

CZ2003

Computer Graphics and Visualization

Lab 2 Report: Parametric Curves

SSR2

U1821610C

Liew Zhi Li (Sherna)

Contents

[Exercise 1 - Straight Line Segment 2](#_Toc24789513)

[Exercise 2 – Circle 3](#_Toc24789514)

[Exercise 3 - Circle Arc 7](#_Toc24789515)

[Exercise 4 – Ellipse 9](#_Toc24789516)

[Exercise 5 – Ellipse Arc 10](#_Toc24789517)

[Exercise 6 – 2D Spiral 11](#_Toc24789518)

[Exercise 7 – 3D Helix 13](#_Toc24789519)

[Exercise 8 – Sine Curve 16](#_Toc24789520)

[Exercise 9 – Extras 17](#_Toc24789521)

# Exercise 1 - Straight Line Segment

Define parametrically in different files: Straight line segment.

Variable t is time. By default, it is from 0 to 1 which maps to 1 second. We can multiply by t in the equation to show the animation of how the curve changes from t=0 to t=1. If we do not want to show animation and just want static image, then we don’t need to multiply by t.

|  |  |
| --- | --- |
| **Snapshot** | **Notes** |
| Straight Line Segment | The curve in file “1.1-straightLineSegment.wrl” is a straight line segment defined by parametric equations  x=u;  y=u;  z=0;  The parameter domain is and we can see that the straight line segments starts from the origin and extends upwards diagonally.  The sampling resolution is 100. |
| Straight Line Segment | The curve in file “1.2-straightLineSegment.wrl” is a straight line segment defined by the same parametric equations  x=u;  y=u;  z=0;  We change the parameter domain to and we can see that the straight line segment extends downwards beyond diagonally.  The sampling resolution is 100. |
| Straight Line Segment | The curve in file “1.3-straightLineSegment.wrl” is a straight line segment defined by by the same parametric equations  x=u;  y=u;  z=0;  The parameter domain is .  We change the sampling resolution to 2 and we can see that it remains the same. |

# Exercise 2 – Circle

Define parametrically in different files: Circle.

|  |  |
| --- | --- |
| **Snapshot** | **Notes** |
| Circle | The curve in file “2.1-circle.wrl” is a circle defined by parametric equations  x=1\*cos(2\*pi\*u);  y=1\*sin(2\*pi\*u);  z=0;  The parameter domain is and we can see that the circle starts from 0 to .  The sampling resolution is 100 which means that the domain is subdivided to sample 100 points and connected with straight line segments. This results in a smooth curvature shape which resembles a circle.  Open the file to see the animation. |
| Triangle | The curve in file “2.2-circle.wrl” is defined by the same parametric equations  x=1\*cos(2\*pi\*u);  y=1\*sin(2\*pi\*u);  z=0;  The parameter domain is but we change the sampling resolution to 3 and we can see that the circle transformed into a triangle.  The circle turned into a triangle because the domain is subdivided to sample 3 points and connected with straight line segments.  The sampling values for are  By subbing in the values for into the equations, we get the points , ,, which will be connected with straight line segments to form the triangle as shown.  Open the file to see the animation. |

|  |  |
| --- | --- |
| Square | The curve in file “2.3-circle.wrl” is defined by the same parametric equations  x=1\*cos(2\*pi\*u);  y=1\*sin(2\*pi\*u);  z=0;  The parameter domain is but we change the sampling resolution to 4 and we can see that the circle transformed into a square.  The circle turned into a square because the domain is subdivided to sample 4 points and connected with straight line segments.  The sampling values for are  By subbing in the values for into the equations, we get the points , , , , which will be connected with straight line segments to form the square as shown.  Open the file to see the animation. |
| Pentagon | The curve in file “2.4-circle.wrl” is defined by the same parametric equations  x=1\*cos(2\*pi\*u);  y=1\*sin(2\*pi\*u);  z=0;  The parameter domain is and we change the sampling resolution to 5 and we can see that the circle transformed into a pentagon.  The circle turned into a pentagon because the domain is subdivided to sample 5 points and connected with straight line segments.  The sampling values for are  By subbing in the values for into the equations, we get the points , ,which will be connected with straight line segments to form the pentagon as shown.  Open the file to see the animation. |
| Decagon | The curve in file “2.5-circle.wrl” is defined by the same parametric equations  x=1\*cos(2\*pi\*u);  y=1\*sin(2\*pi\*u);  z=0;  We change the parameter domain to and sampling resolution is 100 and we can see that the original circle transformed into a decagon.  The circle turned into a decagon because the domain 10 is subdivided to sample 100 points and connected with straight line segments.  Alternatively, we can create a decagon using domain and sampling resolution is 10. The domain 1 is subdivided to sample 10 points and connected with straight line segments. Refer to curve in “2.5-circle-alternative”.  Open the file to see the animation. |
| Circle | The curve in file “2.6-circle.wrl” is a circle defined by the same parametric equations  x=1\*cos(2\*pi\*u);  y=1\*sin(2\*pi\*u);  z=0;  The parameter domain remains at  We change the sampling resolution to 1000 and we can see that the decagon transforms into a circle again.  This is because we increased the sampling resolution to 1000, which means the domain is subdivided to sample 1000 points and connected with straight line segments. With this many points, it results in a smooth curve that resembles a circle.  Open the file to see the animation. |

