CZ2003: Computer Graphics and Visualization

Lab Report 3:

Parametric Solids

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1. Define parametrically using functions $x(u, v, w)$, $y(u, v, w)$, $z(u, v, w)$, $u, v, w \in [0,1]$ in 4 separate files and display:
    a. A solid box with the sides parallel to the coordinate planes and the coordinates of two opposite vertices (N, 0, M), (N+M, M, 2(N+M))).

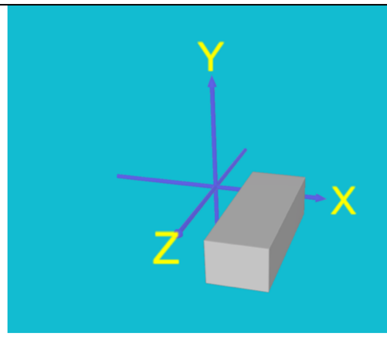


Fig 1.0 Snapshot of "Q1A1.func" which defines a solid box *with parameters [0 1 0 1] and resolution of [75 75 75]*

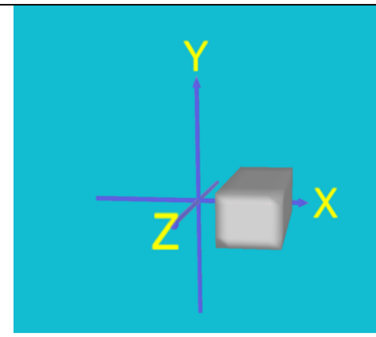


Fig 1.1 Snapshot of "Q1A2.func" which defines a solid box *with parameters [0 1 0 1] and resolution of [5 5 5]*

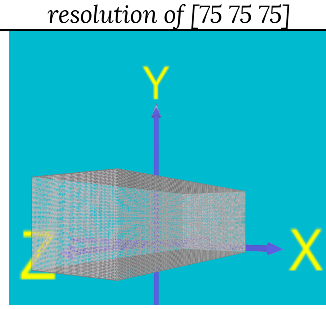


Fig 1.2 Snapshot of "Q1A1.func" when graphic mode is set to "wireframe'.

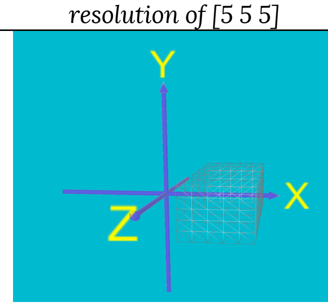


Fig 1.3 Snapshot of "Q1A2.func" when graphic mode is set to "wireframe".

Fig.1s are snapshots of a solid box parallel to the coordinate planes and the coordinates of two opposite vertices (4, 0, 3), (7, 3, 14).

<u>*Parametric Function Definition:*</u>
x = 4 + 3*u
y = 3 * v
z = 3 + 11*w
u, *v*, w∈ [0, 1]

The solid object is first formed by a squared plane which is defined by the parametric equation of
x = 4 + 3*u
y = 3 * v
z = 0
By translating the plane along the z axis and adding an additional parameter w, the final solid object could be obtained.

<u>*Remarks*</u>
The shape of the solid object is not affected by the number of sampling resolution we have. This is because this solid object is constructed using straight lines. However, the sampling resolution will affect the number of lines that are used to form the surface which can be observed by comparing Fig 1.2 and 1.3 when the images are displayed in the wireframe mode.

A resolution of [1, 1, 1] will be sufficient since the box is drawn completely with just one straight line in each axis

b. A solid three-sided pyramid with the vertices of the base with coordinates (0,0,0), (N,0,0), (0,0,M), and the apex at (0,N+M,0)

