Lab 3 Report

Parametric Surfaces and Solids

CZ2003 Computer Graphics and Visualization

Nanyang Technological University

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3D Plane

Parametric equation of a 3D plane can be defined as

$$x = u$$

$$y = v$$

$$z = u + v$$

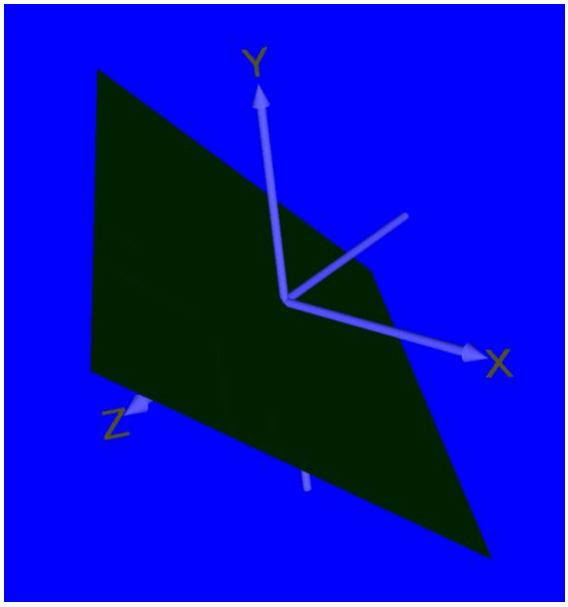


Fig 1. 3D plane with u, v ∈ [0 1] and resolution of [75 75]

Bilinear Surface

Parametric equation of a bilinear surface can be defined as

$$x = u + 0.5v$$

$$y = 2uv$$

$$z = -1 + 2v$$

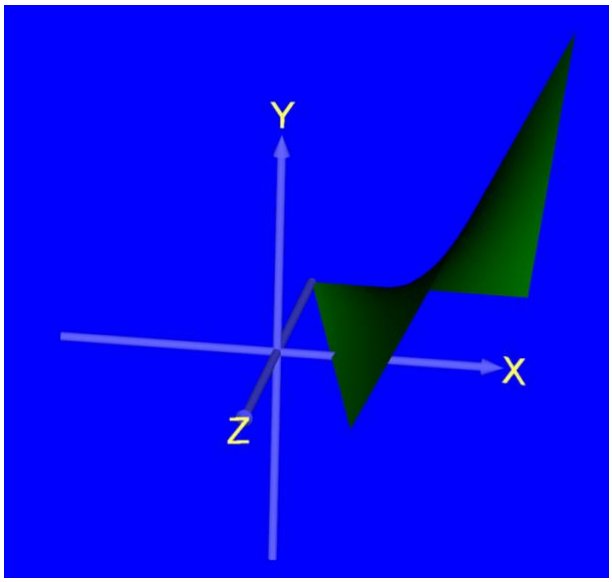


Fig 2. Bilinear surface with u, v ∈ [0 1] and resolution of [75 75]

3D Triangle

Parametric equation of a 3D triangle can be defined as

$$x = -0.5 + u + 0.5v - uv$$

$$y = 0.5v$$

$$z = 0.5 – v$$

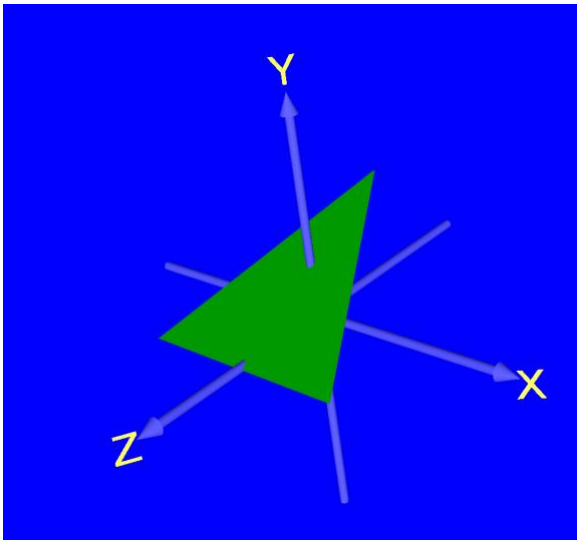


Fig 3. 3D triangle with u, v ∈ [0 1] and resolution of [75 75]

