Don Bosco Institute of Technology

INTERNAL ASSESSMENT II

CSC305: Computer Graphics — Max Marks: 20
Date: 27.10.2023 — Time: 11:30 - 12:30 a.m.

- Attempt <u>any five</u> from 1a to 1f
- Attempt <u>any one</u> sub question from the remaining two questions

Q.1	Attempt any **five out of six** questions	Marks	
a.	Compare object space method & image space method of visible surface detection?	(02)	CSC305.6

	Object Space	Image space	M
i)	Implemented in physical co-ordinate system.	Implemented in Screen co-ordinate system.	$\frac{1}{2}$M
ii)	Determine which object Surfaces are visible	Decides visibility point by point at each pixel position on the view plane.	$\frac{1}{2}$M
iii)	Used in line-display algorithms.	Hidden line / Surface algorithms use image Space method.	$\frac{1}{2}$M
iv)	e.g. Back-surface detection method, BSP tree method	e.g. Z buffer algorithm Scanline Algorithm.	$\frac{1}{2}$M

b.	Explain the steps for 3D rotation about arbitrary points and provide a composite transformation for same.	(02)	CSC305.6

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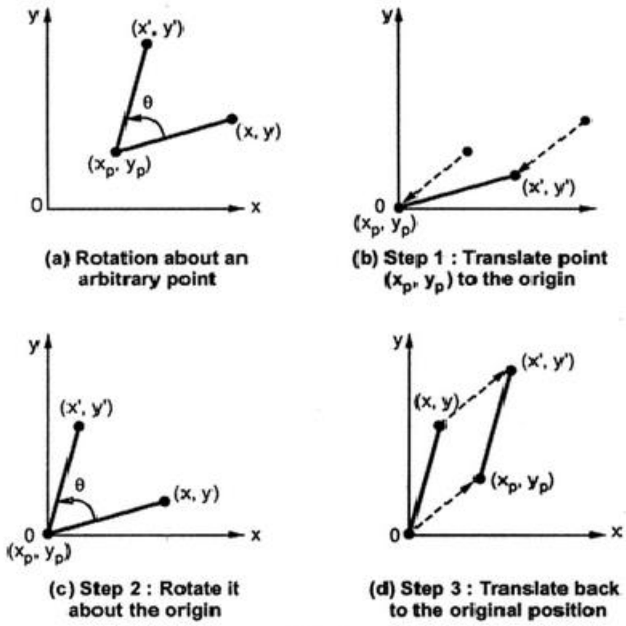

Fig. 1

Composite Matrix

$$T_1 \cdot R \cdot T_2 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -x_p & -y_p & 1 \end{bmatrix} \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ x_p & y_p & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ -x_p\cos\theta + y_p\sin\theta & -x_p\sin\theta - y_p\cos\theta & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ x_p & y_p & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ -x_p\cos\theta + y_p\sin\theta + x_p & -x_p\sin\theta - y_p\cos\theta + y_p & 1 \end{bmatrix}$$
</td>
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<tr>
<td>c.</td>
<td>Explain Back-Surface Detection method.</td>
<td>(02)</td>
<td>CSC305.6</td>
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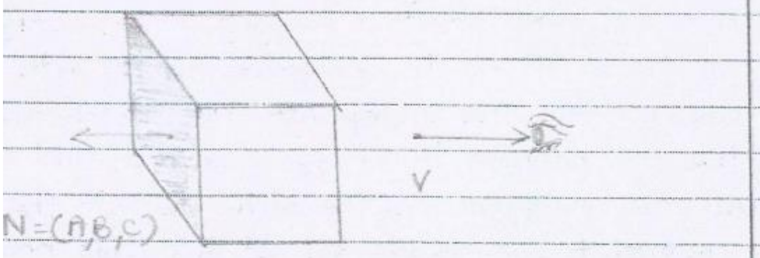
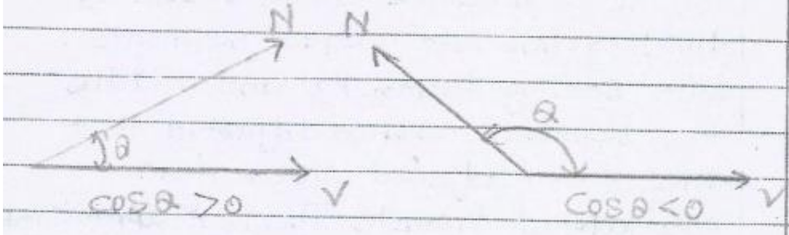
	If a polygon is visible, the light surface should face towards us and the dark surface should face away from us. Therefore, if the direction of the light face is pointing towards the viewer, the face is visible (front face) otherwise, the face is hidden (back face) and should be removed. 1M  		