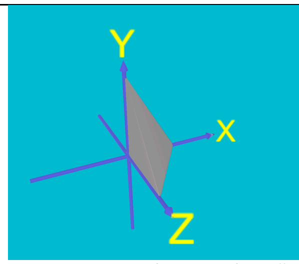
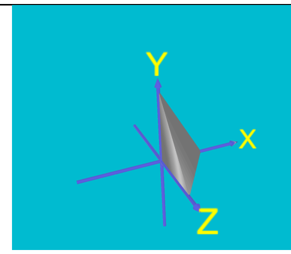
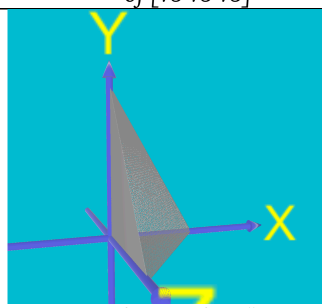
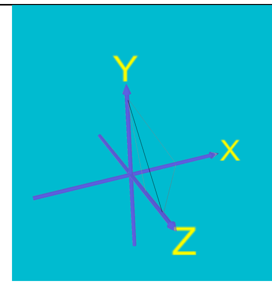
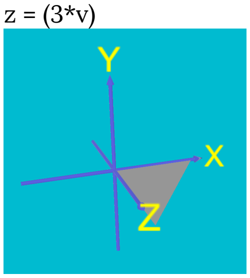
 *Fig 2.0 Snapshot of "Q1B1.func" which defines a three sided pyramid with parameters [0 1 0 1 0 1] and resolution of [75 75 75]*	 *Fig 2.1 Snapshot of "Q1B2.func" which defines a three sided pyramid with parameters [0 1 0 1 0 1] and resolution of [1 1 1]*
 *Fig 2.2 Snapshot of "Q1B1.func" when graphic mode is set to "wireframe"*	 *Fig 2.3 Snapshot of "Q1B2.func" when graphic mode is set to "wireframe"*

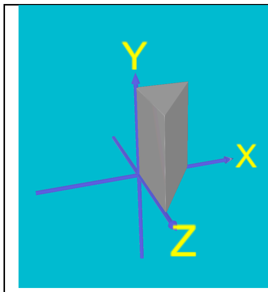
Fig 2s are snapshots defining a three sided pyramid with the vertices of the base with coordinates (0,0,0), (4, 0, 0), (0, 0, 3) and the apex at (0, 7, 0) at different resolutions and graphic viewing modes.

Final Parametric Function Definition:
x =(4*u - 4*u*v)*(1-w)
y = 7*w
z = (3*v)*(1-w)
u, v, w ∈ [0,1]

The three sided pyramid is first created by a triangular plane with the parametric formula:
x =(4*u - 4*u*v)
y = 0
z = (3*v)



The plane is the extended/translated along the y axis



Defined by the parametric equation below:
x =(4*u - 4*u*v)
y = 7*w
z = 3*v
Lastly, by taking another parameter, w and multiply (1-w) to the equation defined by the x and z axis we are able to converge the points to form the final solid shown in the figures above, defined by the final parametric equation.

Remarks
Similarly, in this three-sided pyramid, the sampling resolution does not affect the object because the surface for the solid is constructed by straight lines. A minimum sampling of [1, 1, 1] will be sufficient.

c. A lower half of the origin-centred solid sphere with radius N.

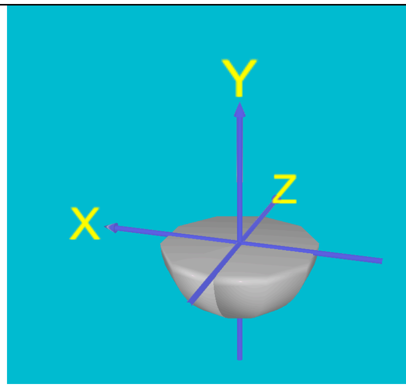


Fig 3.0 Snapshot of "1C1.func" defines a lower half origin-centered solid sphere with parameters [0 1 0 1 0 1] and resolution of [10 10 1]]