Sphere

Parametric equation of a sphere can be defined as

$$x = \cos\left(\frac{\Pi}{2}u\right)\sin\left(\Pi v\right)$$

$$y = \sin\left(\frac{\Pi}{2}u\right)$$

$$z = \cos\left(\frac{\Pi}{2}u\right)\cos\left(\Pi v\right)$$

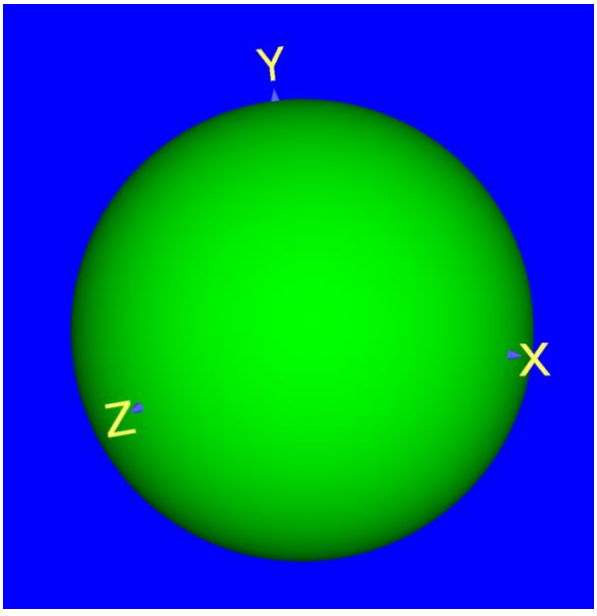


Fig 4. Sphere with u, v ∈ [-1 1] and resolution of [75 75]

Ellipsoid

Parametric equation of an ellipsoid can be defined as

$$x = 1.5 \cos\left(\frac{\Pi}{2} u\right) \sin(\Pi v)$$

$$y = 0.5 \sin\left(\frac{\Pi}{2} u\right)$$

$$z = \cos\left(\frac{\Pi}{2} u\right) \cos(\Pi v)$$

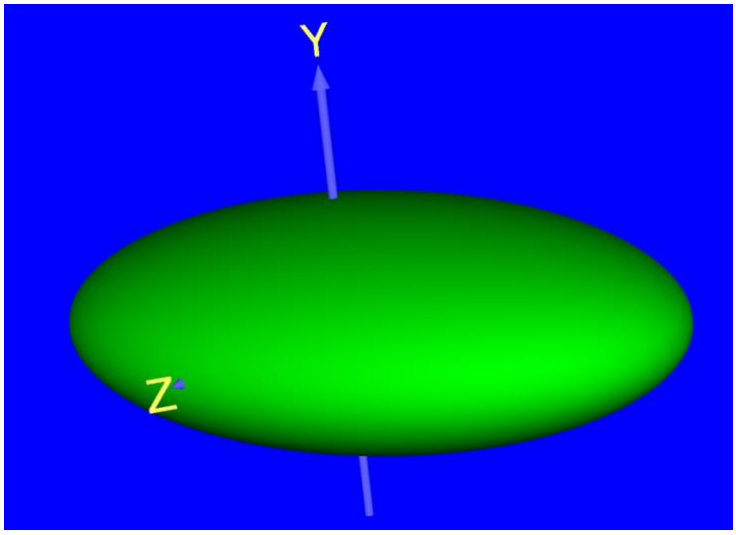


Fig 5. Ellipsoid with u, v ∈ [-1 1] and resolution of [75 75]

