**CZ2003 COMPUTER GRAPHICS & VISUALIZATION**

**EXPERIMENT 2: PARAMETRIC CURVES**

**LAB REPORT**

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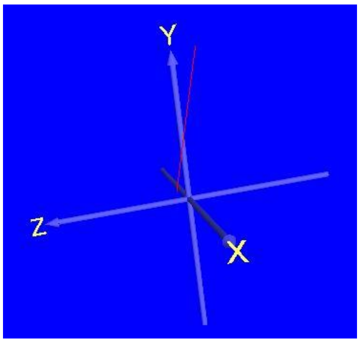
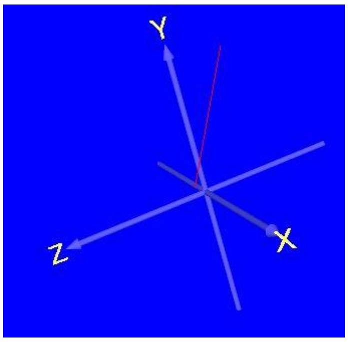
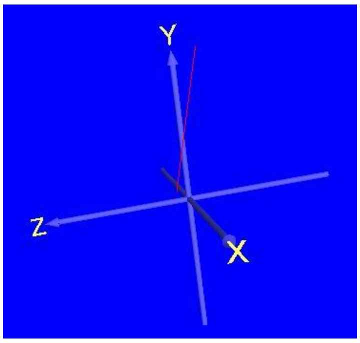
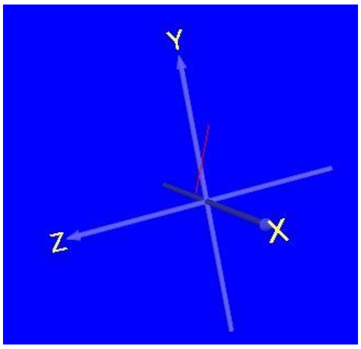
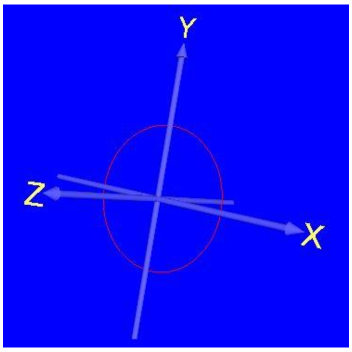
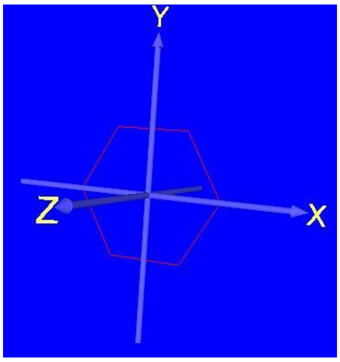
LAB GROUP: SS2

| Curve 1 | Curve 2 | Note |
|---|---|---|
| <br>Above is the snapshot of “straight_line 1.wrl” which defines a straight line by the parametric equations x=0.1 + u, y = 0.1 + u and z = 0.1 which has the starting coordinate (0.1,0.1,0.1). The parameter domain is set to [0,1] and sampling resolution is 100. | <br>Above is the snapshot of “straight_line 1.wrl” which defines a straight line by the parametric equations x=0.1 + u, y = 0.1 + u and z = 0.1 which has the starting coordinate (0.1,0.1,0.1). The parameter domain is set to [0,1] but sampling resolution is changed to 2. | **Note 1:**<br>The sampling resolution for a straight line can be set to as low as a minimum of 1 and the line will have no observable difference because a straight-line segment requires one only a straight-line to create a straight line. |
| <br>Above is the snapshot of “straight_line 1.wrl” which defines a straight line by the parametric equations x=0.1 + u, y = 0.1 + u and z = 0.1 which has the starting coordinate (0.1,0.1,0.1). The parameter domain is set to [0,1] and sampling resolution is 100. | <br>Above is the snapshot of “straight_line 2.wrl” which defines the same line of parametric equations x=0.1 + u, y = 0.1 + u and z = 0.1 which has the starting coordinate (0.1,0.1,0.1). The parameter domain is changed to [0, 0.5] and sampling resolution is 100. | **Note 2:**<br>For a straight-line segment, if we keep the same parametric equations, but change the parameter domain from normalized form of [0,1] to some other domain [0, v], the size of the segment changes in proportion to the original line. For our case, by changing the parameter domain to [0, 0.5] we obtain the same line but with the length of the line exactly half of the first. |



