CZ2003 Computer Graphics and Visualisation

Experiment 3: Parametric Surfaces and Solids

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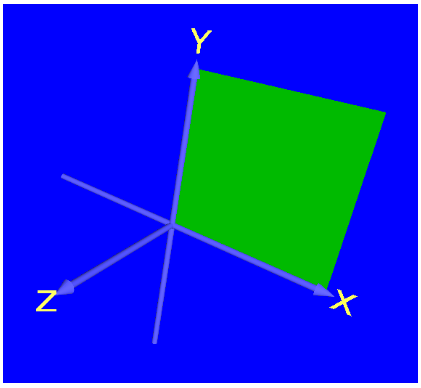
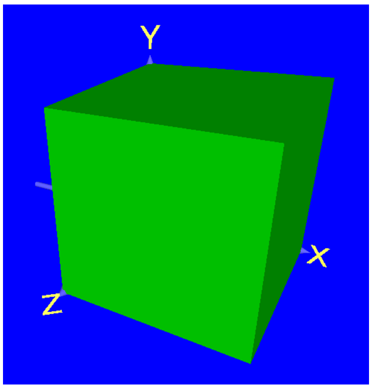
Matriculation Number: XXXXXXXXX

Lab Group: XXX

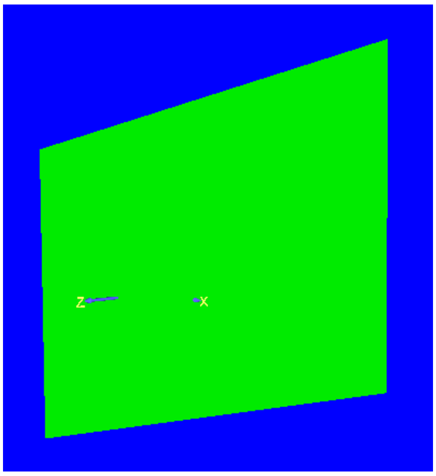
Exercise 1



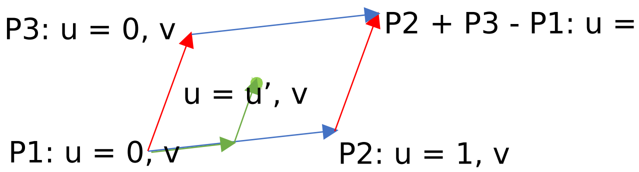


Exercise 2 (may have to pan and zoom to see the shapes)

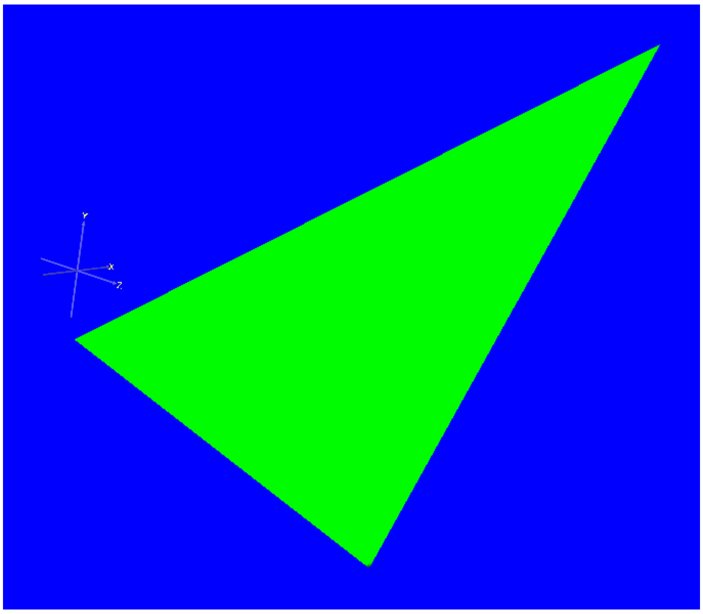
1. **3D Plane**



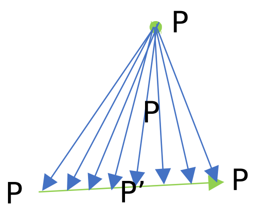
- defines a parallelogram in 3D space
- any point on the parallelogram can be obtained by adding 2 offsets to a base point
- a base point with known, fixed coordinates:
    - P1
- offset in first direction:
    - u(P2 - P1)
- offset in second direction:
    - v(P3 - P1)
- any point on the parallelogram:
    - P1 + u(P2 - P1) + v(P3 - P1)
    - u ∈ [0,1] , v ∈ [0,1]



