Swami Keshvanand Institute of Technology, Management & Gramothan,
Ramnagaria, Jagatpura, Jaipur-302017, INDIA
Approved by AICTE, Ministry of HRD, Government of India
Recognized by UGC under Section 2(f) of the UGC Act, 1956
Tel. : +91-0141- 5160400Fax: +91-0141-2759555
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A
Course File
on
Computer Graphics & Multimedia (5CS4-04)
Programme:B.Tech.
Semester:…V…….
Session…2022-23

(Name : Manish Bhardwaj)
(Designation : Assistant Professor)
(Branch : CSE)

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Contents

Note:

1. *1st lecture of the course should cover prerequisite
2. **E: Easy, M: Moderate, D: Difficult
3. Format for Points 8-11 should be referred from AICTE's Recommendations for Examination Reforms

Institute Vision/ Mission/ Quality Policy :

Vision

To promote higher learning in advanced technology and industrial research to make our country a global player

Mission

To promote quality education, training and research in the field of Engineering by establishing effective interface with industry and to encourage faculty to undertake industry sponsored projects for students

Quality Policy

We are committed to 'achievement of quality' as an integral part of our institutional policy by continuous self-evaluation and striving to improve ourselves.

Institute would pursue quality in

- All its endeavours like admissions, teaching- learning processes, examination, extra and co--curricular activities, industry institution interaction, research & development, continuing education, and consultancy.
- Functional areas like teaching departments, Training & Placement Cell, library, administrative office, accounts office, hostels, canteen, security services, transport, maintenance section and all other services."

Department of Computer Science and Engineering Vision/ Mission:

Vision

V1: Produce quality computer engineers trained in the latest tools and technologies.

V2: Be a leading department in the region and country by imparting in-depth knowledge to the students in an emerging technologies in computer science & engineering

Mission

Delivering resources in IT enable domain through:

M1: Effective Industry interaction and project based learning.

M2: Motivating our students for employability, entrepreneurship, research and higher education

Program Educational Objectives of CSE department

The graduates of CSE program will be:

PEO1: Prepared to be employed in IT industries and be engaged in learning, understanding, and applying new ideas.

PEO2: Prepared to be responsible professionals in their domain of interest.

PEO3: Able to apply their technical knowledge as practicing professionals or engaged in higher education.

PEO4: Able to work efficiently as an individual and in a professional team environment.

Program Outcomes

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and teamwork: Function effectively as an individual, and as a member or leader indiverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes of CSE Department

PSO1: Core Engineering Skills: Exhibit fundamental concepts of Data Structures, Databases, Operating Systems, Computer Network, Theory of Computation, Advanced Programming and Software Engineering.

PSO2: Standard Software Engineering practices: Demonstrate an ability to design, develop, test, debug, deploy, analyze, troubleshoot, maintain, manage and secure a software.

PSO3: Future Endeavors: Recognize the need to have knowledge of higher education institutions/ organizations/ companies related to computer science & engineering.

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RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Teaching & Examination Scheme
B.Tech Computer Science and Engineering (Artificial Intelligence)3rd Year - V Semester

THEORY

SN	Category	Course		Contact hrs/week			Marks				Cr
		Code	Title	L	T	P	Exm Hrs	IA	ETE	Total	
1	PCC	5CAI3-01	Data Mining-Concepts and Techniques	2	0	0	3	30	70	**100**	**2**
2	PCC	5CAI4-02	Compiler Design	3	0	0	3	30	70	**100**	**3**
3		5CAI4-03	Operating System	3	0	0	3	30	70	**100**	**3**
4		5CAI4-04	Computer Graphics & Multimedia	3	0	0	3	30	70	**100**	**3**
5		5CAI4-05	Analysis of Algorithm	3	0	0	3	30	70	**100**	**3**
6	PEC	5CAI5-11	Fundamentals of Blockchain	2	0	0	3	30	70	**100**	**2**
7		5CAI5-12	Mathematical Modelling for DataScience								
8		5CAI5-13	Programming for Data Sciences								
			Sub Total	16	0	0					**16**