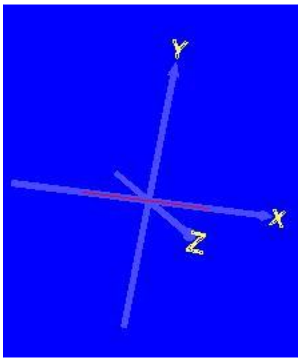

Above is the snapshot of "circle 1.wrl" with the parametric equations x=0.5*cos(2*pi*u), y=0.5*sin(2*pi*u), z=0. It has parameter domain [0,1] and a sampling resolution of 100. This allows us to render a circle of radius 0.5, with no visible edges.



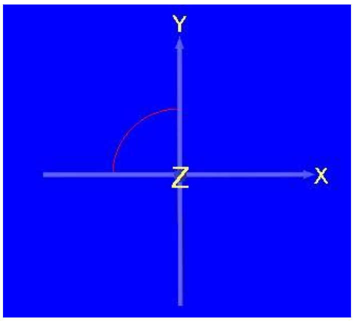

Above is the snapshot of "circle 2.wrl" with the parametric equations x=0.5*cos(2*pi*u), y=0.5*sin(2*pi*u), z=0. It has parameter domain [0,1] and a sampling resolution of 6. This causes the circle to be rendered as a 6-sided polygon as it has only six connected lines.

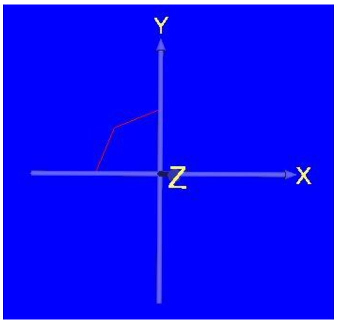
**Note 2:**

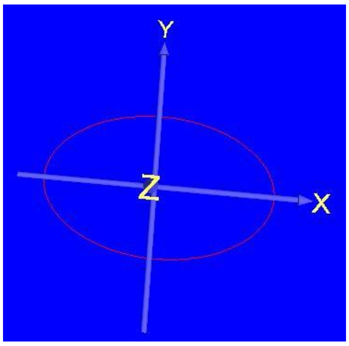
A circle can be thought of as a polygon with infinite number of sides. Therefore, with a lower resolution, the curve rendered has lesser and sharper edges making it look less like a circle. The higher the sampling value, (or resolution), the more edges the curve has, and this causes the curve to take the shape of a circle with no visible edges.

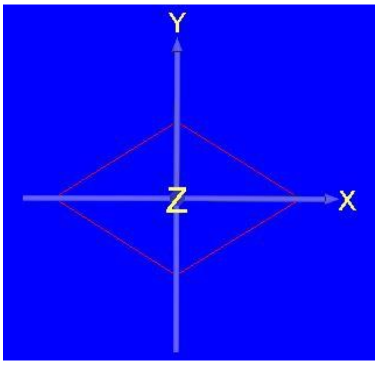



Above is the snapshot of "circle 5.wrl" with the parametric equations x=0.5*cos(2*pi*u), y=0.5*sin(2*pi*u), z=0. It has parameter domain [0,1] and a sampling resolution of 2. As only 2 points are sampled, the circle appears as a straight line.