	The direction of the light face can be identified by examining the result 1M $N \cdot V > 0$ where, N: Normal vector to the polygon surface with Cartesian components (A, B, C). V: A vector in the viewing direction from the eye or camera position The dot product of two vectors, gives the product of the lengths of the two vector times the cosine of the angle between them. If the vectors are in the same direction $(0 \le \theta < \pi/2)$, then the cosine is +ve and overall dot product is +ve otherwise if $(\pi/2 < \theta \le \pi)$ direction are opposite dot product is -ve. ~~If~~ if dot product is +ve surface is visible otherwise it is hidden and should be removed.  fig. cosine angles between two vector.		
d.	Define Shearing transformation and give example. Shearing deals with changing the shape and size of the 2D object along x-axis and y-axis. It is similar to sliding the layers in one direction to change the shape of the 2D object. It is an ideal technique to change the shape of an existing object in a two-dimensional plane. In a two-dimensional plane, the object size can be changed along X direction as well as Y direction. x-Shear: In x shear, the y co-ordinates remain the same but the x co-ordinates changes. If P(x, y) is the point then the new points will be P'(x', y') given as – x'=x+Sh_x*y; y'=y	(02)	CSC305.6

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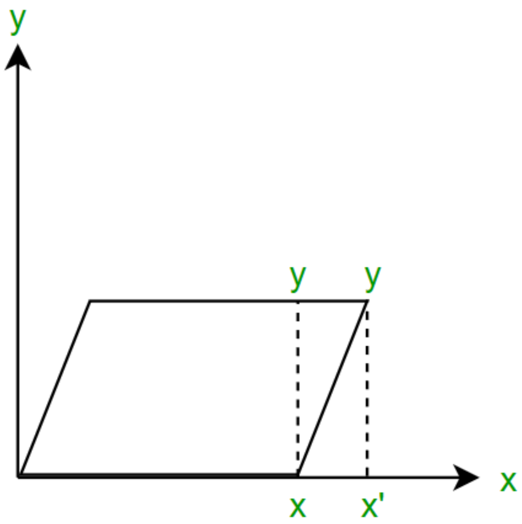
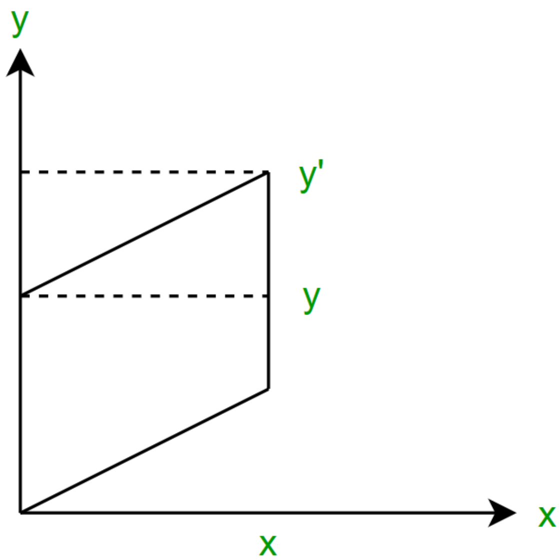
<td>