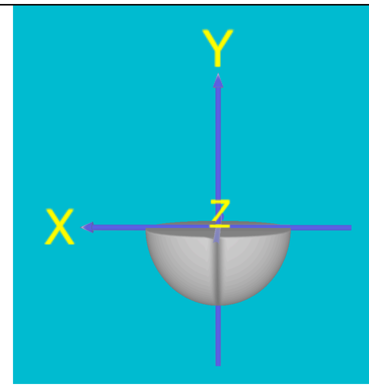


Fig 3.1 Snapshot of "1C2.func" defines a lower half of an origin-centered solid sphere with parameters [0 1 0 1 0 1] and resolution of [40 40 1] of [4 4]

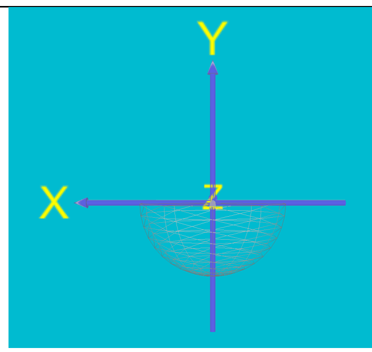


Fig 3.2 Snapshot of "1C1.func" defines an origin-centered solid sphere with graphic mode set to "wireframe"

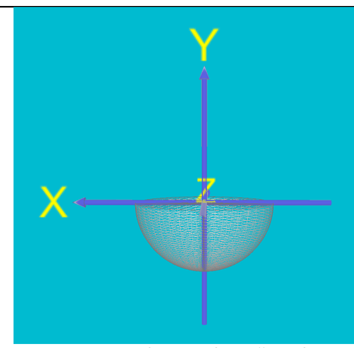


Fig 3.3 Snapshot of "1C2.func" defines origin-centered solid sphere with graphic mode set to "wireframe"

Fig 3 are snapshots of the lower half of origin-centered solid sphere with radius 4 at different resolutions and graphic modes.

<u>*Parametric Function Definition:*</u>
x = 4 * cos((0.5*u-0.5)*pi) * sin((v-0.5)*2*pi)
y = 4 * w * sin((0.5*u-0.5)*pi)
z = 4 * cos((0.5*u-0.5)*pi) * cos((v-0.5)*2*pi)
u, v, w ∈ [0,1]

<u>*Remarks*</u>
The solid object is created by joining multiple straight lines together between the points defined in the formula to form a curved-liked shape. For a curve to be sufficiently approximated to a straight lines, there must be sufficiently larger number of sampling points. The higher the number of samples use, the more accurate and smoother the object will be. The minimum sampling resolution for displaying the lower half of the solid sphere is [40 40 1].

Note that we will also achieve the same results if we were to multiply/include the parameter w into equation x and z.

d. An upper half of the torus which axis is the vertical axis Y. The radius of the torus tube is N/5 . The distance from axis Y to the center of the torus tube is N.

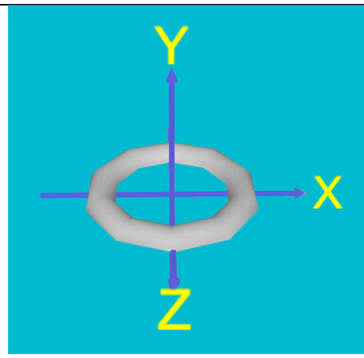


Fig 4.0 Snapshot of "1D1.func" which defines the upper half of the origin centered torus with parameters [0 1 0 1] and resolution of [10 10 10]

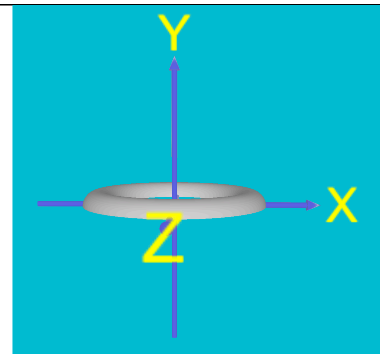


Fig 4.1 Snapshot of "1D2.func" which defines the upper half of the origin centered torus with parameters [0 1 0 1] and resolution of [50 50 50]