<table>
<tr>
<td>

Above is the snapshot of “arc1.wrl” which define an arc of angle 90 degrees. The arc has the parametric equations, x=0.5*cos(u*pi/2+pi/2), y=0.5*sin(u*pi/2+pi/2), z=0 with parameter domain [0, 1]. The sampling resolution is set to 100.</td>
<td>

Above is the snapshot of “arc2.wrl” which define an arc of angle 90 degrees. The arc has the parametric equations, x=0.5*cos(u*pi/2+pi/2), y=0.5*sin(u*pi/2+pi/2), z=0 with parameter domain [0, 1]. The sampling resolution is changed to 2 and the arc consists of two sharp lines.</td>
<td>Note 3:<br>If the sampling resolution is 1, then the arc will become a straight line connecting (0, 0.5) and (-0.5,0). Therefore, a higher resolution is required to render an arc with no visible edges. Or the resolution can be manipulated to display a piece of a polygon with edges.</td>
</tr>
<tr>
<td>

Above is the snapshot of “elipse1.wrl” which defines an ellipse with the parametric equations x=0.8*cos(2*u*pi), y=0.5*sin(2*u*pi), z=0 and the parameter domain [0,1]. The curve is rendered with a resolution of 100. The ellipse has a maximum y height of 0.5 and a maximum x width of 0.8 as defined by the scaling of the circle parametric equation to make it an ellipse.</td>
<td>

Above is the snapshot of “elipse2.wrl” which defines an ellipse with the parametric equations x=0.8*cos(2*u*pi), y=0.5*sin(2*u*pi), z=0 and the parameter domain [0,1]. The curve is rendered with a resolution of 4 which causes the ellipse to look like a diamond shape instead of a rounded ellipse.</td>
<td>Note 4:<br>As with the previous circle example, in order to obtain a smooth curve instead of a polygon with edges, the curve must be sampled with a high enough resolution so that edges are not visible. The ellipse parametric equation is obtained by scaling the radius of a circle parametric equation differently for the x and y equations. To make the ellipse grow along the y-axis, we increase the scaling of y and to make the ellipse grow along the x-axis we increase the scaling of x.</td>
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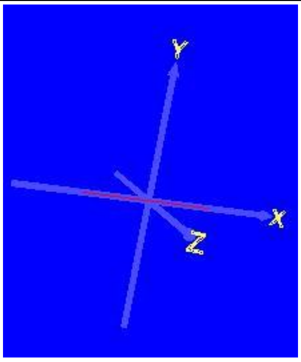
<table>
<tr>
<td colspan="2">

Above is the snapshot of “elipse3.wrl” which defines an ellipse with the parametric equations x=0.8*cos(2*u*pi), y=0.5*sin(2*u*pi), z=0 and the parameter domain [0,1]. The curve is rendered with a resolution of 2 which causes it to take the appearance of a straight line.</td>
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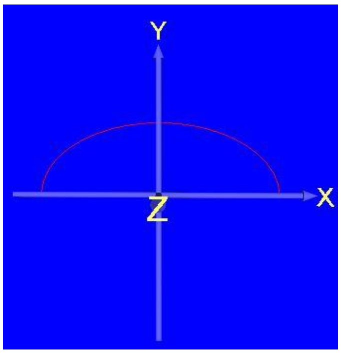
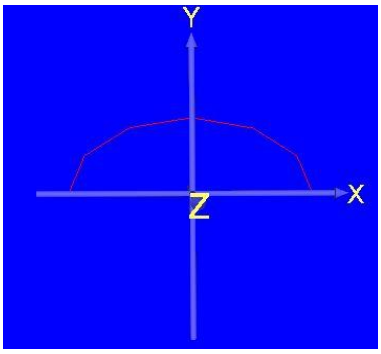
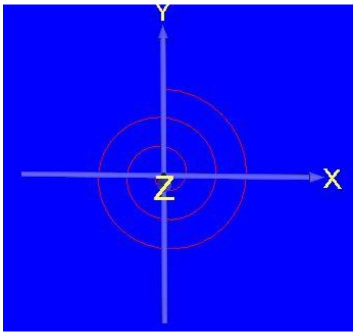
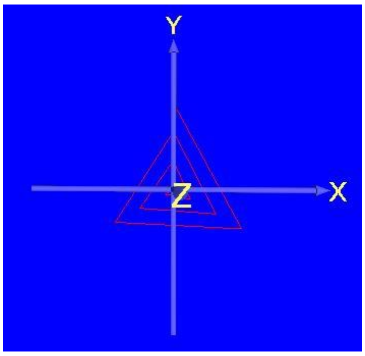
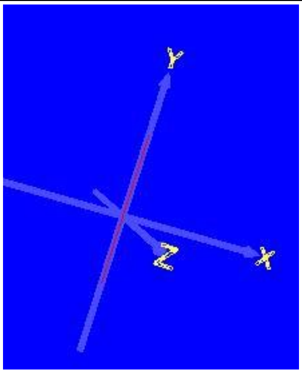
<tr>
<td>