|  |  |
| --- | --- |
| Star | The curve in file “2.7-circle.wrl” is defined by the same parametric equations  x=1\*cos(4\*pi\*u);  y=1\*sin(4\*pi\*u);  z=0;  The parameter domain is and we change the sampling resolution to 5. We can see that the original circle transformed into a star.  The circle turned into a star because the domain 1 is subdivided to sample 5 points and connected with straight line segments.  The sampling values for are  By subbing in the values for into the equations, we get the points ,, , which will be connected with straight line segments to form the star as shown.  Alternatively, you can also draw a star using  x=1\*cos(2\*pi\*u);  y=1\*sin(2\*pi\*u);  z=0;  With parameter domain and sampling resolution 5. Refer to curve in file “2.7-circle-alternative”.  Open the file to see the animation. |
| Straight Line Segment | The curve in file “2.8-circle.wrl” is defined by the same parametric equations  x=1\*cos(2\*pi\*u);  y=1\*sin(2\*pi\*u);  z=0;  The parameter domain is but we change the sampling resolution to 2.  The sampling values for u are . This corresponds to , , and respectively. So it draws a straight line segment from (1,0,0) to (-1,0,0), and (-1,0,0) to (1,0,0,).  The circle changes into a straight line segment that lies along the x-axis. We need to toggle to wireframe view in order to be able to see it.  Open the file to see the animation. |

# Exercise 3 - Circle Arc

Define parametrically in different files: Circle Arc.

|  |  |
| --- | --- |
| **Snapshot** | **Notes** |
| Circle Arc | The curve in file “3.1-circleArc.wrl” is a circle arc defined by parametric equations  x=1\*cos(2\*pi\*(u/4));  y=1\*sin(2\*pi\*(u/4));  z=0;  The parameter domain is  The sampling resolution is 100.  The arc draws counter-clockwise from the positive x-axis.  The reason the arc is in the first quadrant is because we we specify 2\*pi\*u/4.  Open the file to see the animation. |
| Semicircle Arc | The curve in file “3.2-circleArc.wrl” is a semicircle arc defined by parametric equations  x=1\*cos(2\*pi\*(u/2));  y=1\*sin(2\*pi\*(u/2));  z=0;  The parameter domain remains at  The sampling resolution remains at 100.  The arc draws counter-clockwise from the positive x-axis.  Open the file to see the animation. |
| Circle | The curve in file “3.3-circleArc.wrl” is a circle defined by parametric equations  x=1\*cos(2\*pi\*(u/2));  y=1\*sin(2\*pi\*(u/2));  z=0;  We change the parameter domain to and we can see it is a circle again.    The sampling resolution remains at 100.  Open the file to see the animation. |

|  |  |
| --- | --- |
| Pentagon | The curve in file “3.4-circleArc.wrl” is a pentagon defined by parametric equations  x=1\*cos(2\*pi\*(u/2));  y=1\*sin(2\*pi\*(u/2));  z=0;  We change the parameter domain to and sampling resolution to 5 and the arc transforms into a pentagon.  Open the file to see the animation. |
| Roof-like line | The curve in file “3.5-circleArc.wrl” is a straight line segment defined by parametric equations  x=1\*cos(2\*pi\*(u/2));  y=1\*sin(2\*pi\*(u/2));  z=0;  We change the parameter domain back to and we change the sampling resolution to 2.  The sampling values for u are . This corresponds to and and respectively. So it draws a straight line segment from to , and to .  The original semicircle arc changes into the roof-like line as shown.  Open the file to see the animation. |

# Exercise 4 – Ellipse

Define parametrically in different files: Ellipse.

