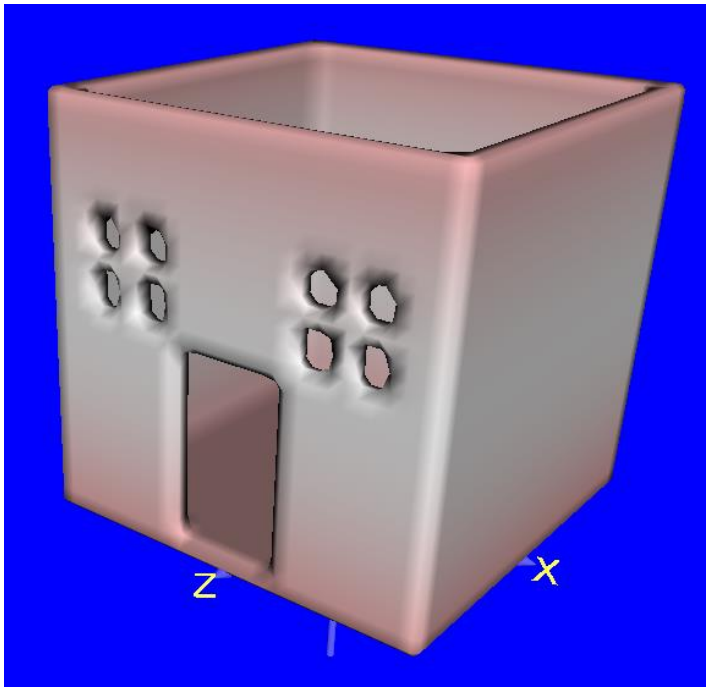
Plane half space



Main body structure of the house

The figure about shows an image of the main body structure of the house in plane half space. It was obtained by having two cubes of different sizes and differences them using min(). This methods was chosen over creating five planes as four walls and one base before union them using max() because it is more optimize. To obtain the door hole and the window, half planes was used to difference with the main house body structure.

The code to obtain the main body structure:

```
outerbox_x = min(x+1, 1-x);

outerbox_y = min(y,2-y);

outerbox_z = min(z+1, 1-z);

outerbox_xy = min(outerbox_x,outerbox_y);

outerbox = min(outerbox_xy, outerbox_z);


interbox_x = min(x+0.9, 0.9-x);

interbox_y = min(y-0.1, 2-y);

interbox_z = min(z+0.9, 0.9-z);

interbox_xy = min(interbox_x, interbox_y);
```

```
interbox = min(interbox_xy, interbox_z);

walls_basee = min(outerbox, -interbox);
door_hole_x = min(x+0.25, 0.25-x);
door_hole_y = min(1-y, y-0.1);
door_hole_z = z-0.9;
door_hole_xy = min(door_hole_x, door_hole_y);
door_hole = min(door_hole_xy, door_hole_z);

body_dh = min(walls_basee, -door_hole);

win_l1_x = min(x+0.75, -0.6-x);
win_l1_y = min(y-1.35, 1.5-y);
win_l1_z = door_hole_z;
win_l1_xy = min(win_l1_x, win_l1_y);
win_l1 = min(win_l1_xy, win_l1_z);

win_l2_x = min(x+0.5, -0.35-x);
win_l2_y = win_l1_y;
win_l2_z = door_hole_z;
win_l2_xy = min(win_l2_x, win_l2_y);
win_l2 = min(win_l2_xy, win_l2_z);

win_l3_x = win_l1_x;
win_l3_y = min(y-1.1, 1.25-y);
win_l3_z = door_hole_z;
win_l3_xy = min(win_l3_x, win_l3_y);
win_l3 = min(win_l3_xy, win_l3_z);

win_l4_x = win_l2_x;
win_l4_y = win_l3_y;
```

```
win_l4_z = door_hole_z;
win_l4_xy = min(win_l4_x, win_l4_y);
win_l4 = min(win_l4_xy, win_l4_z);

win_r1_x = min(x-0.6, 0.75-x);
win_r1_y = win_l1_y;
win_r1_z = door_hole_z;
win_r1_xy = min(win_r1_x, win_r1_y);
win_r1 = min(win_r1_xy, win_r1_z);

win_r2_x = min(x-0.35, 0.5-x);
win_r2_y = win_l1_y;
win_r2_z = door_hole_z;
win_r2_xy = min(win_r2_x, win_r2_y);
win_r2 = min(win_r2_xy, win_r2_z);

win_r3_x = win_r1_x;
win_r3_y = win_l3_y;
win_r3_z = door_hole_z;
win_r3_xy = min(win_r3_x, win_r3_y);
win_r3 = min(win_r3_xy, win_r3_z);

win_r4_x = win_r2_x;
win_r4_y = win_l3_y;
win_r4_z = door_hole_z;
win_r4_xy = min(win_r4_x, win_r4_y);
win_r4 = min(win_r4_xy, win_r4_z);

body_win_l1 = min(body_dh, -win_l1);
body_win_l2 = min(body_win_l1, -win_l2);
body_win_l3 = min(body_win_l2, -win_l3);
```