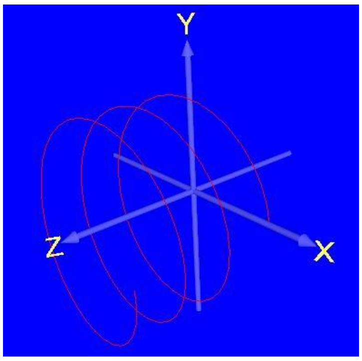
Above is the snapshot of “elipse_arc1.wrl” which defines an elliptical arc with the parametric equations x=0.8*cos(u*pi), y=0.5*sin(u*pi), z=0 and the parameter domain [0,1]. The curve is rendered with a resolution of 100.</td>
<td>

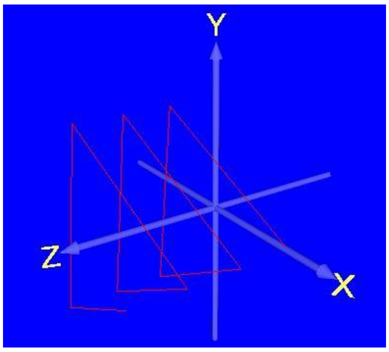
Above is the snapshot of “elipse_arc2.wrl” which defines an elliptical arc with the parametric equations x=0.8*cos(u*pi), y=0.5*sin(u*pi), z=0 and the parameter domain [0,1]. The curve is rendered with a resolution of 6.</td>
<td>Note 5:<br>In order to obtain a smooth curve instead of a polygon with edges, the curve must be sampled with a high enough resolution so that edges are not visible as can be seen from changing the sampling resolution from 6 to 100. The arc is obtained by taking the parametric equation of an ellipse but instead of taking 2*pi*u for a full ellipse, we take v*pi*u for some v lesser than 2 to form an arc instead.</td>
</tr>
<tr>
<td>

Above is the snapshot of “spiral1.wrl” which defines a spiral with the parametric equations x=0.6*u*cos(6*pi*u+pi/2),</td>
<td>

Above is the snapshot of “spiral2.wrl” which defines a spiral with the parametric</td>
<td>Note 6:<br>For a 2D spiral parametric equation of form, x=r*u*cos(b*2*pi*u), y=r*u*sin(b*2*pi*u), to increase the number of rotations of the spiral, simply increase the value of b. b is the amout of rotation the spiral will take. When the sampling resolution is equivalent to 2 times the number of rotations the</td>
</tr>
</table>

