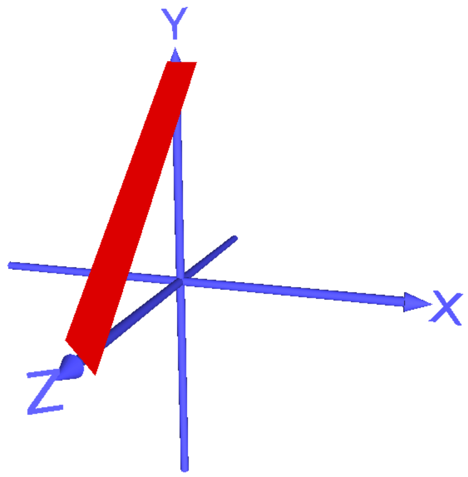
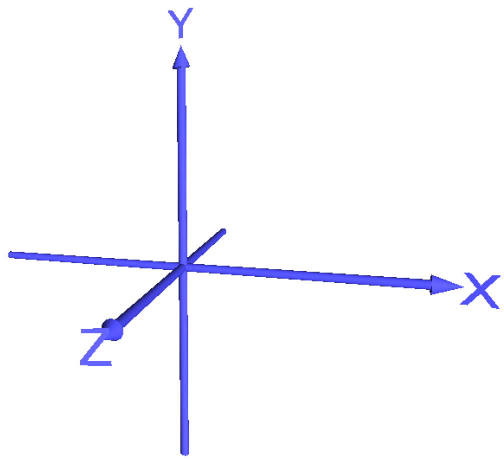
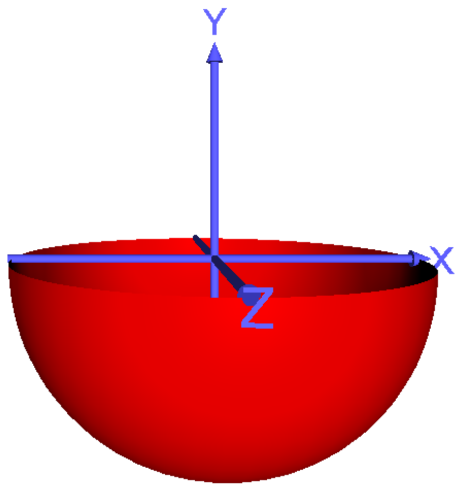
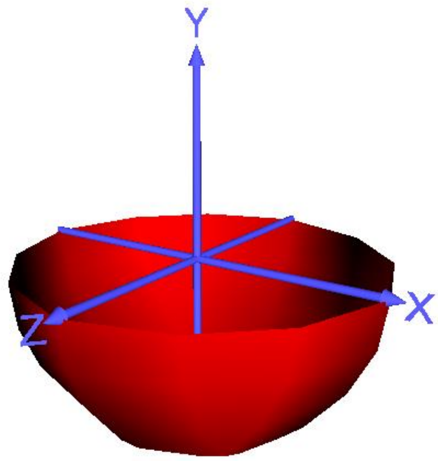
Nanyang Technological University