y-Shear:
In y shear, the x co-ordinates remain the same but the y co-ordinates changes. If P(x, y) is the point then the new points will be P'(x', y') given as –
x'=x; y'=y+Sh_y*x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<tr>
<td>e.</td>
<td>Define Koch curve and write steps to construct Koch curve.</td>
<td>(02)</td>
<td>CSC305.6</td>
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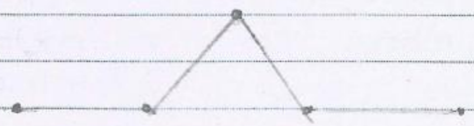
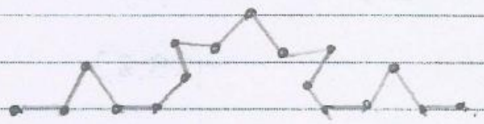
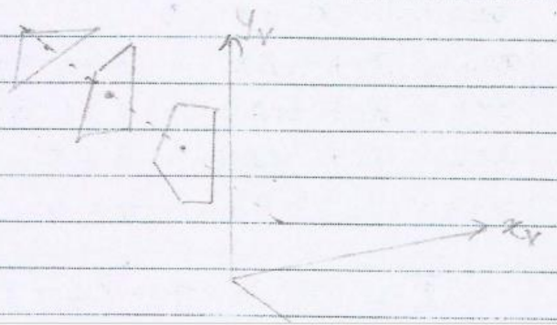
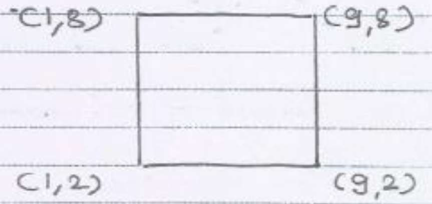
	The Koch curve can be drawn by dividing line into 4 equal segments with scaling factor 1/3 and middle two segments are so adjusted that they form adjacent sides of an equilateral triangle. This is 1^{st} approximation To apply the second approximation to the Koch curve we have to repeat the above process for each of the four segments. 1M  1m Fig. a - First approximation  Fig. b - Second approximation		
f.	State various steps involve in Z-buffer algorithm.	(02)	CSC305.6

	The basic idea is to test the z-depth of each surface to determine the closest surface or visible surface. Declare an array z buffer (x, y) with one entry for each pixel position. Initialize the array to the maximum depth. 1m for each polygon P, for each pixel (x,y) in P compute z-depth x, y if z-depth < z_buffer (x, y) then ~~setpixel <z-buffer (x~~ setpixel (x, y, color) z_buffer (x, y) <= z-depth 1m 		
Q.2	Attempt **any one out of two** questions		
A	Solve using Liang-Barsky line clipping algorithm, where (xwmin, xwmax) = 1, 9 & (ywmin, ywmax) = (2, 8) for line segments P1 (3,7) to P2 (3,10) P3 (6, 6) to P4 (8, 9) P5 (-1, 7) to P6 (11,1)	(05)	CSC305.5



$\frac{1}{2}$m

Case-1 - $P_1(3,7)$ to $P_2(3,10)$

$x_{wmin} = 1 \qquad y_{wmin} = 2$

$x_{wmax} = 9 \qquad y_{wmax} = 8$

$x_1 = 3 \qquad x_2 = 3 \qquad y_1 = 7 \qquad y_2 = 10$

$dy = 3 \qquad dx = 0$

$p_1 = 0 \qquad q_1 = x_1 - x_{wmin} = 2 \qquad q_1/p_1 = 0$ $\quad 1\frac{1}{2}$m

$p_2 = 0 \qquad q_2 = x_{wmax} - x_1 = 6 \qquad q_2/p_2 = 0$

$p_3 = -3 \qquad q_3 = y_1 - y_{wmin} = 5 \qquad q_3/p_3 = -5/3$

$p_4 = 3 \qquad q_4 = y_{wmax} - y_1 = 1 \qquad q_4/p_4 = 1/3$

$t_1 = \max(-5/3) = -5/3$

$t_2 = \min(0,3) = 0$

$xx_1 = x_1 + t_1 \Delta x = 3 + (-5/3)0 = 3$

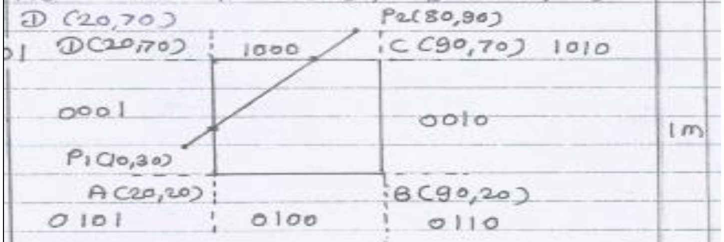
$yy_1 = y_1 + t_1 \Delta y = 7 + (-5/3)3 = 2$