PRACTICAL & SESSIONAL

9		5CAI4-21	Computer Graphics & Multimedia Lab	0	0	2	2	60	40	**100**	**1**

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10	PCC	5CAI4-22	Compiler Design Lab	0	0	2	2	60	40	**100**	**1**
11		5CAI4-23	Analysis of Algorithm Lab	**0**	**0**	**2**	**2**	**60**	**40**	**100**	**1**
12		5CAI4-24	Advanced Java Lab	**0**	**0**	**2**	**2**	**60**	**40**	**100**	**1**
13	PSIT	5CAI7-30	Industrial Training	**0**	**0**	**1**		**60**	**40**	**100**	**2.5**
14	SODECA	5CAI8-00	Social Outreach, Discipline & Extra Curricular Activities						100	**100**	**0.5**
			Sub- Total	**0**	**0**	**9**					**7**
			TOTAL OF V SEMESTER	**16**	**0**	**9**					**23**

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Syllabus

III Year-V Semester: B.Tech. Computer Science and Engineering

5CS4-04: Computer Graphics & Multimedia

Credit: 3
3L+0T+0P

Max. Marks: 100(IA:30, ETE:70)
End Term Exam: 3 Hours

SN	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	01
2	**Basic of Computer Graphics:**Basic of Computer Graphics, Applications of computer graphics, Display devices, Random and Raster scan systems, Graphics input devices, Graphics software and standards.	06
3	**Graphics Primitives:**Points, lines, circles and ellipses as primitives, scan conversion algorithms for primitives, Fill area primitives including scan-line polygon filling, inside-outside test, boundary and flood-fill, character generation, line attributes, area-fill attributes, character attributers. Aliasing, and introduction to Anti Aliasing (No anti aliasing algorithm).	07
4	**Two Dimensional Graphics:**Transformations (translation, rotation, scaling), matrix representation, homogeneous coordinates, composite transformations, reflection and shearing, viewing pipeline and coordinates system, window-to-viewport transformation, clipping including point clipping, line clipping (cohen-sutherland, liang- bersky, NLN), polygon clipping.	08
5	**Three Dimensional Graphics:**3D display methods, polygon surfaces, tables, equations, meshes, curved lies and surfaces, quadric surfaces, spline representation, cubic spline interpolation methods, Bazier curves and surfaces, B-spline curves and surfaces.3D scaling, rotation and translation, composite transformation, viewing pipeline and coordinates, parallel and perspective transformation, view volume and general (parallel and perspective) projection transformations.	08
6	**Illumination and Colour Models:**Light sources – basic illumination models – halftone patterns and dithering techniques; Properties of light – Standard primaries and chromaticity diagram; Intuitive colour concepts – RGB colour model – YIQ colour model – CMY colour model – HSV colour model – HLS colour model; Colour selection.	06
7	**Animations &Realism:**Design of Animation sequences – animation function – raster animation – key frame systems – motion specification – morphing – tweening. **ComputerGraphics Realism:** Tiling the plane – Recursively defined curves – Koch curves – C curves – Dragons – space filling curves – fractals – Grammar based models – fractals – turtle graphics – ray tracing.	06
	Total	42

Office of Dean Academic Affairs
Rajasthan Technical University, Kota

Prerequisite of Course:

1. Good programming skills in C / C++
2. Knowledge of the following mathematical topics
   - Idea about the basic geometric shapes and their mathematical notations
   - Vectors, vector operations, and vector spaces
   - Matrices
   - Basic linear algebra such as solving a system of linear equations
   - Polynomials
3. Basic idea about the memory allocation in Computer's Storage and it's working
4. Knowledge about representing a given data though coordinate system

List of Text and Reference Books :