|  |  |
| --- | --- |
| **Snapshot** | **Notes** |
| Ellipse | The curve in file “4.1-ellipse.wrl” is an ellipse defined by parametric equations  x=1\*cos(2\*pi\*u);  y=0.5\*sin(2\*pi\*u);  z=0;  The parameter domain is  The sampling resolution is 100. Open the file to see the animation. |
| Triangle | The curve in file “4.2-ellipse.wrl” is a triangle defined by parametric equations  x=1\*cos(2\*pi\*u);  y=0.5\*sin(2\*pi\*u);  z=0;  The parameter domain remains at but we change the sampling resolution to 3.  The ellipse turned into a triangle because only 3 points in the sample space is used to draw the ellipse. Open the file to see the animation. |
| Diamond | The curve in file “4.3-ellipse.wrl” is a diamond defined by parametric equations  x=1\*cos(2\*pi\*u);  y=0.5\*sin(2\*pi\*u);  z=0;  The parameter domain remains at but we change the sampling resolution to 4.  The ellipse turned into a diamond shape because only 4 points in the sample space is used to draw the ellipse. Open the file to see the animation. |
| Straight Line Segment | The curve in file “4.4-ellipse.wrl” is a straight line segment defined by parametric equations  x=1\*cos(2\*pi\*u);  y=0.5\*sin(2\*pi\*u);  z=0;  The parameter domain is but we change the sampling resolution to 2.  The ellipse changes into a straight line segment that lies along the x-axis. Open the file to see the animation. |

# Exercise 5 – Ellipse Arc

Define parametrically in different files: Ellipse Arc.

|  |  |
| --- | --- |
| **Snapshot** | **Notes** |
| Ellipse Arc | The curve in file “5.1-ellipse.wrl” is an ellipse arc defined by parametric equations  x=1\*cos(2\*pi\*(u/4));  y=0.5\*sin(2\*pi\*(u/4));  z=0;  The parameter domain is  The sampling resolution is 100.  Open the file to see the animation. |
| Ellipse Arc | The curve in file “5.2-ellipse.wrl” is an ellipse arc defined by parametric equations  x=-1\*cos(2\*pi\*(u/4));  y=-0.5\*sin(2\*pi\*(u/4));  z=0;  The parameter domain is  The sampling resolution is 100.  The arc starts drawing from the negative x-axis going counter-clockwise towards negative y-axis.  Open the file to see the animation. |
| Ellipse Arc | The curve in file “5.3-ellipse.wrl” is an ellipse arc defined by parametric equations  x=-1\*cos(2\*pi\*(u/4));  y=-0.5\*sin(2\*pi\*(u/4));  z=0;  The parameter domain is  The sampling resolution is 2.  The sampling values for are  By subbing in the values for into the equation, we get the points (-1,0,0) and (,,0) and (0,-0.5,0) which will be connected with straight line segments to get the shape as shown.  Open the file to see the animation. |

# Exercise 6 – 2D Spiral

Define parametrically in different files: 2D Spiral.

|  |  |
| --- | --- |
| **Snapshot** | **Notes** |
| 2D Spiral | The curve in file “6.1-2Dspiral.wrl” is spiral defined by parametric equations  x=u\*cos(10\*pi\*u);  y=u\*sin(10\*pi\*u);  z=0;  The parameter domain is  The sampling resolution is 500.  The spiral has 5 oscillations.  Open the file to see the animation. |
| 2D Spiral | The curve in file “6.2-2Dspiral.wrl” is a spiral defined by parametric equations  x=u\*cos(10\*pi\*u);  y=u\*sin(10\*pi\*u);  z=0;  We change the parameter domain to while the sampling resolution remains at 500.  The number of oscillations is doubled from 5 to 10 when the parameter domain is changed from to .  Open the file to see the animation. |
| 2D Spiral | The curve in file “6.3-2Dspiral.wrl” is a spiral defined by parametric equations  x=u\*cos(10\*pi\*u);  y=u\*sin(10\*pi\*u);  z=0;  The parameter domain is but we change the sampling resolution to 30. The spiral has 5 oscillations.  Since sampling resolution is 30, and number of oscillations is 5, each oscillation has 6 sampling points.  30/5=6. This results in a 6-sided spiral.  Open the file to see the animation. |
| Straight Line Segment | The curve in file “6.4-2Dspiral.wrl” is a spiral defined by parametric equations  x=u\*cos(10\*pi\*u);  y=u\*sin(10\*pi\*u);  z=0;  The parameter domain is but we change the sampling resolution to 2.  The sampling values for are . This corresponds to , , and respectively. So it draws a straight line segment from (1,0,0) to (-1,0,0), and (-1,0,0) to (1,0,0,).  The spiral changes into a straight line segment that lies along the x-axis. We need to toggle to wireframe view in order to be able to see it.  Open the file to see the animation. |