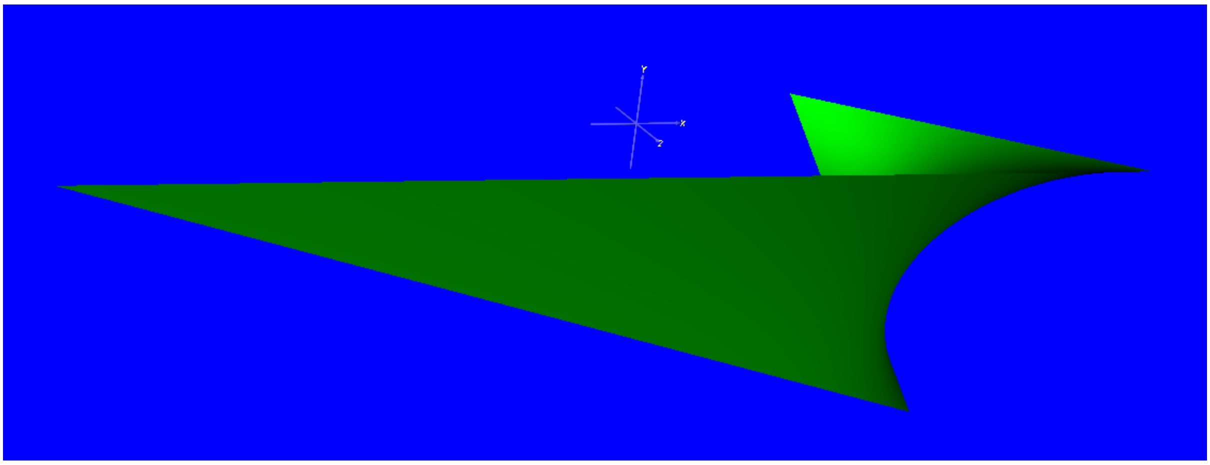
2. 3D Triangle



- defines a triangle in 3D space
- can be thought of as a set of point obtained via interpolation from a point to a set of points on a line segment (or vice versa)
- any point on line segment, P':
    - o P1 + u(P2 - P1)
- point:
    - o P3
- any point on the triangle, P:
    - o P3 + v(P' - P3)
      = P3 + v(P1 + u(P2 - P1) - P3)
      = P3 + v(P1 - P3) + uv(P2 - P1)



3. Bilinear Surface

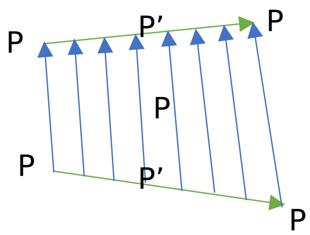


- defines a bilinear surface
- can be thought of as a set of points bounded by 2 line segments
    - each line segment is a set of points, which can be obtained via interpolation from a starting point to an ending point
    - each point on the surface can be obtained via interpolation from a point (of a relative offset determined by parameter u) on the first line segment to a point (of a relative offset, also determined by parameter u) on the second line segment
- any point on first line segment, P’:
    - $P1 + u(P2 - P1)$
- any point on second line segment, P”:
    - $P3 + u(P4 - P3)$
- any point on the surface, P:
    - $P' + v(P'' - P')$

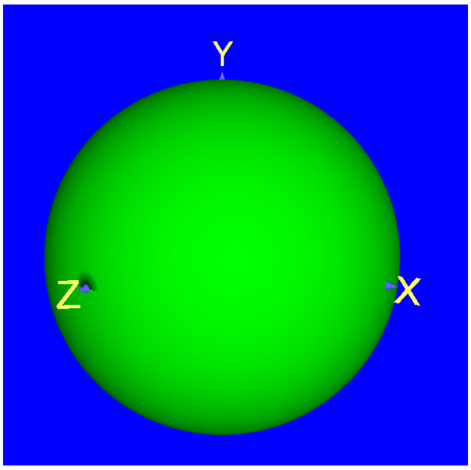
      $= P1 + u(P2 - P1) + v(P3 + u(P4 - P3) - P1 + u(P2 - P1))$