Cone

Parametric equation of a cone can be defined as

$$x = u \sqrt{2}$$

$$y = u \sqrt{2} \cos(2 \Pi v)$$

$$z = u \sqrt{2} \sin(2 \Pi v)$$

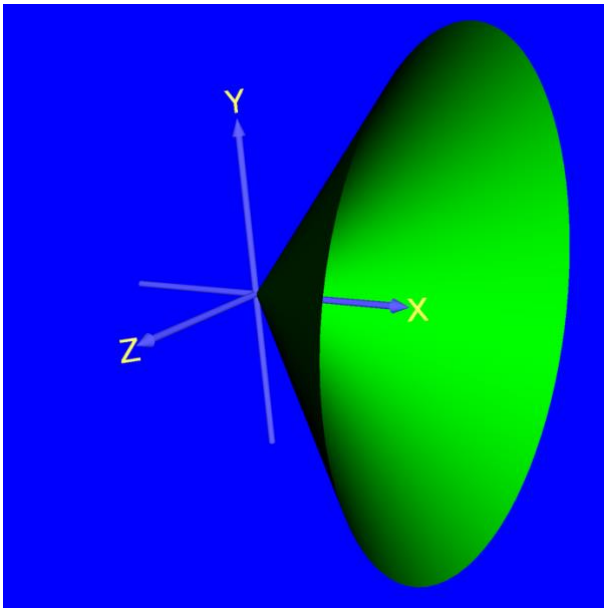


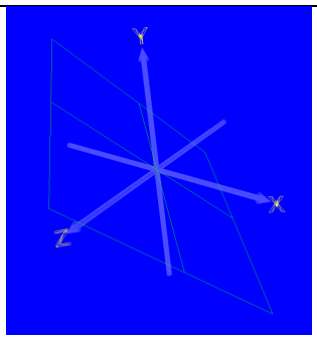
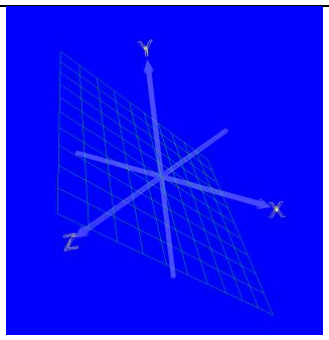
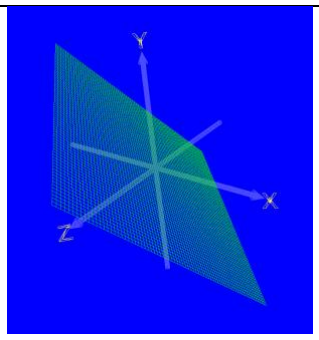
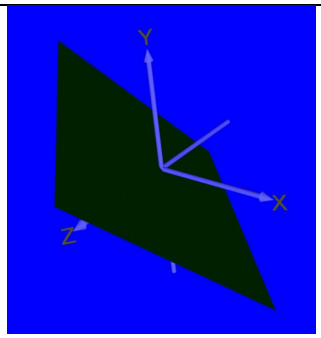
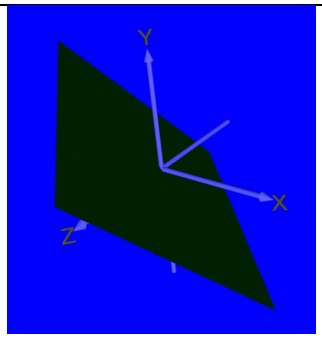
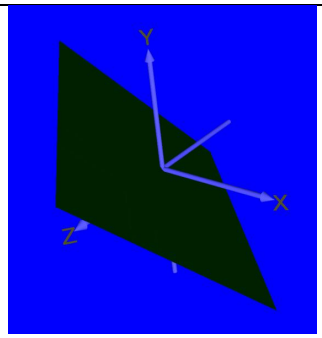
Fig 6. Cone with u, v ∈ [0 1] and resolution of [75 75]

Sampling Resolution

The sampling resolution refers to the number of sampling points that lines will join to form the shape. Below shows how different sampling resolution affects different shapes.

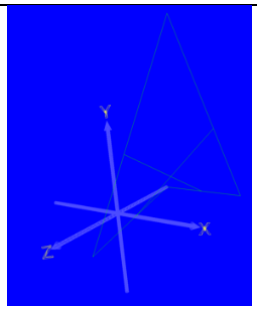
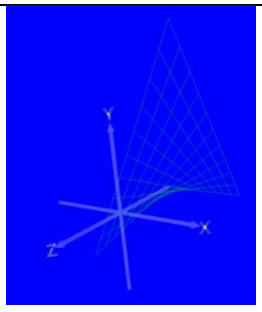
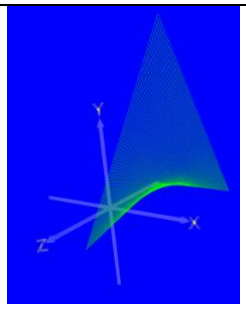
3D Plane

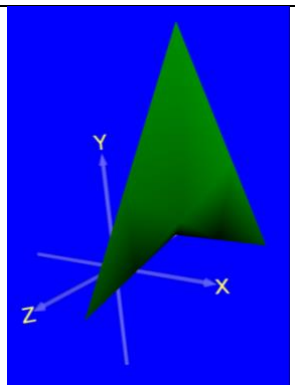
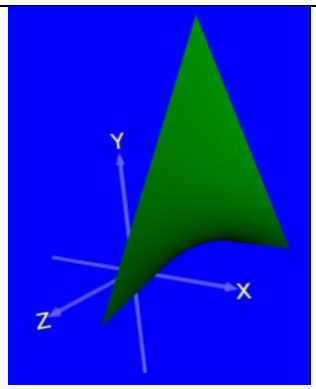
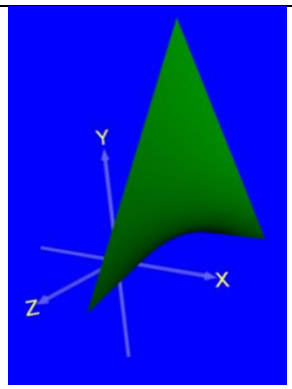
Changes in the sampling resolution does not affect the appearance of the 3D plane.