<table>
<tr>
<td>y=0.6*u*sin(6*pi*u+pi/2), z=0 and the parameter domain [0,1]. The spiral rotates about the z-axis for 3 full rounds. The sampling resolution is 100.</td>
<td>equations x=0.6*u*cos(6*pi*u+pi/2), y=0.6*u*sin(6*pi*u+pi/2), z=0and the parameter domain [0,1]. The spiral rotates about the z-axis for 3 full rounds as derived from 6pi/2pi = 3. The sampling resolution is 9.</td>
<td rowspan="2">spiral forms, a straight line is formed as the sampling is created along the y-axis.</td>
</tr>
<tr>
<td colspan="2">

Above is the snapshot of “spiral6.wrl” which defines a spiral with the parametric equations x=0.6*u*cos(6*pi*u+pi/2), y=0.6*u*sin(6*pi*u+pi/2), z=0and the parameter domain [0,1]. The spiral rotates about the z-axis for 3 full rounds as derived from 6pi/2pi = 3. The sampling resolution is 6 which causes the spiral to be a straight line as it is sampled along the y-axis.</td>
</tr>
<tr>
<td>

Above is the snapshot of “Helix1.wrl” which defines a spiral with the parametric equations<br>x = 0.7*cos(6*pi*u),<br>y=0.7*sin(6*pi*u),</td>
<td>

Above is the snapshot of “Helix2.wrl” which defines a spiral with the parametric equations<br>x = 0.7*cos(6*pi*u),</td>
<td>Note 6:<br>For a 3D helix parametric equation of form, x=r*cos(b*2*pi*u), y=r*sin(b*2*pi*u), z=u, to increase the number of rotations of the spiral, simply increase the value of b. b is the amout of rotation the spiral will take. When the sampling resolution is equivalent to 2 times the number of rotations, it will create a zig zag line on x and z axis. This is because it will create sampling along</td>
</tr>
</table>

| | | |
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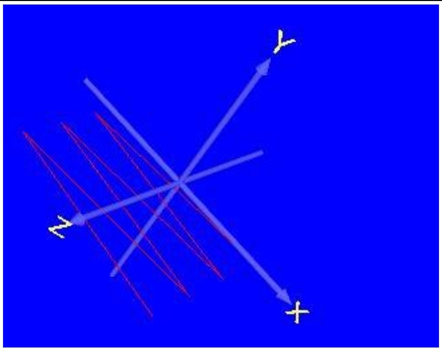
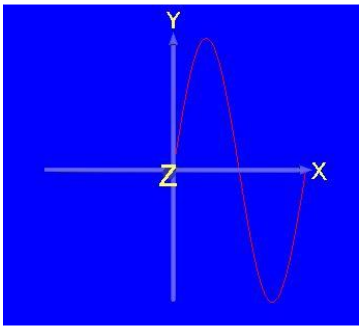
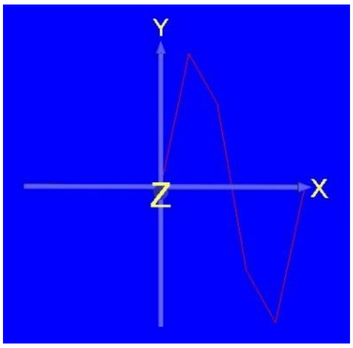
| z=u, and the parameter domain [0,1]. The sampling resolution is 100. The helix rotates 3 full rounds while moving forward in the z-axis direction. | y=0.7*sin(6*pi*u), z=u, and the parameter domain [0,1]. The sampling resolution is 9. The helix rotates 3 full rounds while moving forward in the z-axis direction. | the x and y axis in this example. |
|   Above is the snapshot of “Helix5.wrl” which defines a spiral with the parametric equations x = 0.7*cos(6*pi*u), y=0.7*sin(6*pi*u), z=u, and the parameter domain [0,1]. The sampling resolution is 6 which causes a zig-zag line to be form along the x and z axis. | | |