# Exercise 7 – 3D Helix

Define parametrically in different files: 3D Helix

|  |  |  |
| --- | --- | --- |
| **Snapshot** | **Notes** | |
| 3D Helix | The curve in file “7.1-3Dhelix.wrl” is a 3D helix defined by parametric equations  x=u\*cos(10\*pi\*u);  y=u\*sin(10\*pi\*u);  z=-0.5+1.5\*u;  The parameter domain is  The sampling resolution is 500.  The spiral has 5 oscillations with varying size as u increases from 0 to 1 as it spirals.  Open the file to see the animation. | |
| 3D Helix | The curve in file “7.2-3Dhelix.wrl” is a 3D helix defined by parametric equations  x=0.5\*cos(10\*pi\*u);  y=0.5\*sin(10\*pi\*u);  z=-0.5+1.5\*u;  The parameter domain is  The sampling resolution is 500.  The spiral has 5 oscillations with constant size fixed at 0.5 as it spirals.  Open the file to see the animation. | |
| 3D Helix | The curve in file “7.3-3Dhelix.wrl” is a 3D helix defined by parametric equations  x=0.5\*cos(10\*pi\*u);  y=0.5\*sin(10\*pi\*u);  z=-0.5+1.5\*u;  The parameter domain is , but we change the sampling resolution to 2.  The sampling values for are . This corresponds to , , and respectively. So it draws a straight line segment from to and , to .  The spiral changes into this shape as shown.  Open the file to see the animation. | |
| 3D Helix | The curve in file “7.4-3Dhelix.wrl” is a 3D helix defined by parametric equations  x=0.6\*(sin(u\*2\*pi)\*cos(36\*pi\*u); y=0.6\*(sin(u\*2\*pi)\*sin(36\*pi\*u);  z=-1+2\*u;  The parameter domain is  The sampling resolution is 500.  Open the file to see the animation. | |
| Elongated 3D Helix    The curve in file “7.5-3Dhelix.wrl” is a 3D helix defined by parametric equations  x=0.6\*(sin(u\*2\*pi)\*cos(36\*pi\*u);  y=0.6\*(sin(u\*2\*pi)\*sin(36\*pi\*u);  z=-1+2\*u;  The sampling resolution remains at 500.  When we change the parameter domain to we can see that the curve is not only elongated, but more “shapes” are created.  However, the the curve loses its original curvature. This is because fewer samples are taken when the parameter domain increases but the sampling resolution remains the same.  Open the file to see the animation. | | |
| Straight line segment | | The curve in file “7.6-3Dhelix.wrl” is a straight line segment defined by parametric equations  x=0.6\*abs(sin(u\*2\*pi))\*cos(36\*pi\*u); y=0.6\*abs(sin(u\*2\*pi))\*sin(36\*pi\*u);  z=-1+2\*u;  The parameter domain is , but we change the sampling resolution to 2.  The spiral changes into a straight line segment that lies along the z-axis. |

# Exercise 8 – Sine Curve

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

|  |  |
| --- | --- |
| **Snapshot** | **Notes** |
| Sine Curve | The curve in file “8.1-sinCurve.wrl” is a sine curve defined by parametric equations  x=-1+2u;  y=sin(u\*4\*pi);  z=0;  The parameter domain is  The sampling resolution is 100.  Open the file to see the animation.  The Sine curve starts from x=-1 to x=1 as we use linear interpolation of straight line segment along x-axis:  x= -1+u\*(1-(-1));  Then we get this  x=-1+2u; |
| Elongated Sine Curve    The curve in file “8.2-sinCurve.wrl” is a sine curve defined by the same paramatric equation.  When we change the parameter domain to we can see that the curve is elongated.  Take length of range of domain divided by sampling resolution.  However, the the curve loses its original curvature. This is because fewer samples are taken when the parameter domain increases but the sampling resolution remains the same.  Open the file to see the animation. | |
| Increase Resolution    The curve in file “8.3-sinCurve.wrl” is a sine curve defined by the same paramatric equation.  When we change the sampling resolution to 800 we can see that the curvature of the curve has improved as it is a much smoother curve. Open the file to see the animation. | |

# Exercise 9 – Extras

Let’s explore how to draw different curve functions.