Resolution	2	10	75
Graphic Mode	Wireframe		
Appearance			
Graphic Mode	Smooth		
Appearance			

Bilinear Surface

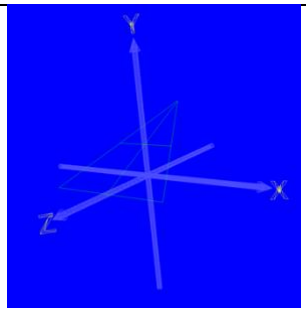
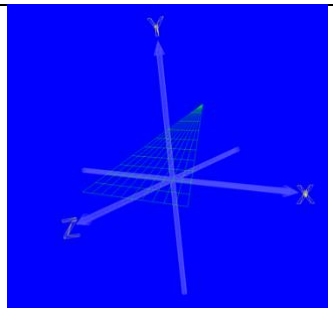
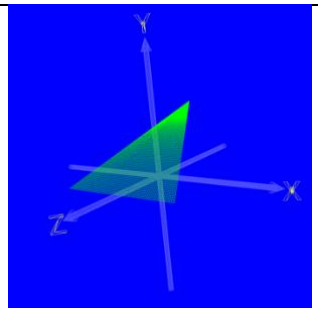
Changes in the sampling resolution affect how smooth the curved portion of the plane looks. Greater resolution results in more sampled points, forming more lines and hence giving a smoother appearance of the curved portion.

Resolution	2	10	75
Graphic Mode	Wireframe		
Appearance			

Graphic Mode	Smooth		
Appearance			

3D Triangle

Lower sampling resolution results in more intense edge shadows. Otherwise, sampling resolution does not affect the appearance of the 3D triangle.

Resolution	2	10	75
Graphic Mode	Wireframe		
Appearance			
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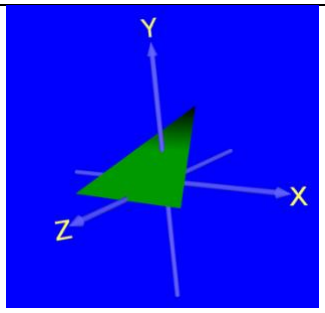
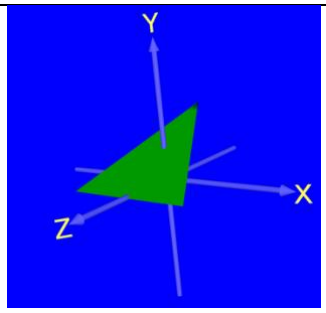
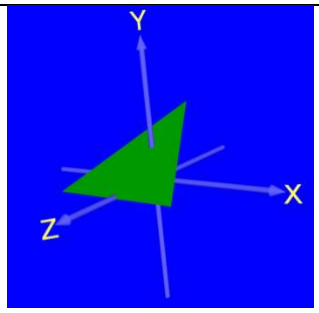
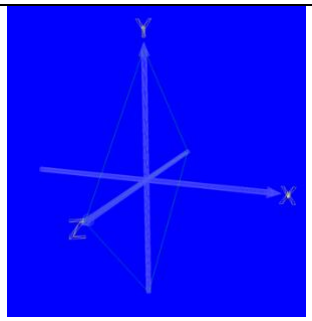
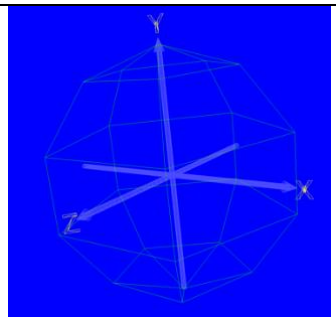
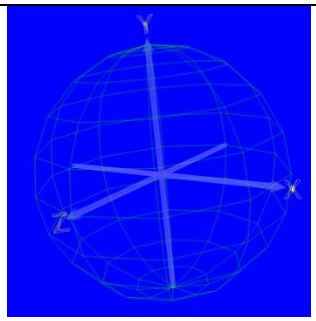
Appearance			

Sphere

Changes in the sampling resolution affect how smooth and round the sphere looks. Greater resolution results in more sampled points, forming more lines and hence giving a smoother and rounder appearance of the sphere. Lower sampling resolution also results in more intense edge shadows.