$xx_2 = x_1 + t_2 \Delta y = 3 + 0$

$yy_2 = y_1 + t_2 \Delta y = 7 + 0$

$\boxed{I_1 = (3,2),\ I_2 = (3,7)}$

	Case-2 P3 (6,6) to P4 (8,9) $x_{wmin} = 1$ $\quad y_{wmin} = 2$ $x_{wmax} = 9$ $\quad y_{wmax} = 8$ $x_1 = 6$ $\quad x_2 = 8$ $\quad y_1 = 6$ $\quad y_2 = 9$ $\quad 1\frac{1}{2}$ m $dy = 3$ $\quad dx = 2$ $p_1 = -2$ $\quad q_1 = 5$ $\quad q_1/p_1 = 5/2 = -2.5$ $p_2 = 2$ $\quad q_2 = 8$ $\quad q_2/p_2 = 4$ $p_3 = -3$ $\quad q_3 = 4$ $\quad q_3/p_3 = -4/3 = -1.3$ $p_4 = 3$ $\quad q_4 = 2$ $\quad q_4/p_4 = 2/3 = 0.6$ $t_1 = -1.3$ $\quad t_2 = 0.6$ $xx_1 = x_1 + t_1 \Delta x = 6 + (-4/3) \cdot 2 = 3.3$ $yy_1 = y_1 + t_1 \Delta y = 6 + (-4/3) \cdot 3 = \cancel{8} \; 2$ $xx_2 = x_1 + t_2 \Delta x = 6 + 2/3 \times 2 = 7.3$ $yy_2 = y_1 + t_2 \Delta y = 6 + 2/3 \times 3 = 8$ $\boxed{I_1 (3.3, 2), I_2 (7.3, 8)}$ Case 3 P4 (-1, 7) to P5 (11, 1) $dy = -6$ $\quad dx = 10$ $\quad 1\frac{1}{2}$ m $p_1 = -10$ $\quad q_1 = -2$ $\quad q_1/p_1 = 2/10$ $p_2 = 10$ $\quad q_2 = 10$ $\quad q_2/p_2 = 1$ $p_3 = 6$ $\quad q_3 = 5$ $\quad q_3/p_3 = 5/6$ $p_4 = -6$ $\quad q_4 = 1$ $\quad q_4/p_4 = -1/6$ $t_1 = 2/10$ $\quad t_2 = 5/6$ $xx_1 = x_1 + t_1 \Delta x = -1 + 2/10 \times 10 = 1$ $yy_1 = y_1 + t_1 \Delta y = 7 + 2/10 \times -6 = 5.8$ $xx_2 = x_1 + t_2 \Delta x = -1 + 5/6 \times 10 = 7.3$ $yy_2 = y_1 + t_2 \Delta y = 7 + 5/6 \times -6 = 2$ $\boxed{I_1 (1, 5.8), I_2 (7.3, 2)}$		
	OR		
B	Find the clipping Co-ordinates to clip the line segment P1, P2 against the window ABCD using Cohen Sutherland line clipping algorithm. P1(10, 30) P2 (80, 90) window ABCD A (20, 20), B (90, 20), C (90, 70), D (20, 70)	(05)	CSC305.5

<table>
<tr><td></td><td>ABCD A(20,20) B(90,20) C(90,70)
D(20,70)


1m

Point / End code / Anding / Result
P1 / 0001 / 0000 / Partially visible
P2 / 1000
1m

$m = \frac{\Delta y}{\Delta x} = \frac{90-30}{80-10} = \frac{60}{70} = \frac{6}{7}$

$x_L, y = m(x_L - x_1) + y_1$
$= \frac{6}{7}(20-10)+30$
$= \frac{6}{7}(10)+30 = \frac{60}{7}+30 = 38.57$
$1\frac{1}{2}m$

$y_T, x = x_1 + (1/m)(y_T - y_1)$
$= 10 + 7/6 * 40$
$= 56.66$
$1\frac{1}{2}m$

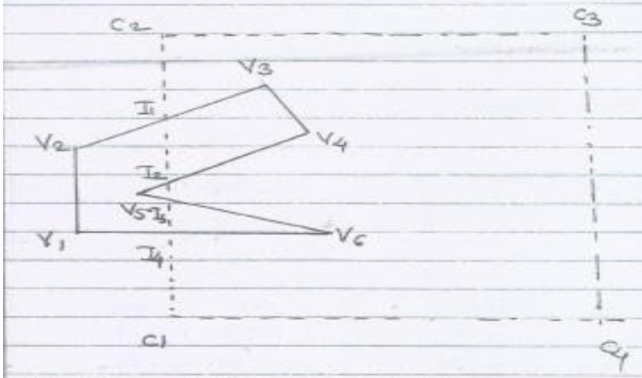
$\boxed{I_1(20, 56.66),\ I_2(38.57, 70)}$</td><td></td><td></td></tr>
<tr><td>Q.3</td><td>Attempt any one out of two questions</td><td></td><td></td></tr>
<tr><td>A</td><td>Explain Weiler-Artherton polygon clipping algorithm with suitable example.</td><td>(05)</td><td>CSC305.4</td></tr>
</table>

Weiler-Atherton algorithm.