|  |  |
| --- | --- |
| **Snapshot** | **Notes** |
| Sine Curve | The curve in file “9.1-sin.wrl” is a sine curve defined by parametric equations  x=u;  y=sin(2\*pi\*u);  z=0;  The parameter domain is  The sampling resolution is 100.  Open the file to see the animation.  Notice how the animation shows how the curve is drawn is different from “8.1-sin.wrl”. |
| Cosine Curve | The curve in file “9.2-cos.wrl” is a cosine curve defined by parametric equations  x=u;  y=cos(2\*pi\*u);  z=0;  The parameter domain is  The sampling resolution is 100.  Open the file to see the animation. |
| Tangent Curve | The curve in file “9.3-tan.wrl” is a cosine curve defined by parametric equations  x=u;  y=cos(2\*pi\*u);  z=0;  The parameter domain is  The sampling resolution is 100.  Open the file to see the animation.  Notice the vertical asymptotes are drawn as well. |
| Exponential | The curve in file “9.4-exp.wrl” is a exponential function curve defined by parametric equations  x=u;  y= exp(u);  z=0;  The parameter domain is  The sampling resolution is 100.  Open the file to see the animation. |
| Absolute | The curve in file “9.5-abs.wrl” is a absolute function curve defined by parametric equations  x=u;  y= abs(u);  z=0;  The parameter domain is  The sampling resolution is 100.  Open the file to see the animation. |
| Butterfly | The curve in file “9.6-butterfly.wrl” is a [butterfly](https://en.wikipedia.org/wiki/Butterfly_curve_(transcendental)) curve, which is a transcendental plane curve. It is defined by parametric equations  x=sin(u\*pi)\*( exp(cos(u\*pi)) -2\*cos(4\*u\*pi)-(sin(u\*pi/12))^5 );  y=cos(u\*pi)\*( exp(cos(u\*pi)) -2\*cos(4\*u\*pi)-(sin(u\*pi/12))^5 );  z=0;  The parameter domain is  The sampling resolution is 2000.  Open the file to see the animation. |
|  | We change the parameter domain to , we get lesser of the inner repetitions. |
|  | We change the parameter domain to , we get even lesser of the inner repetitions. |
| Astroid | The curve in file “9.7-astroid.wrl” is an astroid enclosed by a circle. It is also called tetracuspid as it has 4 cusps.  The curve is formed by rolling a circle of radius 1/4 on the inside of a circle of radius 1.  It is defined by parametric equations  x = 1/4\*(3\*cos(u)+cos(3\*u));  y = 1/4\*(3\*sin(u)-sin(3\*u));  z=0;  The parameter domain is  The sampling resolution is 100.  Open the file to see the animation. |
|  | The curve in file “9.8-epicycloid.wrl” is an [epicycloid](https://en.wikipedia.org/wiki/Epicycloid), a plane curve created by the path traced by a smaller circle rolling around a fixed larger circle.  It is defined by parametric equations  x=(0.1\*(5.5+1)\*cos(u))-(0.1\*cos((5.5+1)\*u));  y=(0.1\*(5.5+1)\*sin(u))-(0.1\*sin((5.5+1)\*u));  z=0;  The parameter domain is  The sampling resolution is 300.  Open the file to see the animation. |
| Curve in Tutorial 3 Q4 | The curve in file “9.9-tut3-q4.wrl” is a sinusoidal curve defined by parametric equations  x=(0.75+0.25\*sin(20\*pi\*u))\*(cos(pi\*u));  y=(0.75+0.25\*sin(20\*pi\*u))\*(sin(pi\*u));  z=0;  The parameter domain is  The sampling resolution is 200.  The sinusoidal curve (sine wave) follow a semicircle (half circle) with the radius of 0.75. The curve has 10 periodic oscillations (cycles) that moves counterclockwise around the semicircle with the oscillations amplitude of ±0.25.  Open the file to see the animation. |
| Flower pattern in Tutorial 5 Q2 | The curve in file “9.10-tut5-q2-flower.wrl” is a sinusoidal curve defined by parametric equations  z=( 0.5\*sin(4\*u\*2\*pi)\*cos(u\*2\*pi) + 1) \* cos(v\*1.5\*pi + 0.5\*pi);  x=( 0.5\*sin(4\*u\*2\*pi)\*cos(u\*2\*pi) + 1) \* sin(v\*1.5\*pi + 0.5\*pi);  y=( 0.5\*sin(4\*u\*2\*pi)\*sin (u\*2\*pi) - 1) + 2\*v;  The parameter domain is  The sampling resolution is 100.  Open the file to see the animation. |