Resolution	2	5	10
Graphic Mode	Wireframe		
Appearance			
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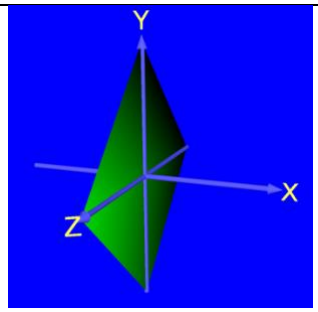
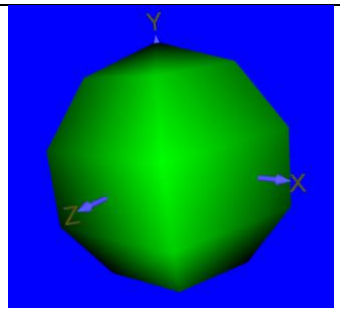
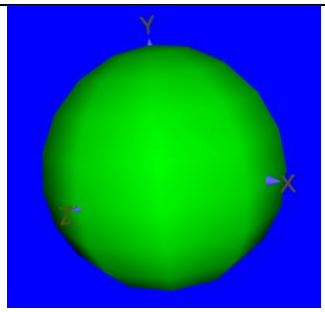
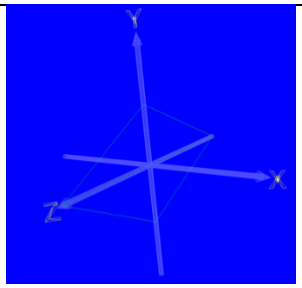
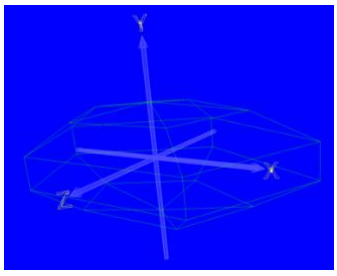
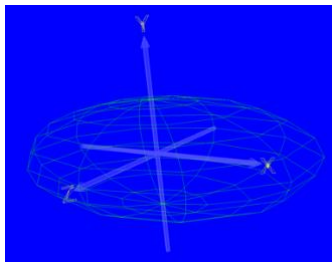
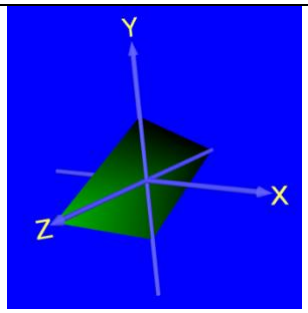
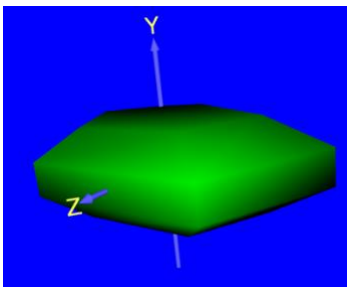
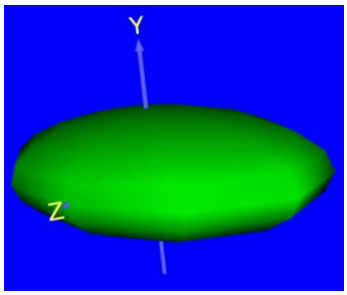
Appearance			

Ellipsoid

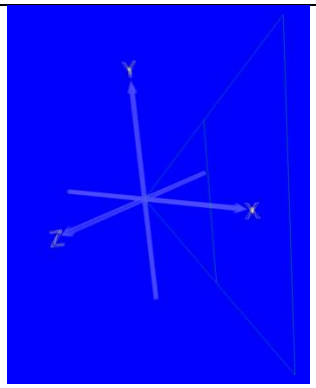
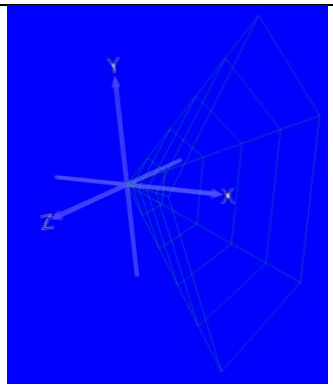
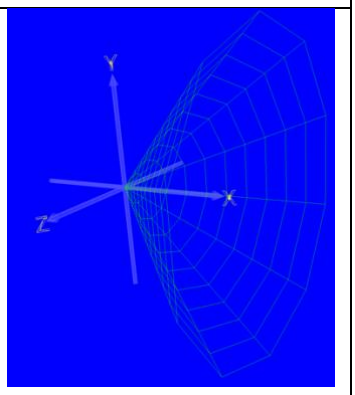
Changes in the sampling resolution affect how smooth and round the ellipsoid looks. Greater resolution results in more sampled points, forming more lines and hence giving a smoother and rounder appearance of the ellipsoid. Lower sampling resolution also results in more intense edge shadows.