body_win_l4 = min(body_win_l3, -win_l4);

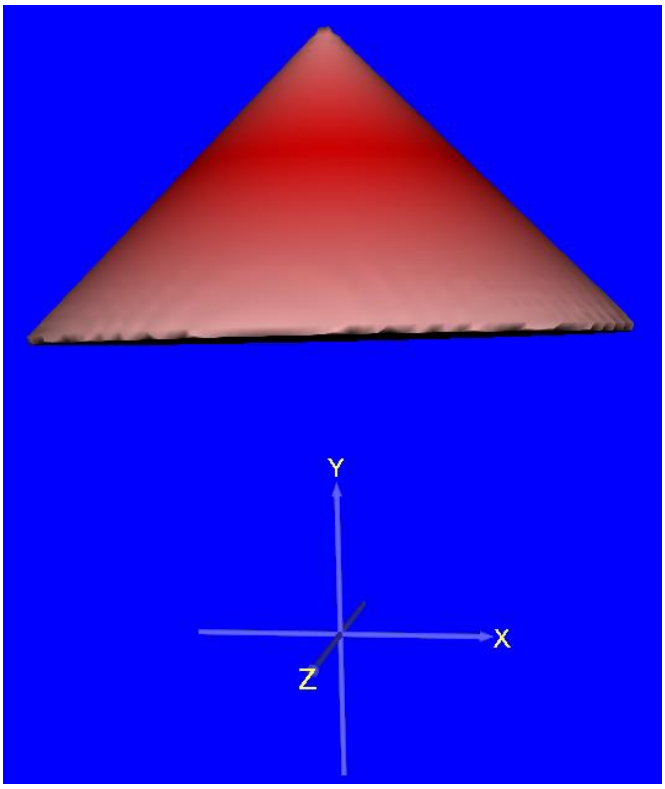
body_win_r1 = min(body_win_l4, -win_r1);

body_win_r2 = min(body_win_r1, -win_r2);

body_win_r3 = min(body_win_r2, -win_r3);

body_win_final = min(body_win_r3, -win_r4);

Cone



Roof of the house

Next, cone is used as the roof top of the house. To position the cone on top of the main house body, I obtained the implicit equation of the cone from parametric equation. Below contains the step that was used to derived the implicit equation of the cone.

Parametric:

x = 2*u*cos(θ)

y = 2*(1-u)+2 = 2-2*u+2 = 4-2*u

z= 2*u*sin(θ)

where u ∈ [0 1].

Convert parametric to implicit:

$x^2+z^2 = (2*u)^2(\cos \theta)^2+ \sin (\theta)^2)$

$x^2+z^2 = (2*u)^2$ – (1)

$y = 4-2*u$

$u = (4-y)/2$ – (2)

Sub (2) into (1)