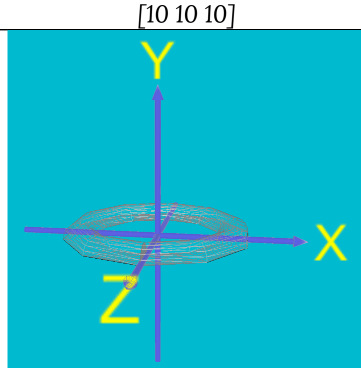


Fig 4.2 Snapshot of "1D1.func" with graphic mode set to "wireframe"

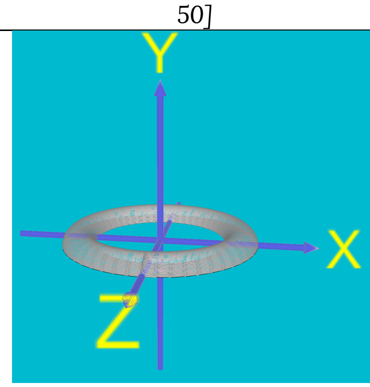


Fig 4.3 Snapshot of "1D2.func" with graphic mode set to "wireframe"

Fig 4s are snapshots of an origin-centered torus with the radius 4 from the center of the torus to the center of the tube and the tube radius 0.8.

<u>Parametric Function Definition:</u>
x = (0.8*cos(pi*u)+4)*(sin(v*2*pi))
y = (0.8*sin(pi*u))*w
z = (0.8*cos(pi*u)+4)*(cos(v*2*pi))
$u, v \in [0,1]$

The torus is first created using a semi-circle with parametric equation
x = (0.8*cos(pi*u)+4)
y = (0.8*sin(pi*u))
Then, rotational sweeping was carried out by rotating along the y axis by a full circle. By multiplying the parameter w to the y equation the solid torus can be created.

<u>Remarks</u>
The higher the sampling resolution, the more accurate and smooth the solid object will be. This is because the object is created by joining multiple straight lines together between the points defined in the formula. The minimum resolution for this object is [50 50 50].

2. Define parametrically using functions $x(u, v, w)$, $y(u, v, w)$, $z(u, v, w)$, $u, v, w \in [0,1]$ a solid object created by translational sweeping of the surface obtained in experiment 2 (exercise 2) along Axis Y so that its lowest point moves from $y = -\boldsymbol{N}$ to $y = \boldsymbol{N} + \boldsymbol{M}$.

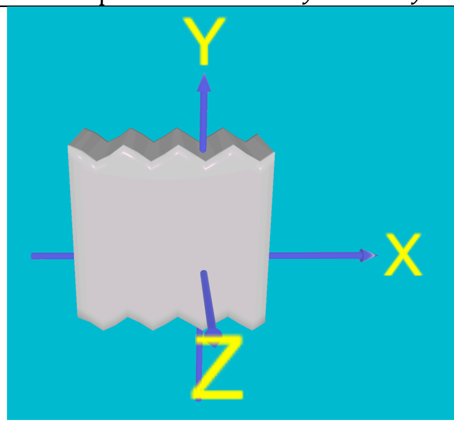


Fig 5.0 Snapshot of "2A.func" which defines a solid object with parameters [0 1 0 1 0 1] and resolution of [15 15 15]

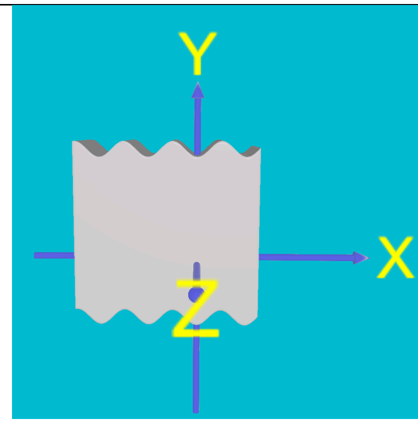


Fig 5.1 Snapshot of "2B.func" which defines a solid object with parameters [0 1 0 1 0 1] and resolution of [75 75 75]