Lab 4 Report: Implicit Surfaces & Solids

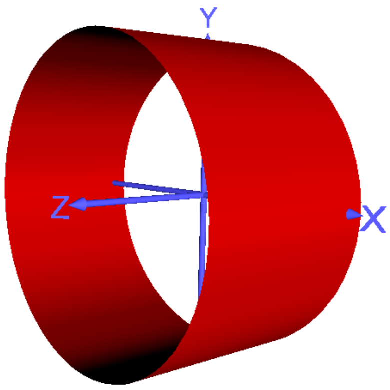
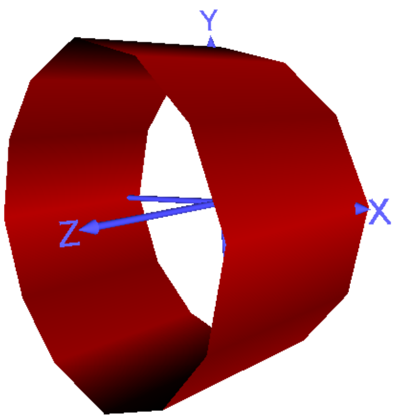
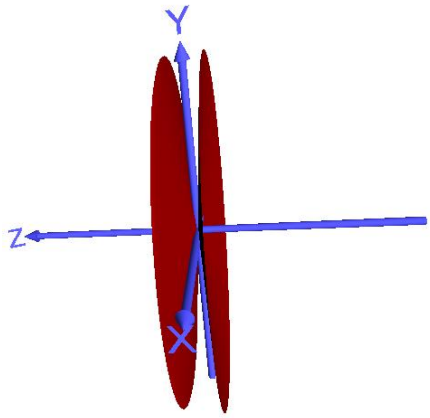
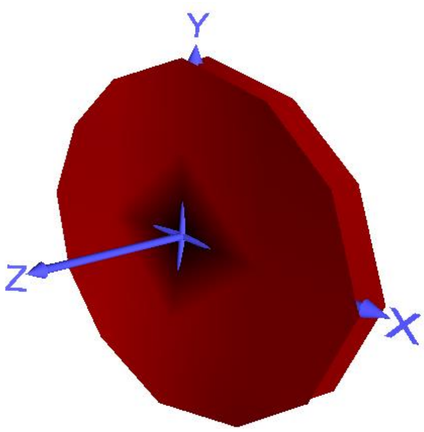
CZ2003 Computer Graphics and Visualization

Name: Ernest Ang Cheng Han
Tutorial Group: SSR1
Matric Number: U1921310H
N, M values: [N: 1, M: 10]

1. In 4 separate files, define by implicit functions $f(x, y, z) = 0$ and by setting a proper bounding box:

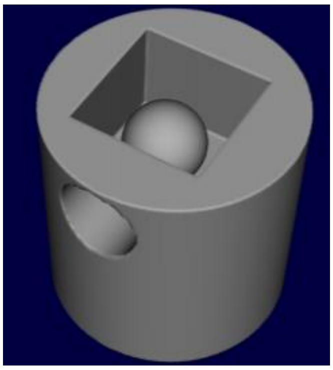
1a. A plane passing through the points with coordinates (***N***, ***M***, 0), (0, ***M***, ***N***), (***N***, 0, ***M***).	1b. A lower half of the surface of the origin-centered sphere with radius ***M***.
Coordinate 1: (1, 10, 0) Coordinate 2: (0, 10, 1) Coordinate 3: (1, 0, 10) $f(x, y, z) = x + y + z - 11$ File: 1a.vrml Box Center: 0.5, 5, 5 Box Dimensions: 1 10 10 Resolution: 2 2 2 Screenshot: 1a(2 Reso).png  Resolution: 1 1 1 Screenshot: 1a(1 Reso).png 	Radius: 10 $f(x, y, z) = 10^2 - x^2 - y^2 - z^2$ File: 1b.vrml Box Center: 0, -5, 0 Box Dimensions: 20 10 20 Resolution: 20 20 20 Screenshot: 1b(20 Reso).png  Resolution: 5 5 5 Screenshot: 1b(5 Reso).png 

Equation of any plane:
p = p1 + u*(p2 – p1) + v*(p3 – p1)
 	
Subbing in the above coordinates, we get:
x = 1 + u*(0 – 1) + v*(1 – 1) = 1 – u
y = 10 + u*(10 – 10) + v*(0 – 10) = 10 – 10v
z = 0 + u*(1 – 0) + v*(10 – 0) = u + 10v
 	
Vector Equation = (1, 10, 0) + u(-1, 0, 1) + v(0, -1, 1)
 	
Normal to u & v = (-1, 0, 1) x (0, -1, 1)
= (1, 1, 1)
 	
