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Last two digits of the matric card: 12

Q1a Derive a transformation matrix performing rotation by $\frac{\pi}{2}$ about an axis parallel to axis Y and passing through the point with coordinates (7, 0, 0).

1. Translate axis of rotation to y-axis.

$$\begin{bmatrix} 1 & 0 & 0 & -7 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

2. Rotate around y-axis by $\frac{\pi}{2}$.

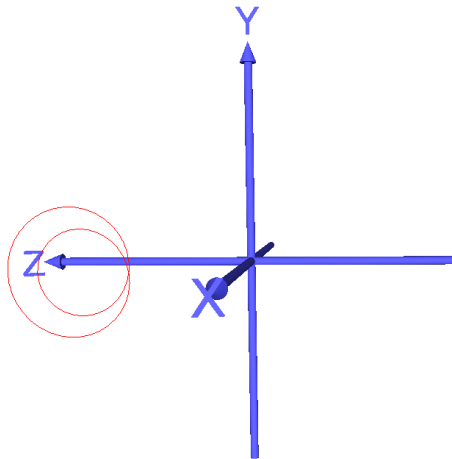
$$\begin{bmatrix} \cos \frac{\pi}{2} & 0 & \sin \frac{\pi}{2} & 0 \\ 0 & 1 & 0 & 0 \\ -\sin \frac{\pi}{2} & 0 & \cos \frac{\pi}{2} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3. Translate axis of rotation back.

$$\begin{bmatrix} 1 & 0 & 0 & 7 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$M = \begin{bmatrix} 1 & 0 & 0 & 7 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos \frac{\pi}{2} & 0 & \sin \frac{\pi}{2} & 0 \\ 0 & 1 & 0 & 0 \\ -\sin \frac{\pi}{2} & 0 & \cos \frac{\pi}{2} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -7 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

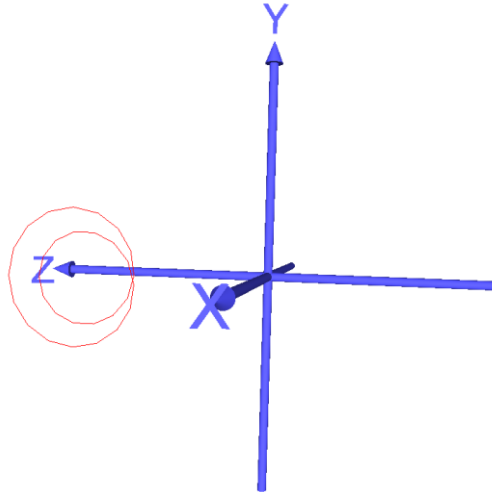
$$= \begin{bmatrix} z + 7 \\ y \\ 7 - x \\ 1 \end{bmatrix}$$

Q1b

$$\begin{aligned} x(u) &= 7 \\ y(u) &= [1 - 7 \cos(2\pi u)] * \sin(2\pi u) \\ z(u) &= 7 - [1 - 7 \cos(2\pi u)] * \cos(2\pi u) \\ u &\in [0, 1] \end{aligned}$$

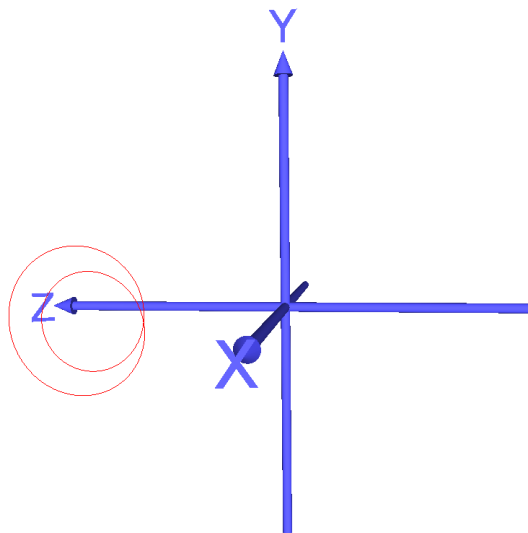
Resolution = [70]