1. Used to clip convex polygon.

It describes both the subject and the clip polygon by a circular list of vertices. The boundaries of the subject polygon and the clip polygon may or may not intersect. If they intersect, ~~th~~ then the intersections occurs in pairs. One of the intersections occurs when a subject polygon edge enters the inside of the clip polygon and one when it leaves.

2½m

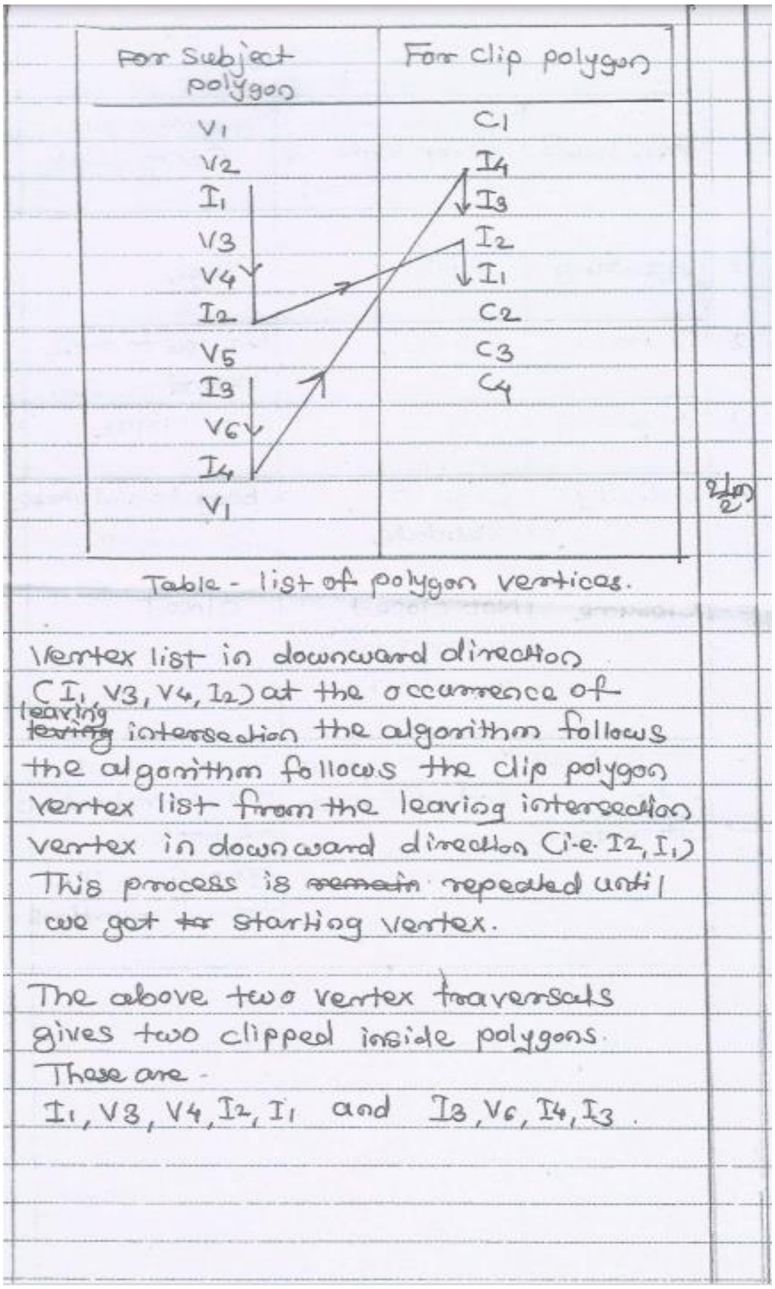


Vertices - $V_1, V_2, V_3, V_4, V_5, V_6$

Intersection points - I_1, I_2, I_3, I_4

clip polygon vertices - C_1, C_2, C_3, C_4

The algorithm starts entering intersections (I_1) and follows the subject polygon



For Subject polygon	For clip polygon
V_1	C_1
V_2	I_4
I_1	I_3
V_3	I_2
V_4	I_1
I_2	C_2
V_5	C_3
I_3	C_4
V_6	
I_4	
V_1	

Table - list of polygon vertices.