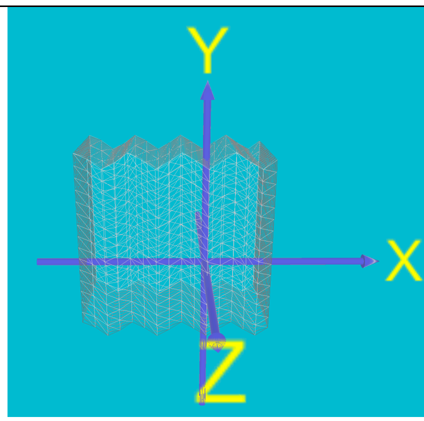


Fig 5.2 Snapshot of "2A.func" which defines a solid object with graphic mode set to "wireframe"

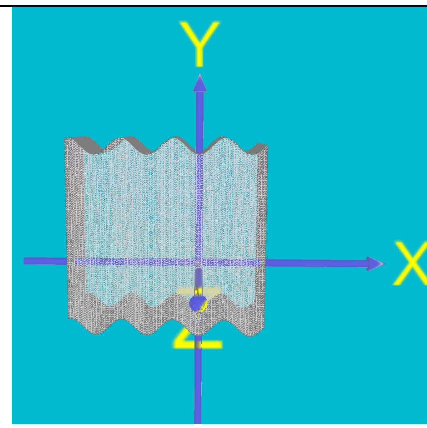


Fig 5.3 Snapshot of "2B.func" which defines a solid object with graphic mode set to "wireframe"

Fig 5 are snapshots for Q2 of a solid object created by translational sweeping of the surface obtained in experiment 2 (exercise 2) along Axis Y so that it spans from $y = -4$ to $y = 7$.

<u>*Parametric Function Definition:*</u>

*x = -8 + (12 * u)*

*y = (sin(u*4*pi))^2 + (11*w-4)*

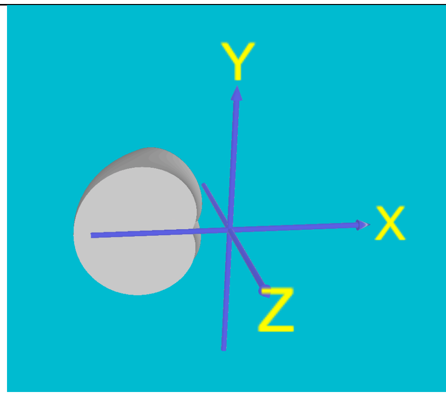
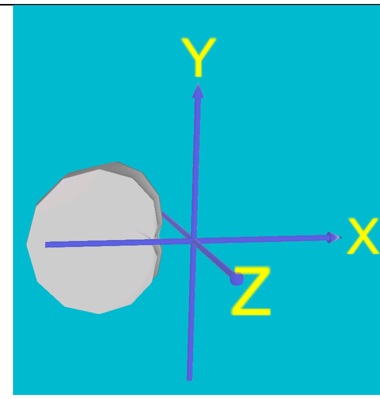
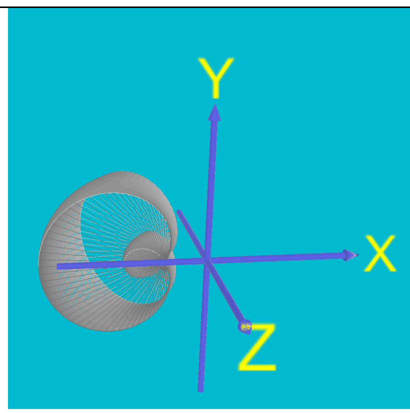
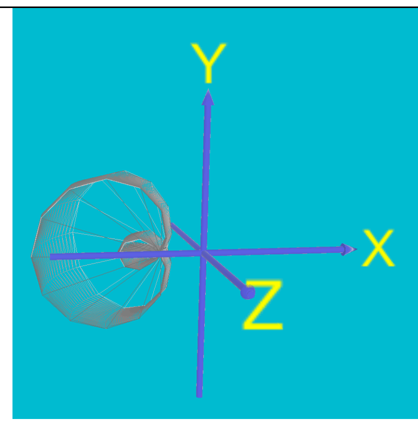
*z = -4 + 7*v*

Compared to Lab 2's equation, we have performed a translational sweep along the y axis from y = -4 to y = 7 by adding (11*w-4) to the y equation

<u>*Remarks:*</u>

A minimum resolution of [60 60 60] could be used for the solid object to be sufficiently smooth. However, I choose a higher resolution of [75 75 75] this is because if we were to observe close enough we can see that the at the apexes of the curve – the highest and lowest point there would still be sharp edges thus I chose a higher resolution the ensure maximum smoothness even at the ends.