Name of the file: Lab5_Qn1_b.wrl



Name of the file: Lab5_Qn1_b_SmallR.wrl
Resolution = [30]

The sampling resolution is lower at 30. As the resolution is lowered, the curve looks less smooth and more jagged. As the resolution is further lowered, for example to 10, the number of jagged lines that form the curve is 10. Thus, the curve looks less smooth and more “boxy” at a lower resolution as a lower number of jagged lines that form the curve.



Name of the file: Lab5_Qn1_b_BigR.wrl
Resolution = [100]

The sampling resolution is higher at 100. As the resolution is increased, the curve looks more smooth as more jagged lines (100 in this case) form the curve.

Q2

Previous Rotation Matrix:

$$M = \begin{bmatrix} 1 & 0 & 0 & 7 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos \frac{\pi}{2} & 0 & \sin \frac{\pi}{2} & 0 \\ 0 & 1 & 0 & 0 \\ -\sin \frac{\pi}{2} & 0 & \cos \frac{\pi}{2} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -7 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Now:

$$M' = \begin{bmatrix} 1 & 0 & 0 & 7 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos \left(\frac{\pi}{2} v \right) & 0 & \sin \left(\frac{\pi}{2} v \right) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin \left(\frac{\pi}{2} v \right) & 0 & \cos \left(\frac{\pi}{2} v \right) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & -7 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} x(u) \cos \left(\frac{\pi}{2} v \right) + z(u) \sin \left(\frac{\pi}{2} v \right) - 7 \cos \left(\frac{\pi}{2} v \right) + 7 \\ y(u) \\ -x(u) \sin \left(\frac{\pi}{2} v \right) + z(u) \sin \left(\frac{\pi}{2} v \right) + 7 \sin \left(\frac{\pi}{2} v \right) \\ 1 \end{bmatrix}$$

Since $z(u) = 0$ from original equation in Lab 1,

$$M' = \begin{bmatrix} x(u) \cos \left(\frac{\pi}{2} v \right) - 7 \cos \left(\frac{\pi}{2} v \right) + 7 \\ y(u) \\ -x(u) \sin \left(\frac{\pi}{2} v \right) + 7 \sin \left(\frac{\pi}{2} v \right) \\ 1 \end{bmatrix}$$

 v is a variable that changes with t and decelerates over a period of 5s.

$$\Rightarrow v = \sin \left(\frac{\pi}{2} 5t \right)$$

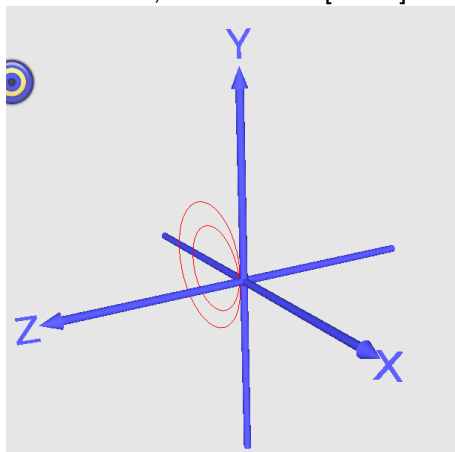
$$x = \{[1 - 7 \cos(2\pi u)] * \cos(2\pi u) - 7\} * \left[\cos \left(\frac{\pi}{2} \sin \left(\frac{\pi}{2} t \right) \right) \right] + 7$$

