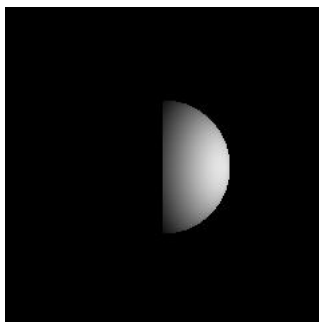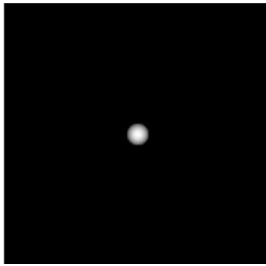
image(a) : S = [0,0,1], r = 50 , a = 0.5, m = 1

image(b) : S = [1/ √3,1/ √3,1/ √3], r = 50 , a = 0.5, m = 1
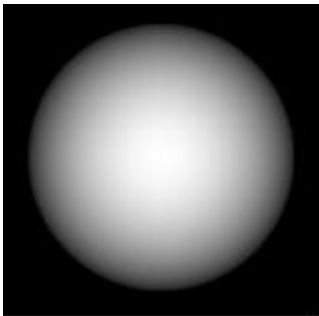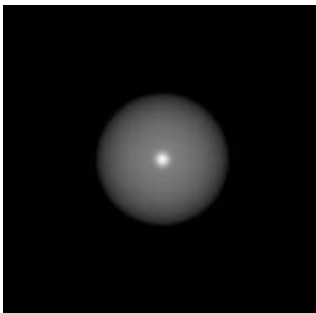

image(c) : S = [1,0,0], r = 50 , a = 0.5, m = 1

image(d) : S = [0,0,1], r = 10 , a = 0.5, m = 1

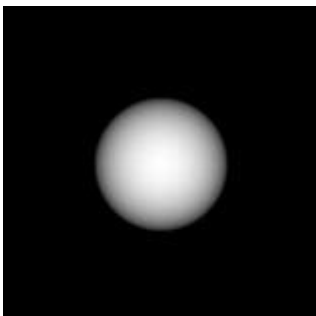**image(e) : S = [0,0,1], r = 100 , a = 0.5, m = 1**

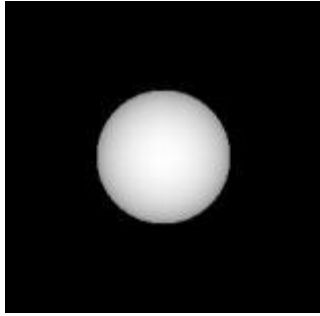**image(f) : S = [0,0,1], r = 50 , a = 1, m = 1**

image(g) : S = [0,0,1], r = 50 , a = 0.5, m = 1

image(i) : S = [0,0,1], r = 50 , a = 0.5, m = 10000

Efffect of S:
S is the source direction it shows where the light source is coming from. By comparing the image_a and image_b, we can see that the changing in x will change the brightest part.

Effect of m:
m is the surface roughness, when m is large, it means that the surface is very rough so the light will reflect in all direction so it object will not have a lot of shade. In image_i, we can see that the circle is actually more brighter than the other images since its m is very large.

Effect of a:
a is the ration of Lambertian reflectance and Specular reflectance. Therefore, if a is large, the Lambertian reflectance is also high. We can compare image_f and image_g and we see that image_g is brighter than image_f.

Effect of r:
 r is the radius of the circle so the larger r is the larger the circle is. We can compare image_e and image_f, which shows that these two circles have different sizes.