Ax + By + Cz + D = 0 // plane function
X + y + z + D = 0 // after sub in (1, 1, 1)
1 + 10 + 0 + D = 0 // after sub in (1, 10, 0)
D = -11
x + y + z – 11 = 0
 	
Since x-coordinate span from 0 to 1, length of box would = 1 and x-coordinate of box center would = (0+1)/2 = 0.5
 	
Since y-coordinate span from 0 to 10, length of box would = 10 and y-coordinate of box center would = (0+10)/2 = 5
 	
Since z-coordinate span from 0 to 10, length of box would = 10 and z-coordinate of box center would = (0+10)/2 = 5
 	
Minimum sampling resolution used is 2. At resolution 1, the plane is not rendered as seen below.
	Implicit equation of sphere:
	$f(x, y, z) = R^2 - x^2 - y^2 - z^2$, where R is the radius of the sphere. Hence we get $f(x, y, z) = 10^2 - x^2 - y^2 - z^2$
	
	Since we want only the lower half surface, the box dimension would be 20, 10, 20, where 20 would be derived from 10 * 2 at the x and z axis and 10 is derived from 20/2 for the y axis.
	
	Box center would be 0, -5, 0 since we need to shift the y-coordinate of the box center from origin by 10/2 in the negative y-direction
	
	Since it is a 3-dimensional sphere, the minimum resolution required would be 20 and any lower resolution would result in a sphere with uneven and pixelated edges

1c. A cylindrical surface with radius ***M*** which is aligned with axis Z, and spans from z1 =$-\boldsymbol{N}$ to $z2$ = ***M***	1d. A two-side conical surface with radius ***M*** at distance 1 from its apex. The cone is aligned with axis Z, and spans from $z1 = -1$ to $z2 = 1$ with the cone apex located at the origin.
Radius = 10 z1 = -1 z2 = 10 $f(x, y, z) = 10^2 - x^2 - y^2$ File: 1c.vrml Box Center: 0, 0, 4.5 Box Dimensions: 20 20 11 Resolution: 20 20 20 Screenshot: 1c(20 Reso)  Resolution: 5 5 5 Screenshot: 1c(5 Reso)  	Radius = 10 Distance from apex = 1 z1 = -1 z2 = 1 $f(x, y, z) = \left(\frac{z}{1}\right)^2 - \left(\frac{y}{10}\right)^2 - \left(\frac{x}{10}\right)^2$ File: 1d.vrml Box Center: 0, 0, 0 Box Dimensions: 20 20 2 Resolution: 20 20 20 Screenshot: 1d(20 Reso)  Resolution: 5 5 5 Screenshot: 1d(5 Reso) 

Implicit equation of cylinder which spans in the Z-axis infinitely: $f(x, y, z) = R^2 - x^2 - y^2$, where R is the radius of the cylinder Hence we get $f(x, y, z) = 10^2 - x^2 - y^2$. Since we need the cylinder to span from -1 to 10, we need to translate the z-coordinate of the box center by (-1 + 10)/2 = 4.5 in the negative direction Dimensions of the box would be 20 20 11 since the radius of the cylinder is 10 and the diameter of the cylinder would be 20 and that the cylinder spans from -1 to 10 and the difference of those values would be 10 - (-1) = 11 Since it is a 3-dimensional surface, the minimum resolution required would be 20 and any lower resolution would result in a sphere with uneven and pixelated edges	Implicit equation of the cone aligned to z-axis: $f(x, y, z) = (z)^2 - (y)^2 - (x)^2$. Since the radius of the cones are 10 and the distances from the cones to its apex are 1, then we get $f(x, y, z) = \left(\frac{z}{1}\right)^2 - \left(\frac{y}{10}\right)^2 - \left(\frac{x}{10}\right)^2$ Box center is at origin without any displacement/translation. Since the radius of the conical surface is 10, and the length in which the conical surface spans is 1-(-1) = 2, the box dimensions would be 10 10 2. Since it is a 3-dimensional surface, the minimum resolution required would be 20 and any lower resolution would result in a sphere with uneven and pixelated edges