$$y = [1 - 7 \cos(2\pi u)] * \sin(2\pi u)$$

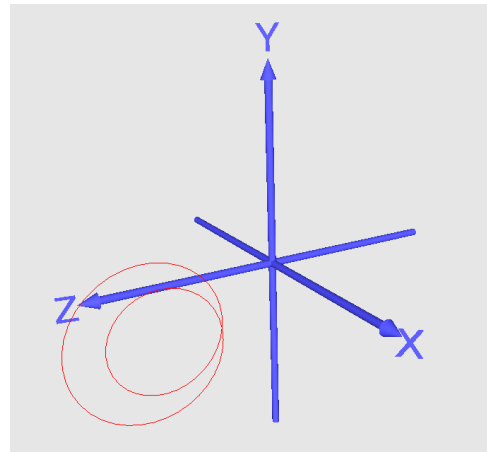
$$z = -\{[1 - 7 \cos(2\pi u)] * \cos(2\pi u) - 7\} * \left[\sin \left(\frac{\pi}{2} \sin \left(\frac{\pi}{2} t \right) \right) \right]$$

$$u, t \in [0, 1]$$

Cycle interval = 5, Resolution = [70 70]

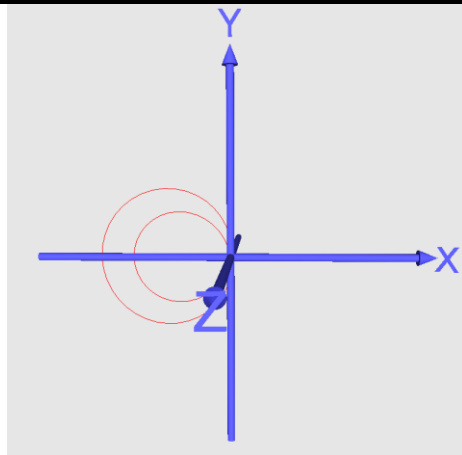


When time = 0s

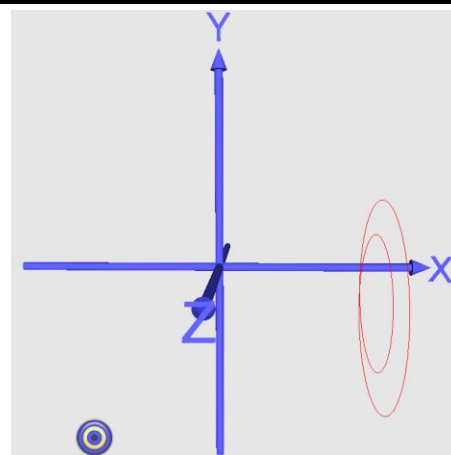


When time = 5s

Screenshots from a different angle:

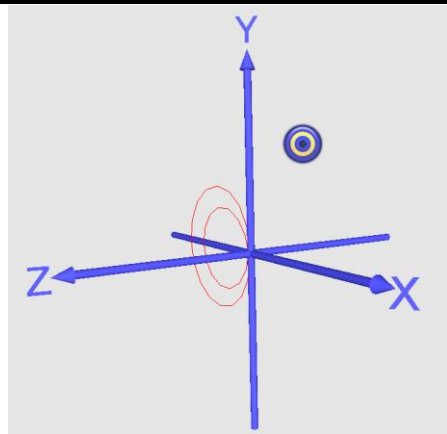


When time = 0s

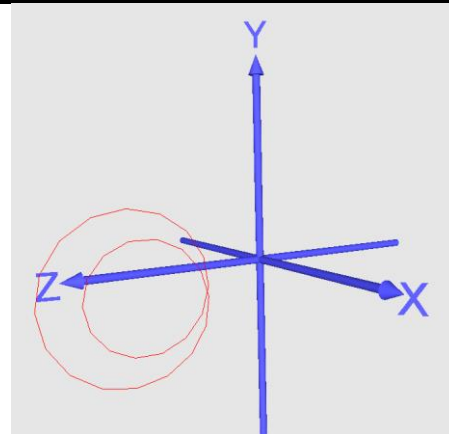


When time = 5s

Name of the file: Lab5_Qn2.wrl



When time = 0s

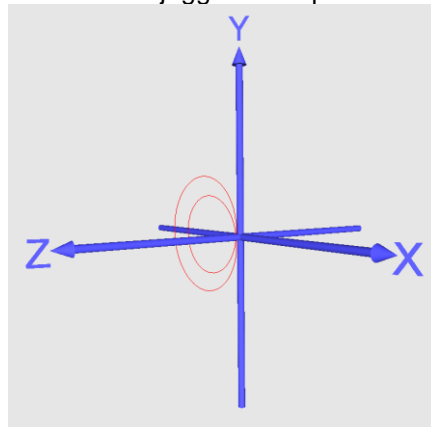


When time = 5s

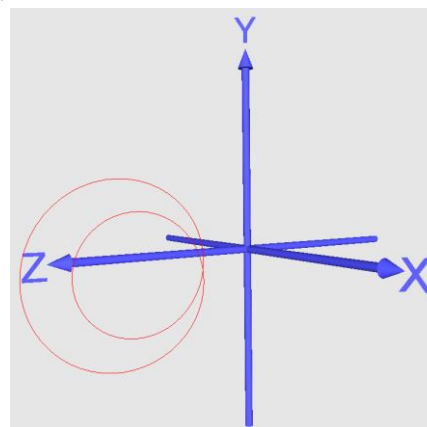
Name of the file: Lab5_Qn2_SmallR.wrl

Resolution = [30 30]

The resolution is lower at 30. The rotation of the curve is the same as with higher resolution, but the curve is more jagged as explained in Question 1b.



When time = 0s



When time = 5s

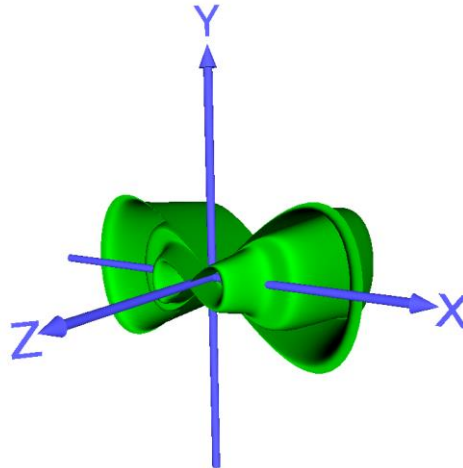
Name of the file: Lab5_Qn2_BigR.wrl

Resolution = [100 100]

The resolution is higher at 100. The rotation of the curve is the same as with lower resolution, but the curve is smoother and less jagged as explained in Question 1b.

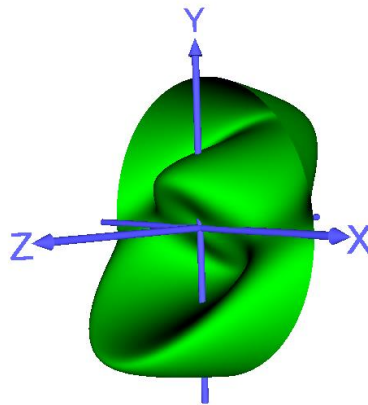
Q3a

Surface M=2:



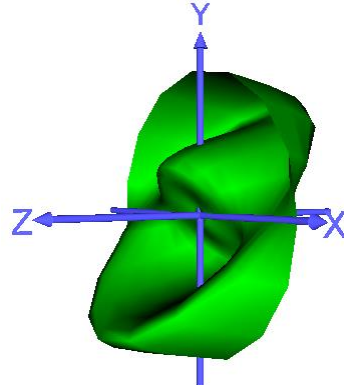
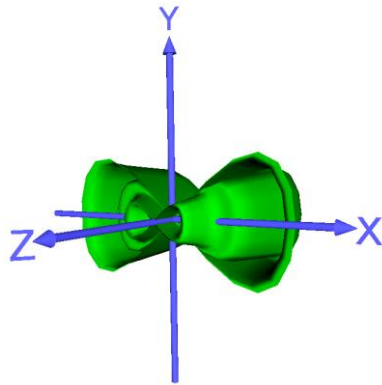
$$\begin{aligned}x &= 1.5u * \cos(2\pi v) \\y &= 1.5u * \sin(2\pi v) * \cos(2\pi v) \\z &= 1.5u * [\sin(2\pi u)]^5 \\u, v &\in [0,1] \\ \text{Resolution} &= [75 \ 75]\end{aligned}$$