$x^2+z^2 = (2*(4-y)/2))^2$

$= (4-y)^2$

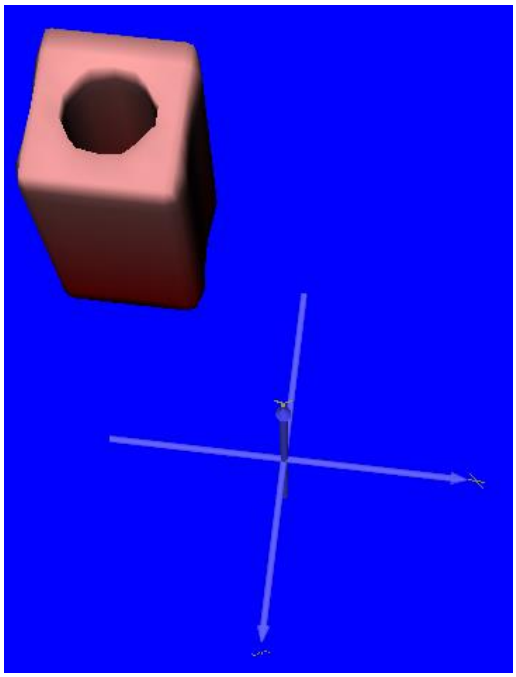
$(4-y)^2-x^2-z^2= 0$

As two cones will be rendered, one of the cones is removed by differencing $(4-y)^2-x^2-z^2$ with the y-axis planes. Finally, the cone is union with the main body of the house.

The code to obtain the roof:

```
roof = min(min(((4-y)^2)-(x^2)-(z^2), 4-y), y-2);
```

Cylinder



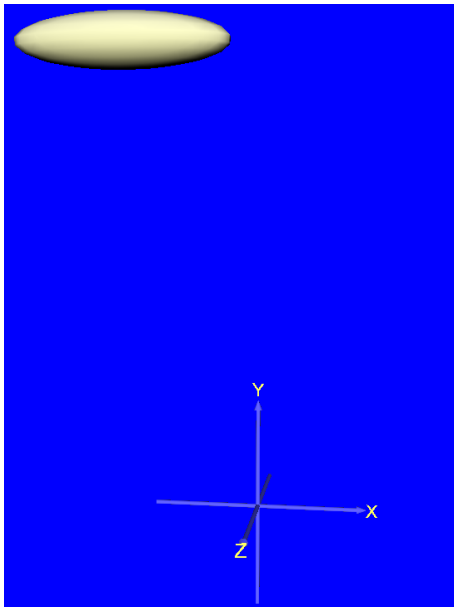
Chimney of the house

The chimney of the house is contained by forming a solid rectangle and union it to the rest of the house structure. A cylinder hole in the chimney is created by differencing the cylinder from the solid rectangle.

The code to obtain the chimney of the house:

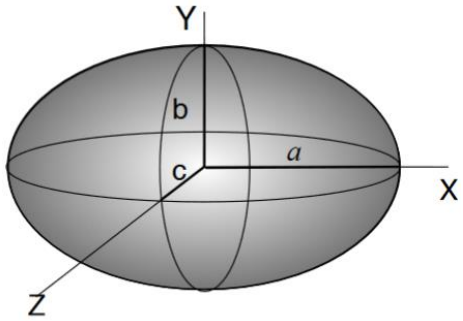
```
chimney_holeless_x = min(x+0.75, -0.25-x);

chimney_holeless_y = min(y-3, 4-y);

chimney_holeless_z = min(z+0.25, 0.25-z);

chimney_holeless_xy = min(chimney_holeless_x, chimney_holeless_y);

chimney_holeless = min(chimney_holeless_xy, chimney_holeless_z);


body_chimney_holeless = max(body_roof, chimney_holeless);


body_chimney = min(body_chimney_holeless, -min((0.02-((x+0.5)^2)-(z^2)), y-1));
```

Ellipsoid



Ellipsoid as smoke from chimney

To form smoke that is coming out from the chimney of the house, ellipsoid is used. It is position directly above the chimney.



Ellipsoid implicit equation:

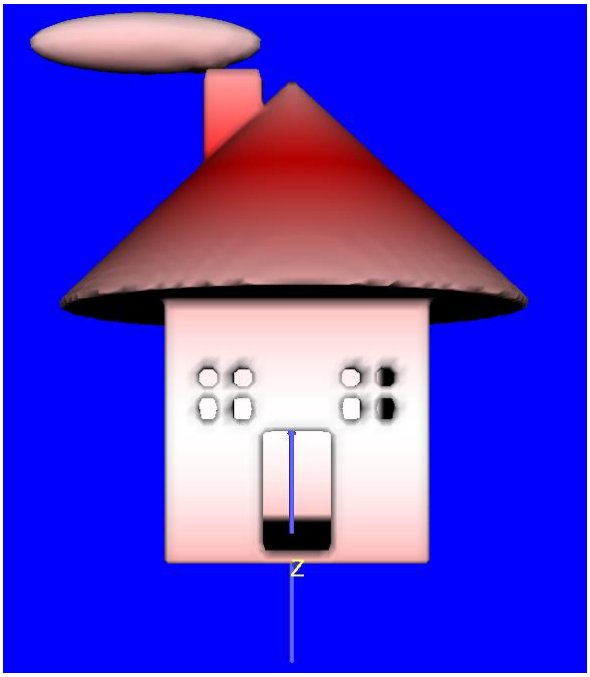
$1 – ((x-x_0)/a)^2 – ((y-y_0)/b)^2 – ((z-z_0)/c)^2 = 0,$

where $x_0 = -1.25$, $y_0 = 4.3$, $z_0 = 0$, $a = 1$, $b = 0.25$, $c = 0.25$.