<table>
<tr>
<td>2. With reference to Table 2, build one complex shape using set-theoretic operations following the design sketch number M. It has to be one function script created with MIN/MAX functions and functions $f(x, y, z) \geq 0$ of the participating shapes. Note that in FVRML each min/max function can take only two arguments and therefore nested functions have to be used.</td>
<td>3. This exercise can only be done using FVRML. Color the shape defined in exercise 2 with a variable color. To do it, define in FMaterial field a function-defined diffuse color for the whole shape by writing functions $r(u, v, w)$, $g(u, v, w)$, $b(u, v, w)$ where $u = x$, $v = y$, and $w = z$.

Use function number M from Table 1 as a color profile but scale it so that the color values will be located within [0,1] on the visible surfaces of the shape.</td>
</tr>
<tr>
<td>Number = 10


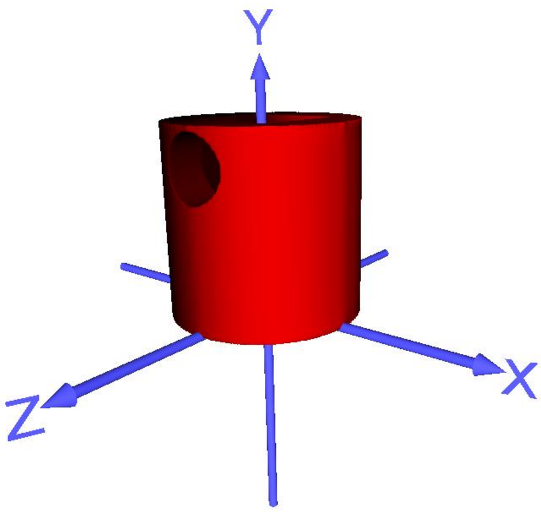
definition "function frep(x,y,z){
xline=min(x+3,3-x);
yline=min(y-8,12.5-y);
zline=min(z+3,3-z);
xyline=min(xline,yline);
box=min(zline,xyline);

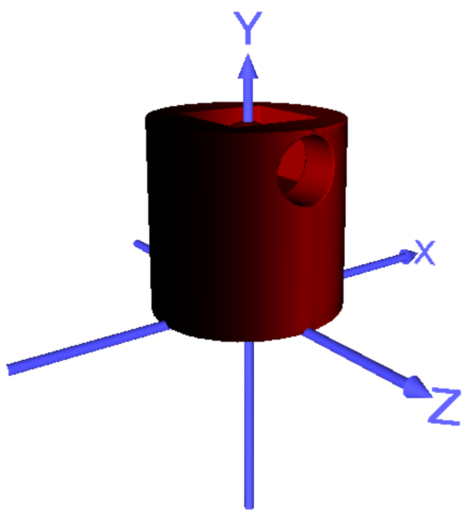
circle=6^2-x^2-z^2;
ymin=y;
ymax=12.5-y;
tempcyly=min(circle, ymin);
cyly=min(tempcyly, ymax);

cylz = min(2^2-x^2-(y-10.1)^2,z+2);

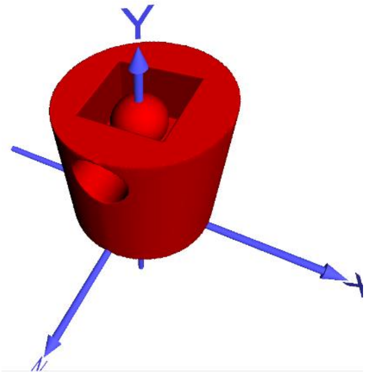
sphere=2^2-x^2-(y-10)^2-z^2;

tempf1 = min(cyly,-box);
tempf2=min(tempf1,-cylz);
final = max(tempf2, sphere);