      $= P1 + u(P2 - P1) + v(P3 - P1 + u(P4 - P3 + P2 - P1))$

      $= P1 + u(P2 - P1) + v(P3 - P1) + uv(P4 - P3 + P2 - P1)$

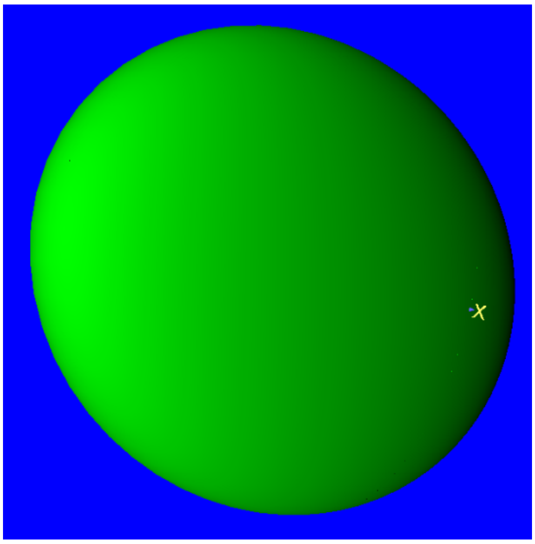


4. Sphere



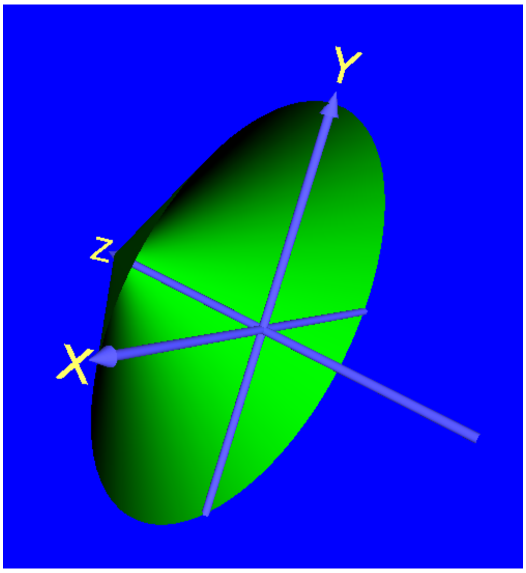
- defines a spherical surface (hollow inside)
- can be thought of as a ring that does rotational sweeping about an axis
- start with a circle on the y-z plane:
  - $z = r * \cos(2\pi*u)$
  - $y = r * \sin(2\pi*u)$
  - $u \in [0,1]$
- rotate the circle about z-axis by half a revolution:
  - rotation appears to draw a circle on the x-y plane:
    - $x = r' * \cos(\pi*v)$
    - $y = r' * \sin(\pi*v)$
    - $v \in [0,1]$
  - during the drawing (rendering) of the sphere, the x and y coordinates change, but z coordinates stay constant
    - $x = (r * \sin(2\pi*u)) * \cos(\pi*v)$
    - $y = (r * \sin(2\pi*u)) * \sin(\pi*v)$
    - $z = r * \cos(2\pi*u)$
    - $u \in [0,1]$, $v \in [0,1]$

5. Ellipsoid



- defines an ellipsoidal surface (hollow inside)
- can be thought of as a deformed ring that is spun about an axis
  - o essentially a deformed sphere
  - o deformation done using 3 parameters: a, b, and c
- apply semi-axes to sphere:
  - o $x = (r/a * \sin(2\pi*u)) * \cos(\pi*v)$
  - o $y = (r/b * \sin(2\pi*u)) * \sin(\pi*v)$
  - o $z = r/c * \cos(2\pi*u)$
  - o $u \in [0,1]$, $v \in [0,1]$

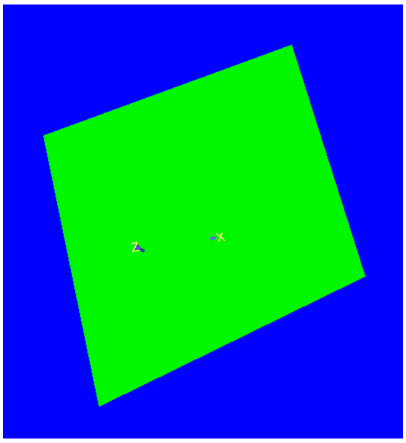
6. Cone



- defines a conical surface (hollow inside)
- can be thought of as smaller and smaller rings stacked on top of a base ring

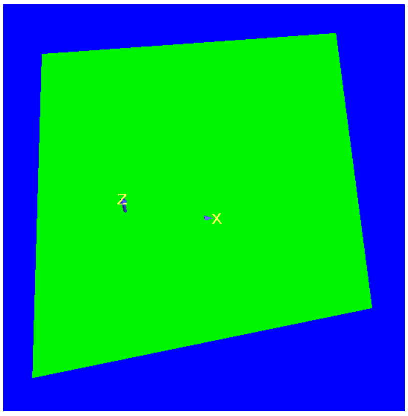
Exercise 3

1. **3D Plane**
    a. resolution 1 1:



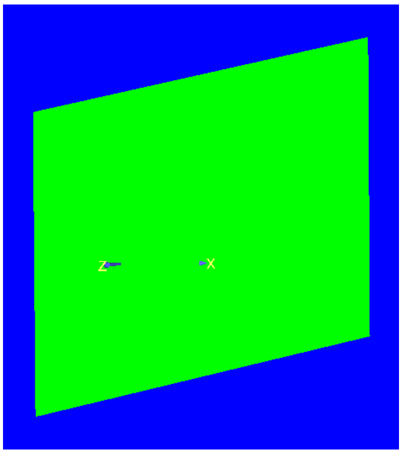
- no noticeable change from the original

    b. resolution 1000 1000:



- takes a few seconds to render, unlike the original which renders almost instantaneously
- panning and zooming feels more laggy

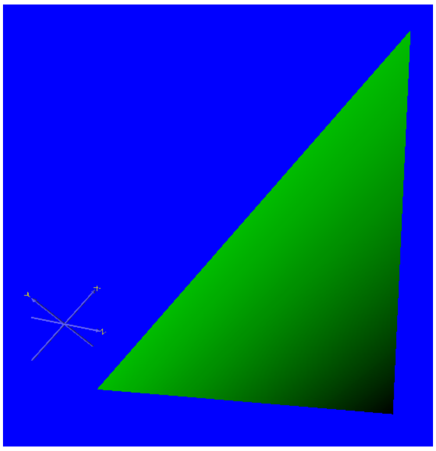
    c. resolution 100 20:



- no noticeable change from the original

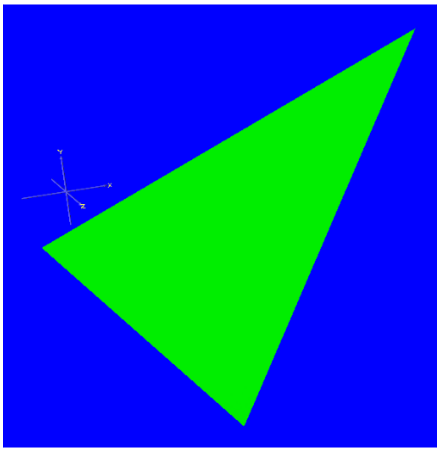
2. 3D Triangle

a. resolution 1 1:



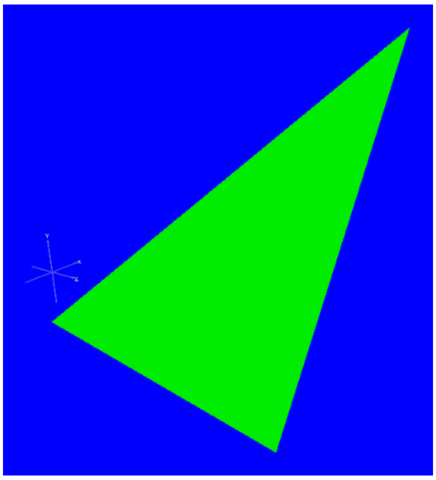
- no noticeable change from the original

b. resolution 1000 1000:



- takes a few seconds to render, unlike the original which renders almost instantaneously
- panning and zooming feels more laggy

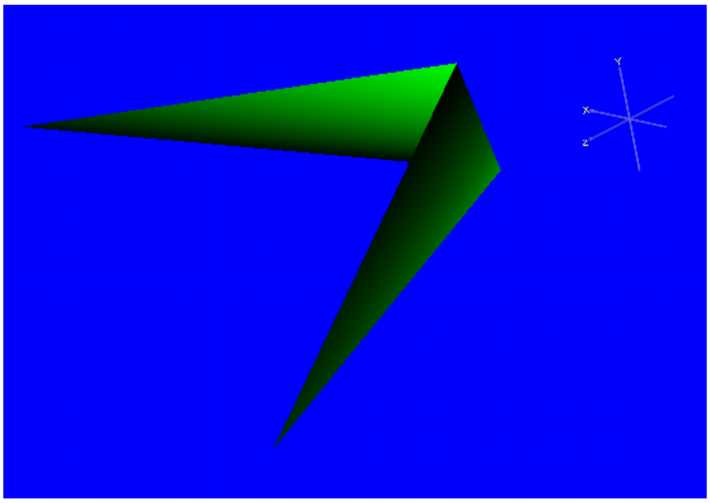
c. resolution 1 500:



- no noticeable change from the original

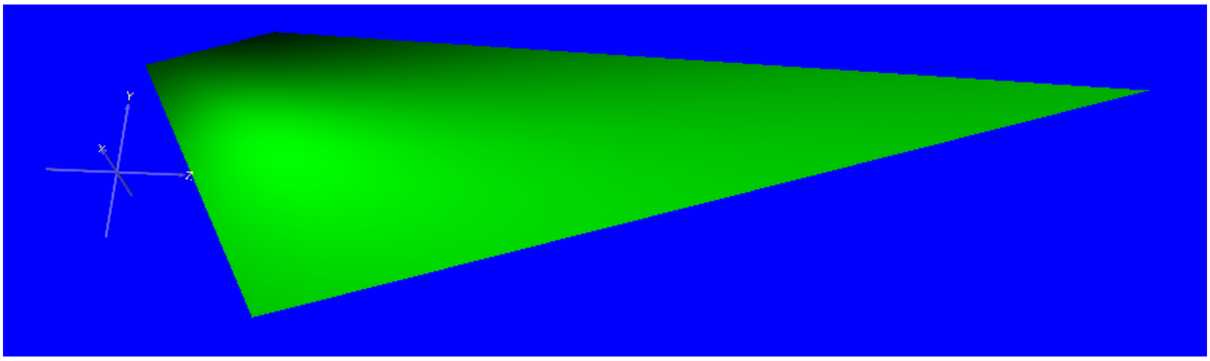
3. **Bilinear Surface**

a. resolution 1 1:



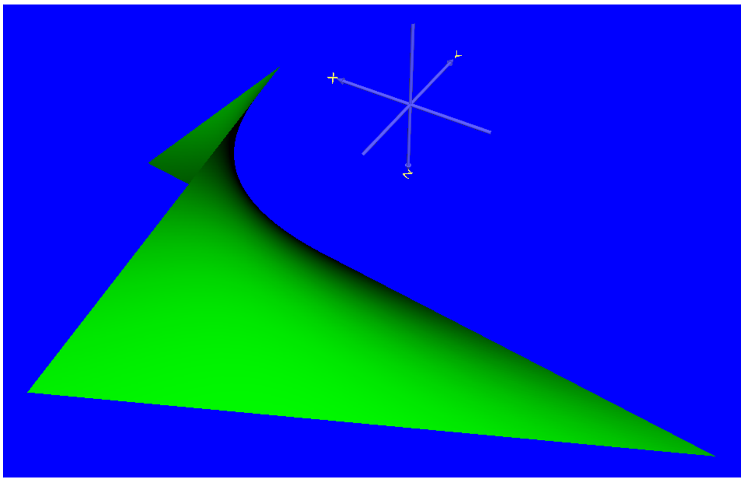
- becomes flattened
  - looks like 2 planes joined together

b. resolution 1000 1000:



- takes a few seconds to render, unlike the original which renders almost instantaneously
- panning and zooming feels more laggy

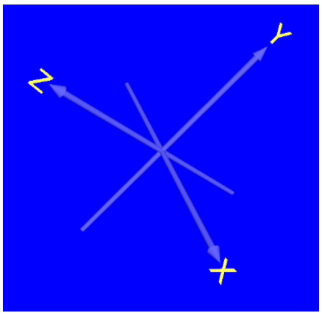
c. resolution 69 420:



- no noticeable change from the original

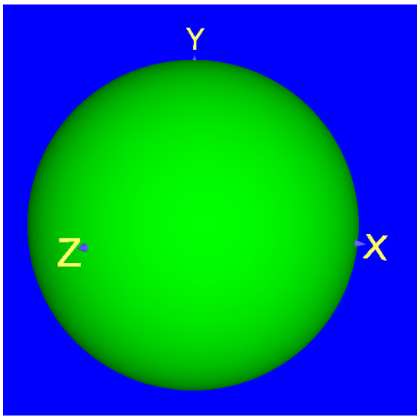
4. **Sphere**

   a. resolution 1 1:



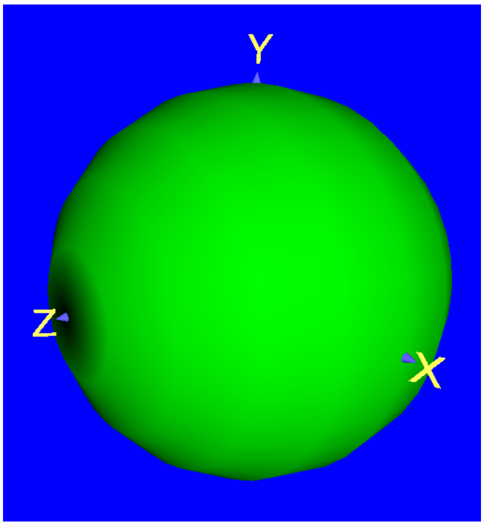
- appears that no shape was rendered

   b. resolution 1000 1000:



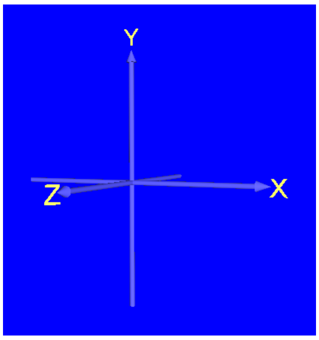
- takes a few seconds to render, unlike the original which renders almost instantaneously
- panning and zooming feels more laggy
- no ‘shadow’ near the z-axis label

   c. resolution 20 20:

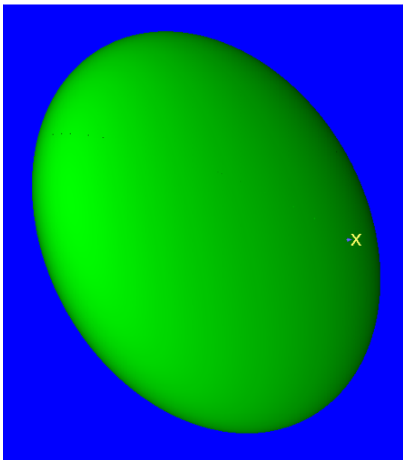


- surface is not smooth, unlike the original

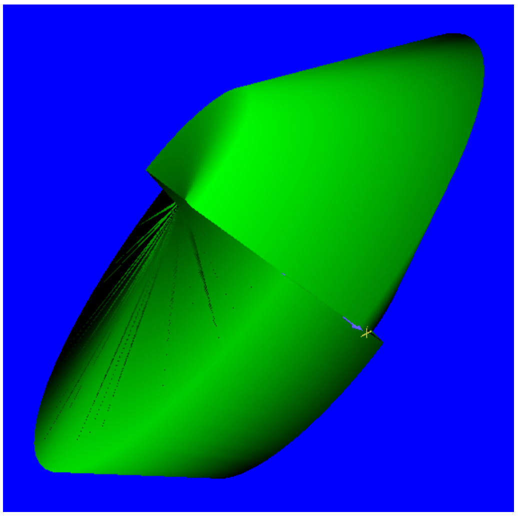
5. **Ellipsoid**
    a. resolution 1 1:



- appears that no shape was rendered
    b. resolution 1000 1000:

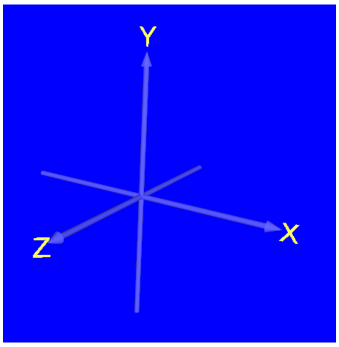


- takes a few seconds to render, unlike the original which renders almost instantaneously
- panning and zooming feels more laggy
- looks very smooth
    c. resolution 5 30:



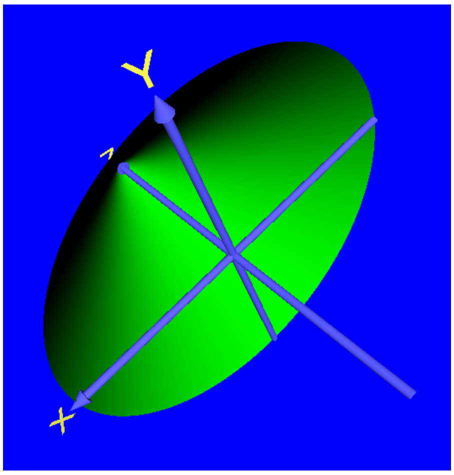
- weird shape

6. **Cone**
    a. resolution 1 1:



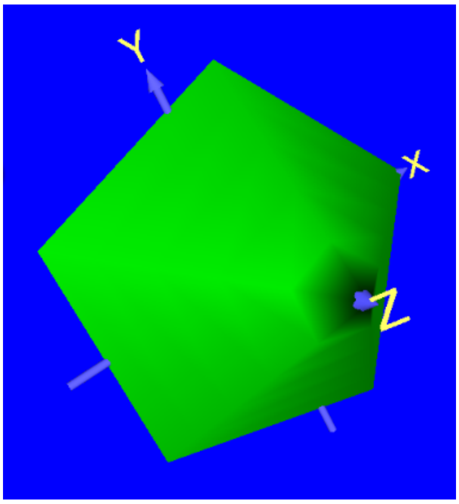
- appears that no shape was rendered

    b. resolution 1000 1000:



- takes a few seconds to render, unlike the original which renders almost instantaneously
- panning and zooming feels more laggy

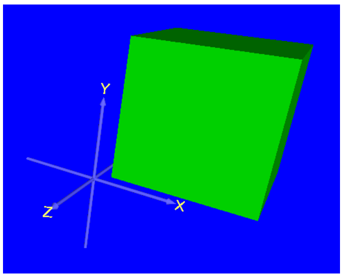
    c. resolution 5 5:



- a 3D pentagon
    - a penta-cone

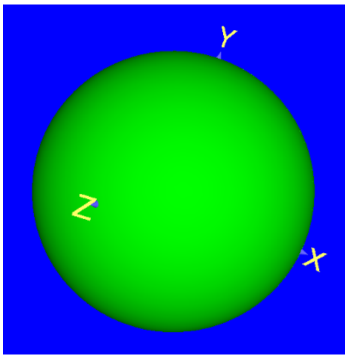
Exercise 4

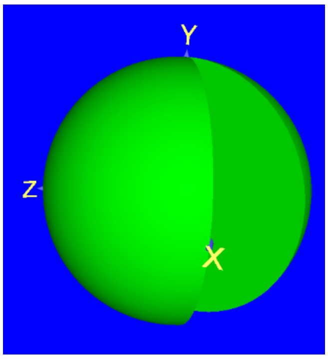
1. Solid Box



- defines a solid cuboid

2. Solid Sphere

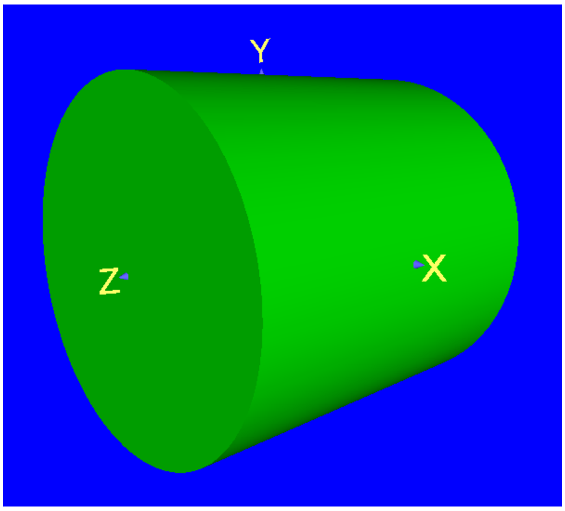




(cut open)

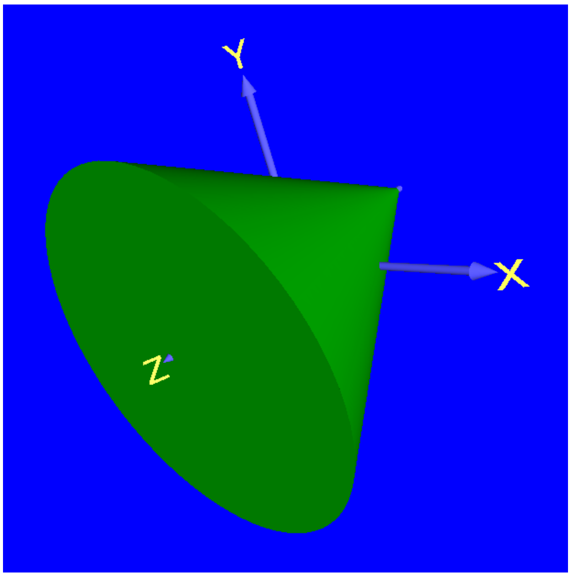
- defines a solid sphere
- can be thought of as a disk that is spun about an axis
- start with a circle on the x-y plane:
    - $x = r * \cos(2\pi*u)$
    - $y = r * \sin(2\pi*u)$
    - $u \in [0,1]$
- fill the circle with infinitely many concentric circles to form a disk:
    - $x = (v * r) * \cos(2\pi*u)$
    - $y = (v * r) * \sin(2\pi*u)$
    - $u \in [0,1]$, $v \in [0,1]$
- rotate the disk about x-axis by half a revolution:
    - rotation appears to draw a circle on the y-z plane:
        - $z = r' * \cos(\pi*w)$
        - $y = r' * \sin(\pi*w)$
        - $w \in [0,1]$
    - during the drawing (rendering) of the sphere, the y and z coordinates change, but x coordinates stay constant
        - $x = (v * r) * \cos(2\pi*u)$
        - $y = ((v * r) * \sin(2\pi*u)) * \sin(\pi*w)$
        - $z = ((v * r) * \sin(2\pi*u)) * \cos(\pi*w)$
        - $u \in [0,1]$, $v \in [0,1]$, $w \in [0,1]$

3. Solid Cylinder



- defines a solid cylinder
- can be thought of as a set of disks of the same radius that are stacked on top (or in front) of each other
- start with a circle on the x-y plane:
  - o $x = r * \cos(2\pi * u)$
  - o $y = r * \sin(2\pi * u)$
  - o $u \in [0,1]$
- fill the circle with infinitely many concentric circles to form a disk:
  - o $x = (v * r) * \cos(2\pi * u)$
  - o $y = (v * r) * \sin(2\pi * u)$
  - o $u \in [0,1]$, $v \in [0,1]$
- extend the disk in the z-direction (translational sweeping), from -1 to 1:
  - o $x = (v * r) * \cos(2\pi * u)$
  - o $y = (v * r) * \sin(2\pi * u)$
  - o $z = -1 + 2*w$
  - o $u \in [0,1]$, $v \in [0,1]$, $w \in [0,1]$