The code to obtain smoke and union to the house:

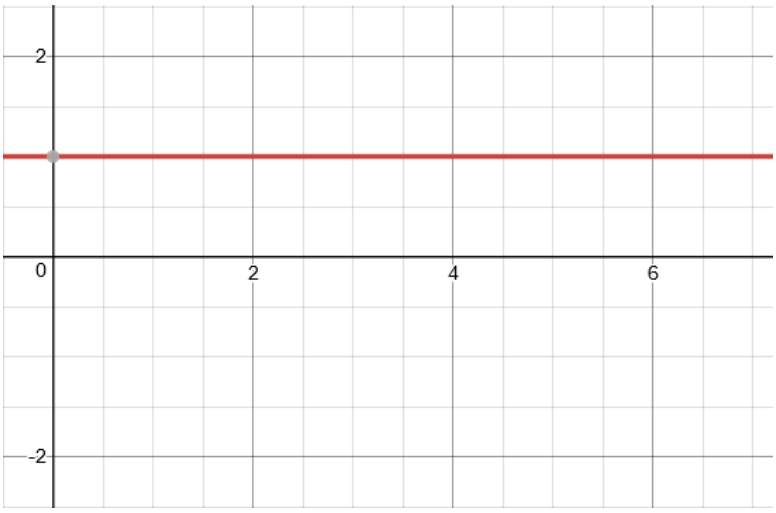
body_cloud1 = max(body_chimney, 1-((x+1.25)^2)-(((y-4.3)/0.25)^2)-((z/0.25)^2));

Finally, combining all the different geometries together forms a complete house.

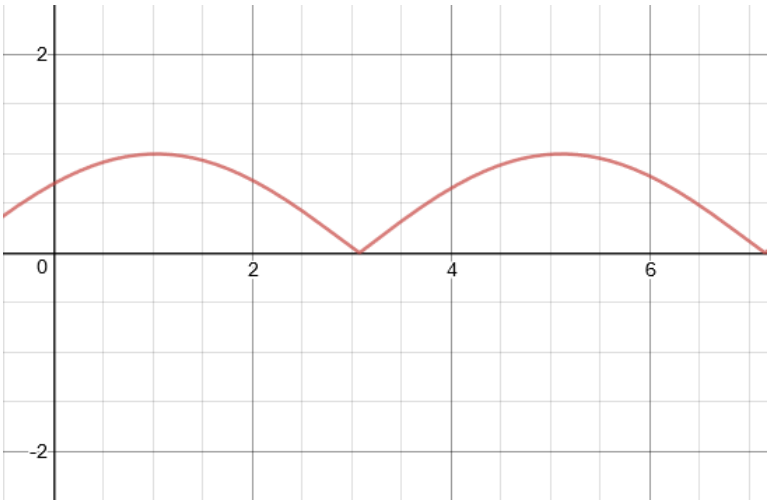


To color the top part of the roof red while having the smoke and bottom of the house white, abs() and sine waves was used to obtain the desired color. Red is assigned a value of 1 as red color is required throughout the object as red is one of the colors that resulted in white color and it is used to color the roof of the house. However, green and blue are only required at the bottom half of the house and the cloud to obtain white when mix with red. Green and blue are not needed when coloring the

roof of the house. Therefore, sine wave was used so that when the value is lesser than one, the color produced by green blue will be lighter and no green and blue color will be produced when the value is 0. As the value of green and blue slowly increase or decrease, this results in the color transition between red and white to be less sharp, thus causing certain area of the bottom of the house to be slightly red. Abs() is used to make sure the blue and green have a value between 0 and 1.



r = 1



g = abs(cos(0.245*pi*v+2.35))

b=abs(cos(0.245*pi*v+2.35))