Surface N+M = 1+2 = 3:



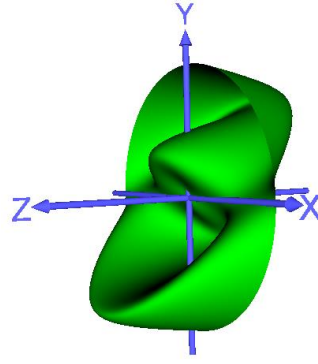
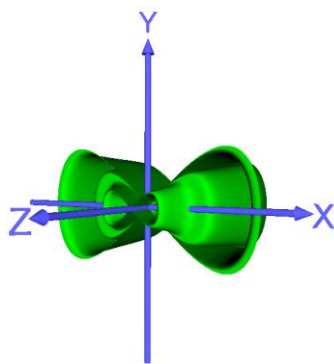
$$\begin{aligned}x &= u\cos(2\pi v) \\y &= u\sin(2\pi v) \\z &= u\sin(2\pi u) * \sin(2\pi v) \\u, v &\in [0,1] \\ \text{Resolution} &= [75 \ 75]\end{aligned}$$

Name of the file: Lab5_Qn3_a_Surface2.wrl, Lab5_Qn3_a_Surface3.wrl



Name of the file: Lab5_Qn3_a_Surface2_SmallR.wrl, Lab5_Qn3_a_Surface3_SmallR.wrl
Resolution = [25 25] Resolution = [15 15]

The surfaces have lower resolution of 25 and 15 respectively. Both appear to be more jagged and less smooth as compared to higher resolutions, because lesser number of surfaces are used to form the entire surface.



Name of the file: Lab5_Qn3_a_Surface2_BigR.wrl, Lab5_Qn3_a_Surface3_BigR.wrl
Resolution = [100 100] Resolution = [100 100]

The surfaces have higher resolution of 100. Both appear to be smoother and less jagged, and the shadows appear more obvious. This is because more number of surfaces are used to form the entire surface and this makes the surface look more even.

Q3b

Equation for x:

$$\begin{aligned}
 x1 &= 1.5u * \cos(2\pi v) \\
 x2 &= u\cos(2\pi v) \\
 x &= x1 + (x2 - x1)[1 - f_{abs}(1 - 2t)] \\
 u, v, t &\in [0,1]
 \end{aligned}$$

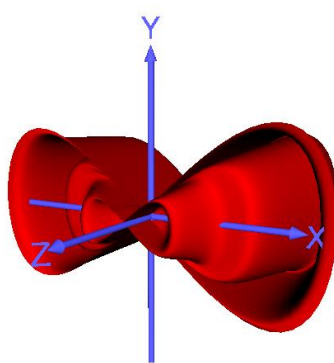
Equation for y:

$$\begin{aligned}
 y1 &= 1.5u * \sin(2\pi v) * \cos(2\pi v) \\
 y2 &= u\sin(2\pi v) \\
 y &= y1 + (y2 - y1)[1 - f_{abs}(1 - 2t)] \\
 u, v, t &\in [0,1]
 \end{aligned}$$

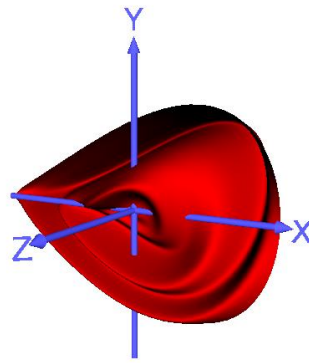
Equation for z:

$$\begin{aligned}
 z1 &= 1.5u * [\sin(2\pi u)]^5 \\
 z2 &= u\sin(2\pi u) * \sin(2\pi v) \\
 z &= z1 + (z2 - z1)[1 - f_{abs}(1 - 2t)] \\
 u, v, t &\in [0,1]
 \end{aligned}$$