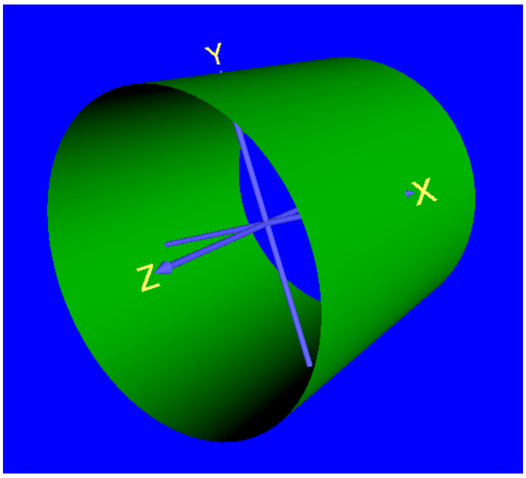
4. Solid Cone



- defines a solid cone
- can be thought of as a set of disks, each smaller in radius than the last, that are stacked on top of each other
- same idea as that of a cylinder, but the radius varies with respect to the growth/extension of the disk stack (cylinder)
- start with a cylinder:
  - $x = (v * r) * \cos(2\pi * u)$
  - $y = (v * r) * \sin(2\pi * u)$
  - $z = -1 + 2 * w$
  - $u \in [0,1]$, $v \in [0,1]$, $w \in [0,1]$
- let r, the radius of the disks, varies with respect to w, the parameter that is responsible for controlling the growth of the disk stack
  - $x = (w * v * r) * \cos(2\pi * u)$
  - $y = (w * v * r) * \sin(2\pi * u)$
  - $z = -1 + 2 * w$
  - $u \in [0,1]$, $v \in [0,1]$, $w \in [0,1]$

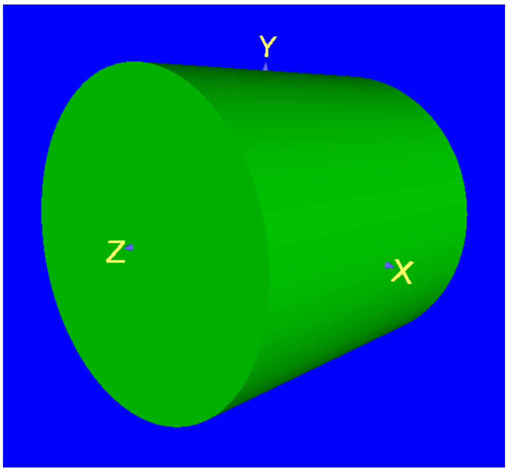
Exercise 5

cylindrical surface:



- 2 parameters: u ∈ [0, 1], v ∈ [0, 1]
- x= cos(2πu)
- y= sin(2πu)
- z= 2v – 1

solid cylinder:



- additional parameter: w ∈ [0, 1]
    - controls growth in radius of circle
- x= w * cos(2πu)
- y= w * sin(2πu)
- z= 2v – 1

Exercise 6

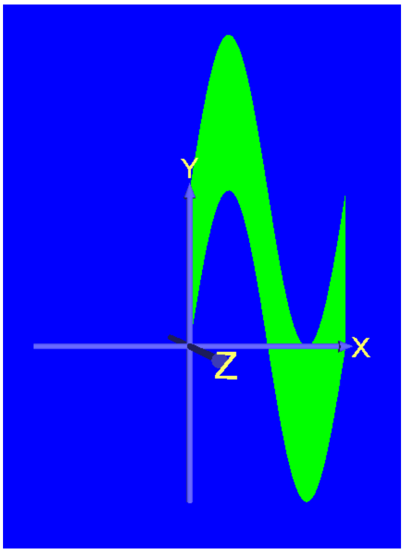
- translational sweeping – refer to cones and cylinders
- rotational sweeping – refer to spheres and ellipsoid

Exercise 7

start with a sine curve:

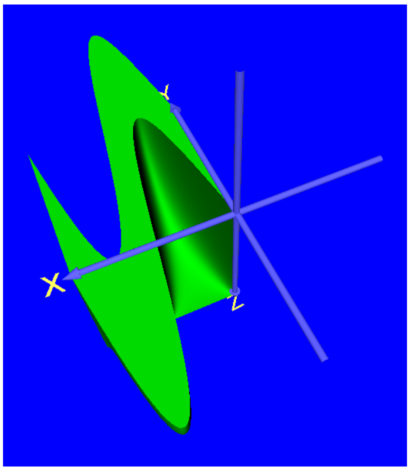
- unable to get it to render
    - not sure of the reason (tried changing resolution and domain of u)
- x = u
- y = sin(2πu)
- z = 0

translational sweeping in y-directional by v units to get a surface:



- x = u
- y = sin(2πu) + v
- z = 0

rotational sweeping about x-axis to get solid:



- rotate by π/2 instead of π to see cross-section
- x = u
- y = (sin(2πu) + v) * cos(π/2 * w)
- z = sin(π/2 * w)

Exercise 8

- refer to the folder “Created_Shapes”

Exercise 9

- refer to this report