## Convert the explicitly defined curve y=sin(x) to parametric representation x(u), y(u) and define it in FVRML file

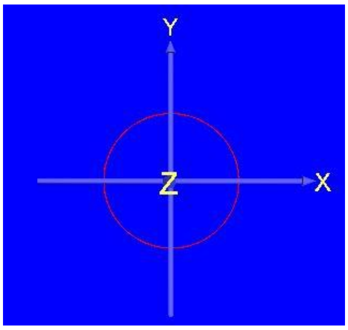
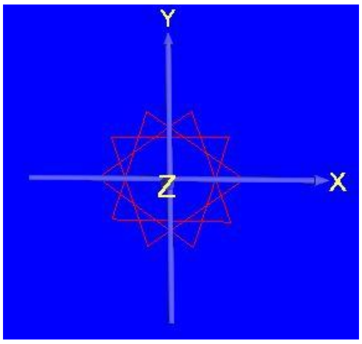
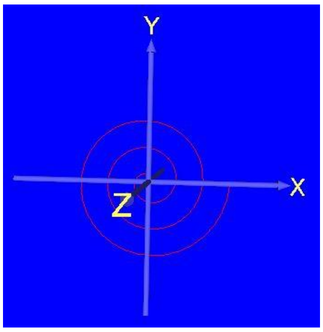
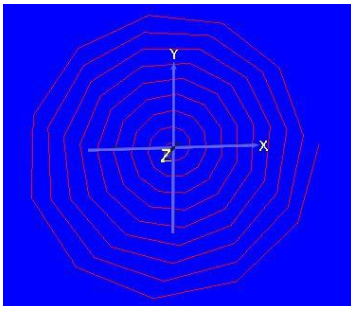
y=sin(x)

let x = u where domain of u is [0,1]

Therefore, y = sin(2*pi*u)

| | | |
|---|---|---|
| <br>Above is the snapshot of "sine1.wrl" which defines a sine wave with the parametric equations<br>x = u, y=sin(2*pi*u),<br>z=0, and the parameter domain [0,1]. The sampling resolution is 100. | <br>Above is the snapshot of "sine2.wrl" which defines a sine wave with the parametric equations<br>x = u, y=sin(2*pi*u),<br>z=0, and the parameter domain [0,1]. The sampling resolution is 5. | **Note 7:**<br>When the sampling resolution is less than 100, fewer straight lines are joined together between the points along the curve, in the formula, resulting in a less smooth curve with visible edges. |

## Changing the curves parameter domain

| | | |
|---|---|---|
| <br>Above is the snapshot of "Circle 3.wrl" which defines a circle with the parametric equations x=0.5*cos(2*pi*u), y=0.5*sin(2*pi*u), z=0 and the parameter domain [0,6]. The sampling resolution is 200. The program will take 200 samples along the 6 rotations of the circle which gives it a smooth circle rendering at the end. | <br>Above is the snapshot of "Circle 4.wrl" which defines a circle with the parametric equations x=0.5*cos(2*pi*u), y=0.5*sin(2*pi*u), z=0 and the parameter domain [0,6]. The sampling resolution is 20. The program will take 20 samples along the 6 rotations of the circle which gives it an interesting polygon shape symertical about the y-axis. | **Note 8:**<br>When the parameter is increased for a circle parametric equation, the circle rotates for more rounds and more sampling points are needed to ensure that there are enough sampling points per revolution to make a smooth circle with no visible edges. |
| <br>Above is the snapshot of "spiral3.wrl" which defines a spiral with the parametric equations x=0.6*u*cos(6*pi*u), y=0.6*u*sin(6*pi*u), z=0 and the parameter domain [0,1]. The spiral rotates about the z-axis for 3 full | <br>Above is the snapshot of "spiral4.wrl" which defines a spiral with the parametric equations x=0.6*u*cos(6*pi*u), y=0.6*u*sin(6*pi*u), z=0 and the parameter domain [0,3]. The spiral rotates about the z-axis for 9 full rounds. The sampling | **Note 9:**<br>As the parameter domain increases, the number of rotations is elongated. When the spiral is elongated, the resolution sampling has to be increased as well to compensate for the increase in parameter domain, so as to generate a smooth curve. Curve 3 shows the 2D spiral with parameter domain [0,3] and sampling resolution of 300. |