Resolution	2	5	10
Graphic Mode	Wireframe		
Appearance			

Graphic Mode	Smooth		
Appearance			

Cone

Changes in the sampling resolution affect how smooth and curved the sphere cone. Greater resolution results in more sampled points, forming more lines and hence giving a smoother and curvier appearance of the cone. Lower sampling resolution also results in more intense edge shadows.

Resolution	2	5	10
Graphic Mode	Wireframe		
Appearance			
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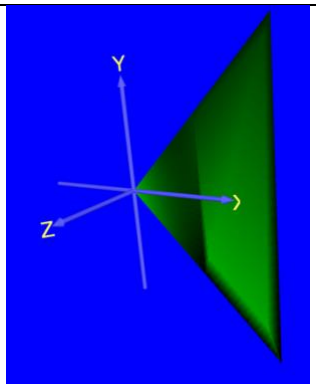
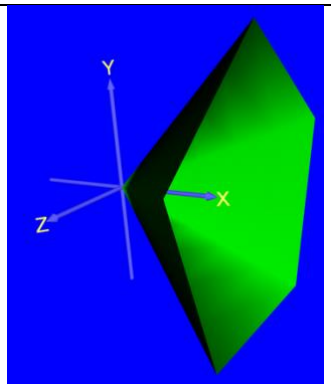
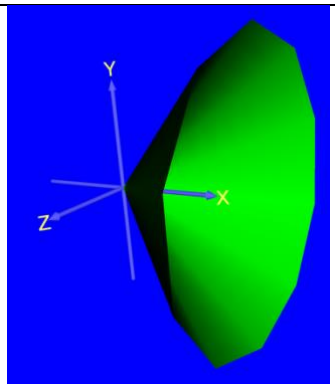
Appearance			

Solid Box

Parametric equation of a solid box can be defined as

$$x = u$$

$$y = v$$

$$z = w$$

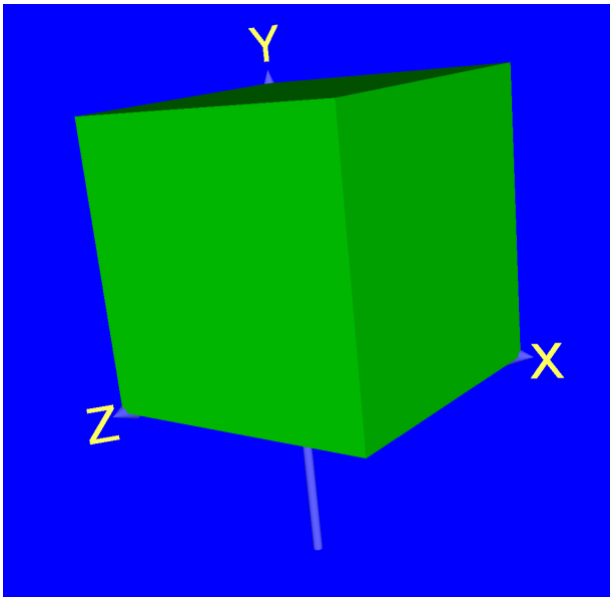


Fig 7. Solid box with u, v, w ∈ [0 1] and resolution of [75 75]

Solid Sphere

Parametric equation of a solid sphere can be defined as

$$x = w \cos\left(\frac{\Pi}{2} u\right) \sin(\Pi v)$$

$$y = w \sin\left(\frac{\Pi}{2} u\right)$$

$$z = w \cos\left(\frac{\Pi}{2} u\right) \cos(\Pi v)$$

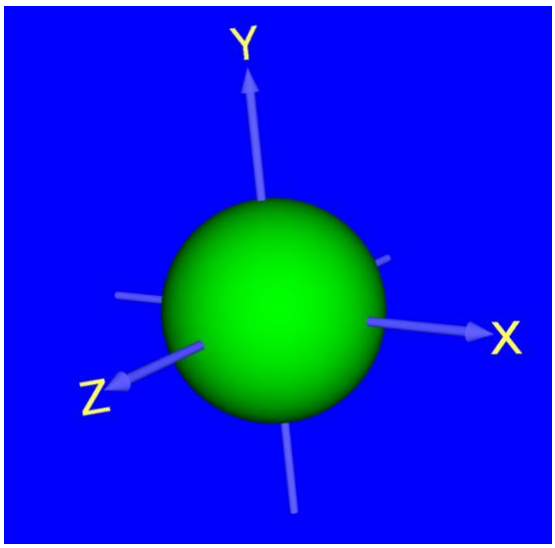


Fig 8. Solid sphere with u, v ∈ [-1 1], w ∈ [0 0.5] and resolution of [75 75]