Vertex list in downward direction (I_1, V_3, V_4, I_2) at the occurrence of leaving ~~leving~~ intersection the algorithm follows the algorithm follows the clip polygon vertex list from the leaving intersection vertex in downward direction (i.e. I_2, I_1) This process is ~~remain~~ repeated until we got ~~to~~ starting vertex.

The above two vertex traversals gives two clipped inside polygons. These are -
I_1, V_3, V_4, I_2, I_1 and I_3, V_6, I_4, I_3.

	OR		
B	Explain Bezier curve with its properties and construct.	(05)	CSC305.4

Properties of Bezier curve:-

1. The basis functions are real.
2. Bezier curve always passes through the first and last control points i.e. curve has same end points as the guiding Polygon.
3. The degree of the polynomial defining the curve segment is one less than the number of defining polygon point. Therefore, for 4 control points, the degree of the polynomial is three, i.e. cubic polynomial.
4. The curve generally follows the shape of the defining polygon.

5. The direction of the tangent vector at the end points is the same as that of the vector determined by first and last segments.
6. The curve lies entirely within the convex hull formed by four control points.
7. The convex hull property for a Bezier curve ensures that the polynomial smoothly follows the control points.
8. The curve exhibits the variation diminishing property. This means that the curve does not oscillate about any straight line more often than the defining polygon.
9. The curve is invariant under an affine transformation.

In cubic Bezier curve four control Points are used to specify complete curve. Unlike the B-spline curve, we do not add intermediate points and smoothly extend Bezier curve, but we pick four more points and construct a second curve which can be attached to the first. The second curve can be attached to the first curve smoothly by selecting appropriate control points.

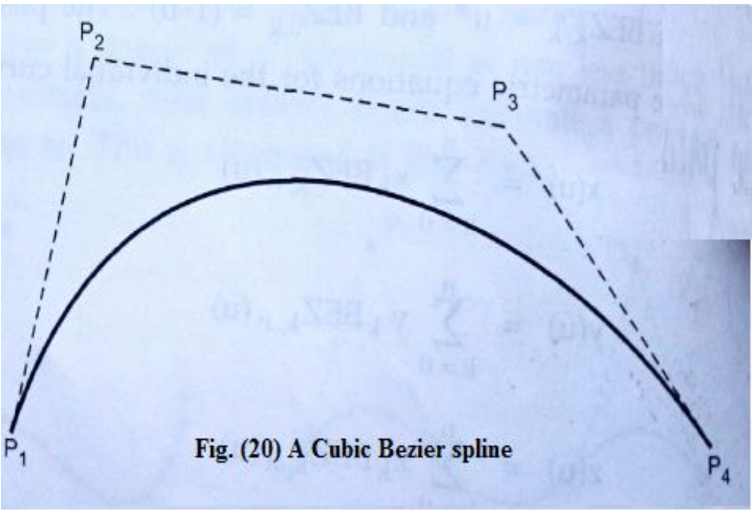


Fig. (20) A Cubic Bezier spline

Fig. shows the Bezier curve and its four control points. As shown in the Fig. (20), Bezier curve begins at the first control point and ends at the fourth control point. This means that if we want to connect two Bezier curves, we have to make the first control point of the second Bezier curve match the last control point of the first curve. we can also observe that at the start of the curve, the curve is tangent to the line connecting first and second control points. Similarly at the end of curve, the curve is tangent to the line connecting the third and fourth control point. This means that, to join two Bezier curves smoothly we have to place the third and the fourth control Points of the first curve on the same line specified by the first and the second control points of the second curve.

	The Bezier matrix for periodic cubic polynomial is $$M_B = \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$ $\therefore$ $$P(u) = U \cdot M_B \cdot G_B$$ where $$G_B = \begin{bmatrix} P_1 \\ P_2 \\ P_3 \\ P_4 \end{bmatrix}$$ and the product $P(u) = U \cdot M_B \cdot G_B$ is $$P(u) = (1-u)^3 P_1 + 3u(1-u)^2 P_2 + 3u^2(1-u) P_3 + u^3 P_4$$ Therefore, the four blending functions for cubic Bezier curve are $$BEZ_{0,3}(u) = (1-u)^3$$ $$BEZ_{1,3}(u) = 3u(1-u)^2$$ $$BEZ_{2,3}(u) = 3u^2(1-u)$$ $$BEZ_{3,3}(u) = u^3$$			