| | | |
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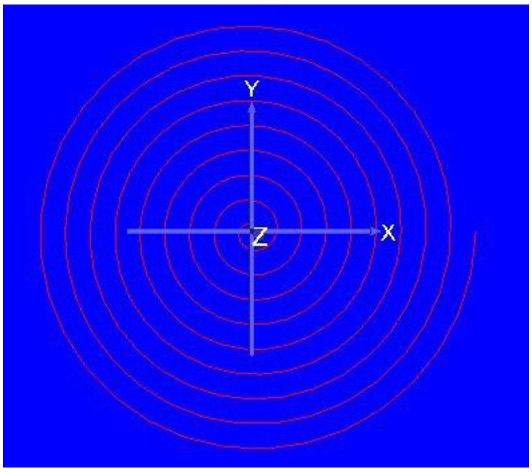
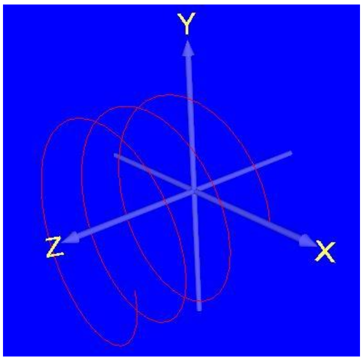
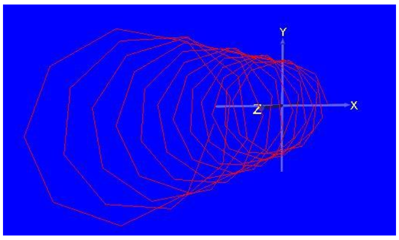
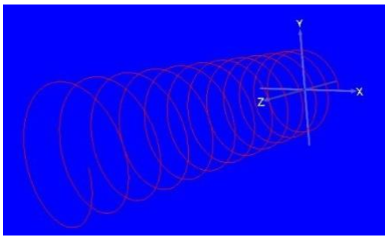
| rounds. The sampling resolution is 100. | resolution is 100. | |

| **Curve 3** |
|---|
|  |

<table>
<tr><th>Curve 1</th><th>Curve 2</th><th>Curve 3</th></tr>
<tr>
<td>

Above is the snapshot of “Helix1.wrl” which defines a spiral with the parametric equations<br>x = 0.7*cos(6*pi*u),<br>y=0.7*sin(6*pi*u),<br>z=u, and the parameter domain [0,1]. The sampling resolution is 100. The helix rotates 3 full rounds while moving forward in the z-axis direction.</td>
<td>

Above is the snapshot of “Helix3.wrl” which defines a spiral with the parametric equations<br>x = 0.7*cos(6*pi*u),<br>y=0.7*sin(6*pi*u),<br>z=u, and the parameter domain [0,4]. The sampling resolution is 100. The helix rotates 12 full rounds while moving forward in the z-axis direction. This causes a non-circular helix to be formed.</td>
<td>

Above is the snapshot of “Helix4.wrl” which defines a spiral with the parametric equations<br>x = 0.7*cos(6*pi*u),<br>y=0.7*sin(6*pi*u),<br>z=u, and the parameter domain [0,4]. The sampling resolution is 400. The helix rotates 12 full rounds while moving forward in the z-axis direction. There are enough sampling points per revolution which causes a circular helix to be rendered.</td>
</tr>
<tr><td colspan="3">Notes:<br>As the parameter domain increases, the helix becomes longer and the number of rotations is elongated (see transformation from Curve 1 to Curve 2). When the helix is elongated, the sampling has to be increased as well to compensate for the increase in parameter domain, so as to generate a smooth curve instead of a curve with visible edges. Curve 3 shows the 3D helix with parameter domain [0,4] and sampling resolution of 400.</td></tr>
</table>