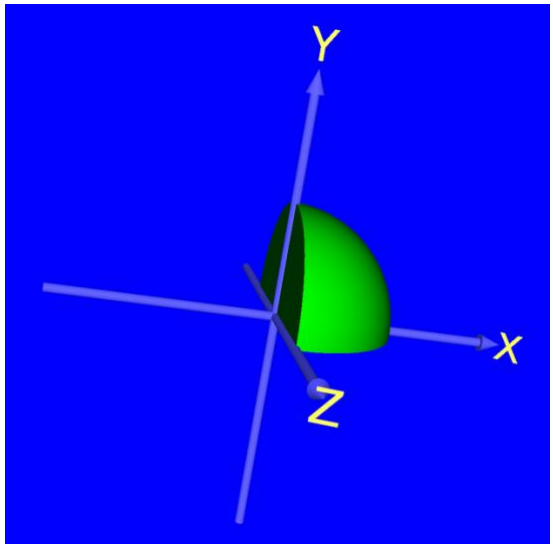


Fig 9. Solid sphere with u, v ∈ [0 1], w ∈ [0 0.5] and resolution of [75 75]

Solid Cylinder

Parametric equation of a solid cylinder can be defined as

$$x = 0.75u \sin (2 \Pi v) + 0.1$$

$$y = w + 0.1$$

$$z = 0.75u \cos (2 \Pi v) + 0.1$$

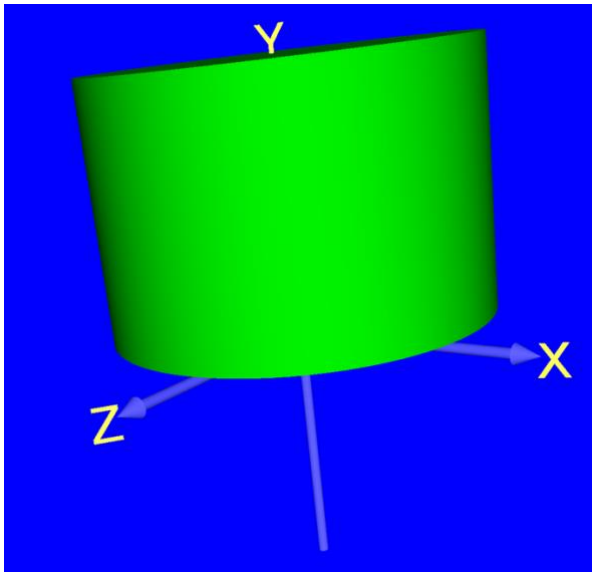


Fig 10. Solid cylinder with u, v, w ∈ [0 1] and resolution of [75 75]

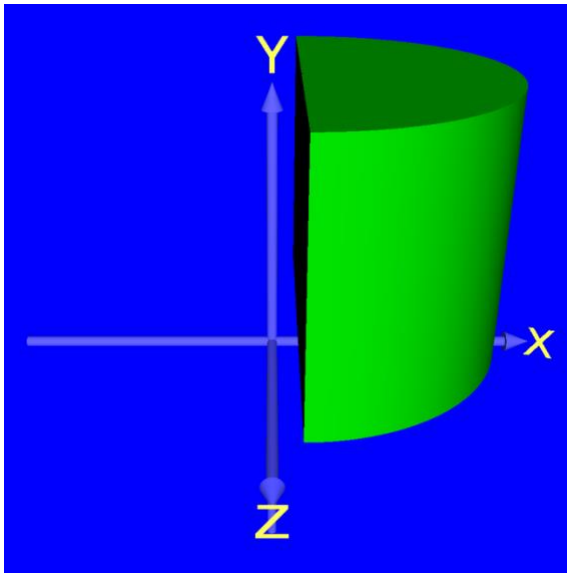


Fig 11. Solid cylinder with u, w ∈ [0 1], v ∈ [0 0.5] and resolution of [75 75]

Solid Cone

Parametric equation of a solid cone can be defined as

$$x = 1.5u$$

$$y = 0.75uv \cos (2 \Pi w)$$

$$z = 0.75uv \sin (2 \Pi w)$$

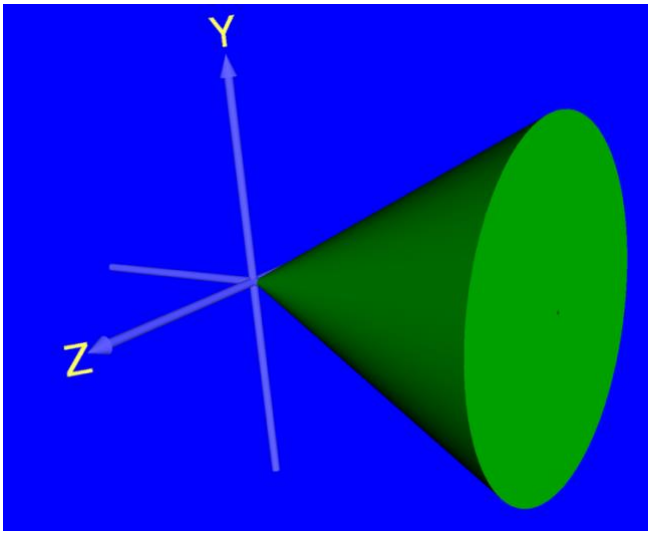


Fig 12. Solid cone with u, v, w ∈ [0 1] and resolution of [75 75]