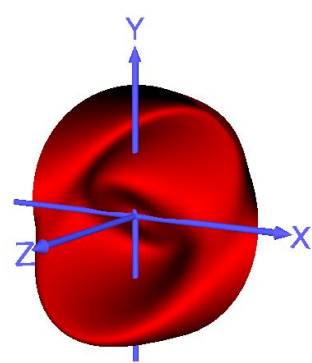
Cycle interval = 5, Resolution = [70 70]



When time = 0s

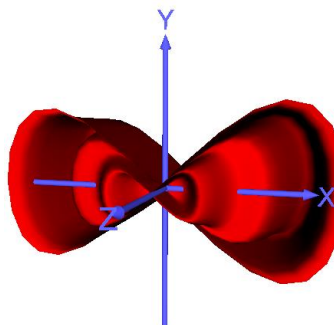


When time = 2.5s

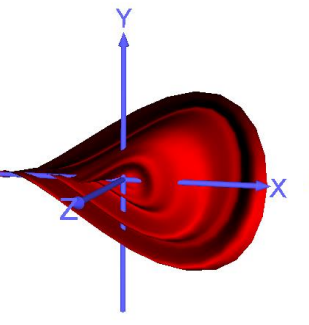


When time = 5s

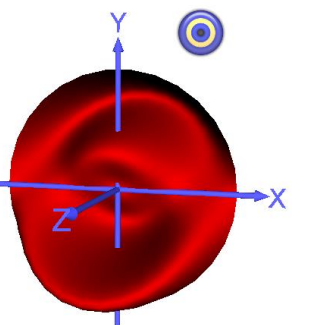
Name of the file: Lab5_Qn3_b.wrl



When time = 0s



When time = 2.5s

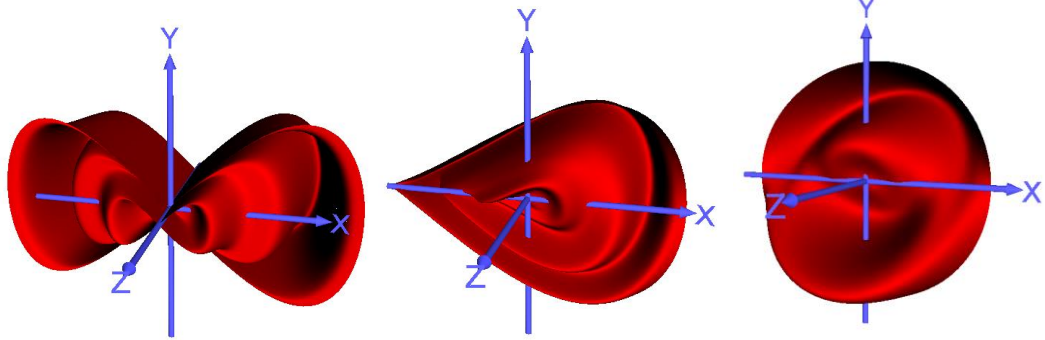


When time = 5s

Name of the file: Lab5_Qn3_b_SmallR.wrl

Resolution = [30 30]

The surface has lower resolution of 30. It appears more jagged and less smooth as compared to higher resolutions, because lesser number of surfaces are used to form the entire surface. The morphing of the surface is the same as higher resolutions.



When time = 0s

When time = 2.5s

When time = 5s

Name of the file: Lab5_Qn3_b_BigR.wrl

Resolution = [100 100]

The surface has higher resolution of 100. It appears smoother and less jagged as compared to lower resolutions, because more surfaces are used to form the entire surface. The morphing of the surface is the same as lower resolutions.