3. Define parametrically using functions $x(u, v, w)$, $y(u, v, w)$, $z(u, v, w)$, $u, v, w \in [0,1]$ a solid object created by filling in the surface defined in experiment 2 exercise 3).

 *Fig 6.0 Snapshot of "3A.func" which defines a solid object created by filling in the surface defined in experiment 2 exercise 3) with parameters [0 1 0 1 0 1] and resolution of [100 100 1]*	 *Fig 6.1 Snapshot of "3B.func" which defines a solid object created by filling in the surface defined in experiment 2 exercise 3). with parameters [0 1 0 1 0 1] and resolution of [20 20 1]*
 *Fig 6.2 Snapshot of "3A.func" with graphic mode set to "wireframe"*	 *Fig 6.3 Snapshot of "3B.func" with graphic mode set to "wireframe"*

<u>*Parametric Equation:*</u>

*x =((cos(2*pi*u))*(4*w-8*w*cos(2*pi*u))-4)*sin(0.25*-v*pi+pi/2)*

*y=(sin(2*pi*u))*(4*w-8*w*cos(2*pi*u))*

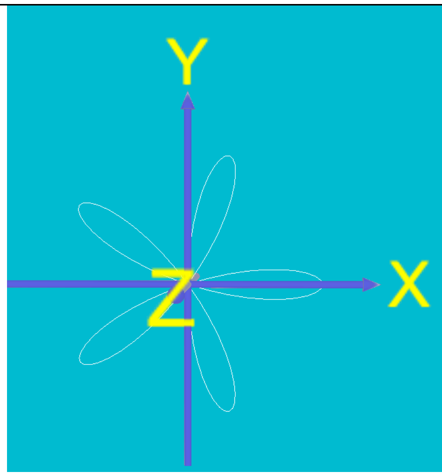
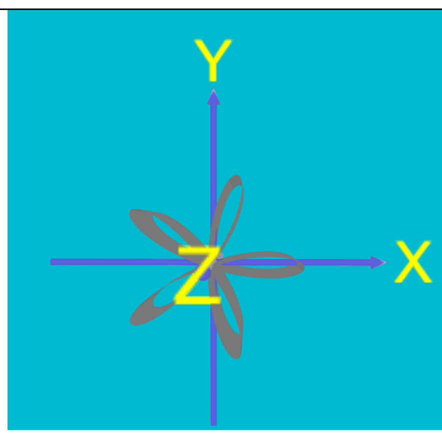
*z=((cos(2*pi*u))*(4*w-8*w*cos(2*pi*u))-4)*cos(0.25*-v*pi+pi/2)*

<u>*Remarks:*</u>

The minimum resolution use to form this solid object is [100 100 1]

4. Besides the above compulsory part, you are welcome to add any other shapes of parametric solids into folder Lab3/Extras. These extra exercises may increase your total mark.