Conversion of Closed Surface to Solid Object

We can observe that closed surfaces have 2 parameters while solid objects have 3 parameters. The third parameter is used to fill the hollow space of the previously closed surface.

For example, below is the parametric representation for a sphere and a solid sphere.

Sphere	Solid Sphere
$x = \cos\left(\frac{\Pi}{2} u\right) \sin(\Pi v)$	$x = w \cos\left(\frac{\Pi}{2} u\right) \sin(\Pi v)$
$y = \sin\left(\frac{\Pi}{2} u\right)$	$y = w \sin\left(\frac{\Pi}{2} u\right)$
$z = \cos\left(\frac{\Pi}{2} u\right) \cos(\Pi v)$	$z = w \cos\left(\frac{\Pi}{2} u\right) \cos(\Pi v)$

One can notice that the only difference is the additional parameter w, which is responsible for creating infinite spheres of varying radius as specified by the range of w. This makes the inside of the sphere filled and thus obtaining a solid object.

Rotational and Translational Sweeping of y = sin (x)

Explicit equation: y = sin (x)

Parametric equation: x = u

y = sin (u)

<u>Apply Rotational Sweeping</u>

x = u

y = 0.5 cos (Π v) sin (2 Π u)

z = 0.5 sin (Π v)

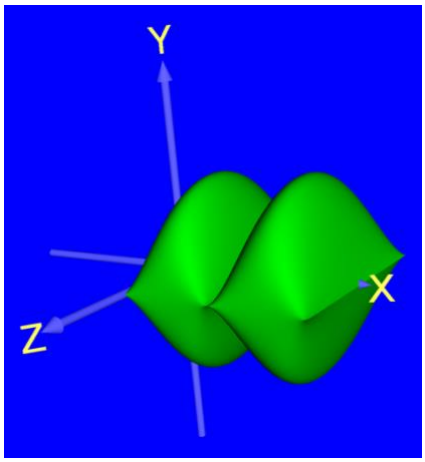


Fig 13. Solid object formed after rotational sweeping with u, w ∈ [0 1], v ∈ [0 2] and

<u>Apply Rotational & Translational Sweeping</u>

x = u - 0.1w

y = 0.5 cos (Π v) sin (2 Π u)

z = 0.5 sin (Π v)

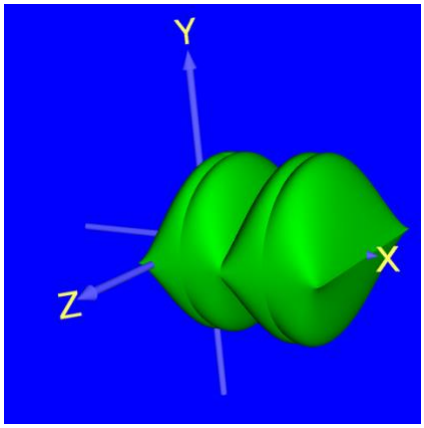


Fig 14. Solid object formed after rotational and translational sweeping with u, w ∈ [0 1], v ∈ [0 2] and resolution of [75 75]

Description of Files

1. 3D plane.wrl - Shows 3D plane as per Fig 1's specifications
2. 3D triangle.wrl - Shows a 3D triangle as per Fig 3's specifications
3. bilinear surface.wrl - Shows a bilinear surface as per Fig 2's specifications
4. cone.wrl - Shows a cone as per Fig 6's specifications
5. ellipsoid.wrl - Shows an ellipsoid as per Fig 5's specifications
6. solid box.wrl – Shows a solid box as per Fig 7's specifications
7. solid cone.wrl - Shows a solid cone as per Fig 12's specifications
8. solid cylinder.wrl - Shows a solid cylinder as per Fig 10's specifications
9. solid sphere.wrl - Shows a solid sphere as per Fig 8's specifications
10. sphere.wrl - Shows a sphere as per Fig 4's specifications
11. y = sin (x).wrl - Shows a solid object as per Fig 14's specifications