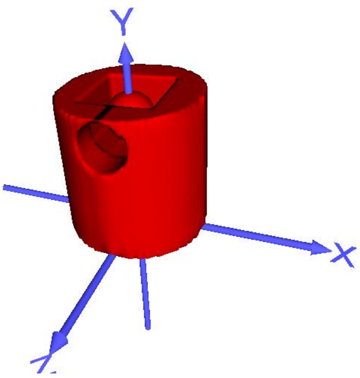
return final;}"</td>
<td>File: 3.vrml
Screenshot: 3(150 Reso)


Screenshot: 3.1(150 Reso)

</td>
</tr>
</table>

File: 2.vrml
Box Dimensions: 12 12.5 12
Box Center: 0, 6.25, 0
Resolution: 150 150 150
Screenshot: 2(150 Reso)



Resolution: 50 50 50
Screenshot: 2(50 Reso)



The above given shape is made out of 4 components:

1. Cylinder spans axis (cylz)
2. Box (box)
3. Main Cylinder span y axis (cyly)
4. Sphere (sphere)

After plotting the 4 shapes, you get the first temporary final shape (tempf1) by intersecting cyly and box via a intersecting min() function. After which, you get the next temporary final shape (tempf2) by intersecting tempf1 and cylz via again the min() function. Finally, you get the final shape expected in table 10 via merging the sphere and tempf2 via the max() function.

Equation:

```
appearance FAppearance {
material FMaterial {
# Variable color is defined for the CGS solid
diffuseColor "r=(1/(tanh(2)+abs(tanh(-1.3))))*(tanh(3.3/12*(u)+0.35)+abs(tanh(-1.3)));
g=0; b=0;"
parameters [-6, 6]
   }   }
}
```

M = 10, N = 1
Equation: $y = \tanh x$, $x \in [-1.3,2]$
Length of domain: 3.3

y = tanh(-1.3)
y = tanh(2)
y varies from tanh(-1.3) -> tanh(2)

Translate y by abs(tanh(-1.3)) to make the minimum 0, equation:
y = tanhx + abs(tanh(-1.3))

Now the maximum value of y = tanh(2) + abs(tanh(-1.3)). To reduce the upper limit of y to 1, scale y by 1/(tanh(2) + abs(tanh(-1.3)))

Hence we arrive at:
y = (1/(tanh(2) + abs(tanh(-1.3))))(tanh(x) + abs(tanh(-1.3))), $x \in [-1.3,2]$

Shape in exercise 2: $x \in [-6,6]$, derived from 12/2, where 12 is the x-axis box dimension.

Length of domain: 12
y = (1/(tanh(2) + abs(tanh(-1.3))))(tanh($\frac{3.3}{12}$x - $\frac{3.3}{2} + 2$) + abs(tanh(-1.3)))

y = (1/(tanh(2) + abs(tanh(-1.3))))(tanh($\frac{3.3}{12}$x + 0.35) + abs(tanh(-1.3)))

Given that x = u, we finally arrive at the colouring profile equation:
y = (1/(tanh(2) + abs(tanh(-1.3))))(tanh($\frac{3.3}{12}$u + 0.35) + abs(tanh(-1.3))), u ∈ [−6,6]

Set red as with this function

Thus, we arrive at:
appearance FAppearance {

Based on the shape, the box dimension is 12 12.5 12 and the box center is 6 6.25 6.
 	
The chosen resolution is 150 and as the resolution of the shape decreases, the edges become blurry and less distinct.
	material FMaterial {
	# Variable color is defined for the CGS solid
	diffuseColor
	"r=(1/(tanh(2)+abs(tanh(-1.3))))*(tanh(3.3/12*(u)+0.35)+abs(tanh(-1.3)));
	g=0; b=0;"
	parameters [-6, 6]
	} }
	}

P.S. For each of the vrml file, the following function is added so that the bounding box can be visualized:

Transform {translation x1 y1 z1 children [
Shape {geometry Box {size x2 y2 z2 } appearance Appearance {material Material {diffuseColor 0 1 0 transparency 0.6}}}]}

(Where x1, x2, y1, y2, z1, z2 will vary based on the question)