Using Parametric Equations, we are able to make a 5 petaled flower

 *Fig 7.0 Screenshot "Bonus1.func" of an origin-centered 5 petaled flower with a resolution of [200 200 200] and parameter of u∈ [0 1]*	Making use of then concepts learnt from lab 1. A parametric equation of a 2D image of a flower can be derived. The flower is defined by the equation in polar coordinates r = 0.5*cos(5*α) = 0.5cos(5(2 π)) = 0.5 cos(10 πu) $\alpha \in [0,2\pi]$ A circular curve is defined by r = r*cos(2 πu), y = r cos(2 πu), $u \in [0,1]$ *<u>To convert into Parametric Equation:</u>* *Substitute* r = 0.9 cos(10 πu) into the equations: x = 0.5*cos(10*pi*u) * cos(2*pi*u) y = 0.5*cos(10*pi*u) * sin(2*pi*u) z = 0 $u \in [0,1]$
 *Fig 7.1 Screenshot "Bonus2.func" of an origin-centered 5 petaled flower surface with a resolution of [200, 200, 200] and parameter of u, $v \in [0,1]$*	Using the concept of translation sweeping. We can define a surface of the flower by translational sweeping of axis z so that it spans from -0.5 to 1 *<u>Parametric Equation:</u>* x = 0.5*cos(10*pi*u) * cos(2*pi*u) y = 0.5*cos(10*pi*u) * sin(2*pi*u) z = 1.5*v - 0.5 u, $v \in [0,1]$

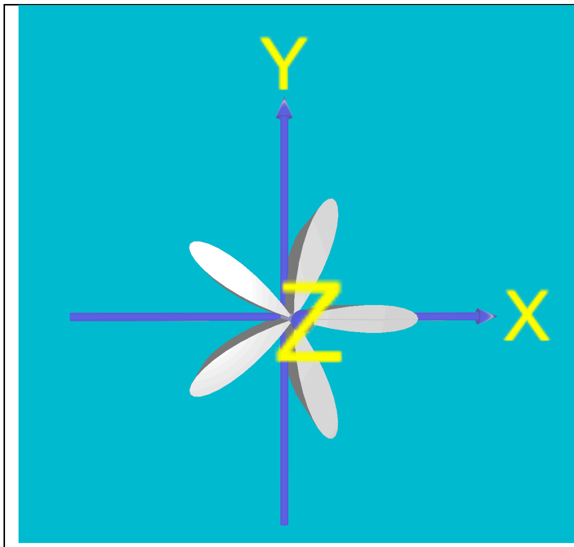


Fig 7.2 Screenshot "Bonus3.func" of an origin-centered 5 petaled flower solid with a resolution of [200, 200, 200] and parameter of u, v, w ∈ [0 1]

By multiplying another parameter, w to all the x, y equation we can achieve a solid flower.

<u>*Parametric Equation:*</u>

x = 0.5*w * cos(10*pi*u) * cos(2*pi*u)
y = 0.5 *w* cos(10*pi*u) * sin(2*pi*u)
z = 1.5*v - 0.5
u, v, w ∈ [0,1]

I also tried to create my favorite food, mookata. '**Mookata**' loosely translates from Thai to mean 'pork' and 'skillet'. It looks like a 'dome-shape hotpot'.

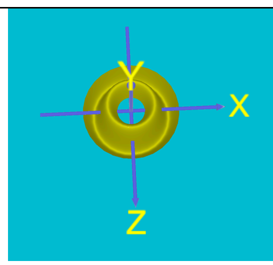


Fig 8.1 Screenshot "Bonus4.func" of a half complete mookata pot with a resolution of [75,75,75] and parameter of u, v, w ∈ [0,1]

Parametric equation:
x = (0.5+1.25*u)*sin(2*pi*v)
y = sin(2*pi*u)
z = (0.5+1.25*u)*cos(2*pi*v)

However, this still doesn't look very much like mookata as it has open ends and lacks a "grill".

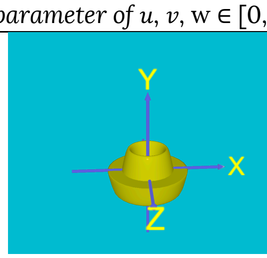


Fig 8.2 Screenshot "Bonus5.func" of a mookata pot with a resolution of [75,75,75] and parameter of u, v, w ∈ [0,1]

x = w*(0.5+1.25*u)*sin(2*pi*v);
y = w*sin(2*pi*u);
z = (0.5+1.25*u)*cos(2*pi*v);

By multiplying parameter w to the x and y equations, we are able to get a grill like plate and a pot in the middle.