1. J. Foley, A. Van Dam, S. Feiner, J. Hughes: Computer Graphics- Principles and Practice, Pearson
2. Hearn and Baker: Computer Graphics, PHI
3. Multimedia Systems Design, Prabhat Andleigh and hakkar, PHI.
4. Schaum Outline Computer Graphics by Xiang, McGraw Hill
5. Introduction To Multimedia Systems 2002 Edition by Bhatnagar G, Elsevier
6. Multimedia Systems , John F. Koegel Buford, Pearson Education

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Course Coverage

Course Coverage (Computer Graphics & Multimedia)			
Branch & Sem: CSE - V			**L/T/P : ..3../..0../..0..**
Lecture No.	**Unit**	**Date**	**Topic**
1	1		Objective, Scope and Outcome of the Course
2	2		Basics of Computer Graphics, Applications of Computer Graphics
3			Display Devices, Raster and Random Scanning Systems
4			Graphics Input Devices, Graphics Software and Standards
5	3		Graphics Primitives : Points and Lines
6			Graphics Primitives : Circle (Midpoint Circle algorithm)
7			Graphics Primitive : Ellipse (Midpoint Ellipse algorithm),
8			Polygon filling algorithms (Boundary fill)
9			Polygon filling algorithms (Flood fill)
10			Character Generation, Inside-outside test
11			Aliasing (Anti-aliasing Algorithms)
12	4		Two Dimensional Graphics : Introduction
13			Transformations (Translation, Scaling)
14			Transformations (Rotation)
15			Composite Transformations
16			Reflection and Shearing
17			Pipelining and Coordinate System
18			Window to Viewport Transformation
19			Introduction to Clipping
20			Point Clipping, Line Clipping (Cohen-Sutherland)
21			Line Clipping (Liang-Bersky, NLN)
22			Polygon Clipping Algorithm
23			Weiler-Atherton Polygon Clipping
24	5		Three Dimensional Graphics+Quiz
25			3D display methods, polygon surfaces,
26			tables, equations, meshes, curved lines and surfaces
27			Quiz, quadric surfaces, spline representation
28			cubic spline interpolation methods,Bazier curves and surfaces
29			B-Spline curves and surfaces

30			3D transformations, viewing pipeline and coordinates	
31			Parallel & perspective transformation	
32			view volume & general(parallel and perspective) projection transformation	
33			Revision & Problem Solving	
34	6		Introduction to Illumination & color model	
35			light sources - basic illumination models	
36			half-tone patterns & dithering techniques	
37			properties of light- starndard primaries & chromaticity diagram	
38			Color Models: RGB, YIQ, CMY, HSV, HIS	
39	7		Principles of Animation, design of animation sequence - Animation function	
40			Raster animation, Key-Frame systems	
41			motion specifications, morphing, tweenning	
42			Computer Graphics Realism: Tiling the plane	
43			koch curves, C-curves, Dragons curves, Space filling curves	
44			fractals, grammer based models, turtle graphics, tay tracing	

7E4241

Roll No. :_____ Total Printed Pages : 2

7E4241

B.Tech. (Sem. VII) (Main) Examination, Nov-Dec - 2011
Computer Science
7CS5 Computer Graphics & Multimedia Techniques

Time : 3 Hours

Total Marks : 80
Min. Passing Marks : 24

Attempt any five questions, selecting one question from each unit. All questions carry equal marks. (Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.)

UNIT - I

1. (a) What is the scan conversion. Explain Rastar scan system with the help of block diagram. (8)

   (b) In a Raster system with resolution 2560 × 2048. How many pixels could be accessed per second by a display controller that refresh that screen at a rate of 60 frames per second. Also calculate access time per pixel in the system. (8)

OR

1. (a) Explain Bresenham's line drawing algorithm. Also write it's procedure in any programming language. (8)

   (b) Explain basic principle to draw a circle. Also explain mid-point circle algorithm. (8)

UNIT - II

2. (a) What is the need of transformation between coordinate systems. Explain with example. (8)

   (b) Drive a formula to rotate a point by θ°. (8)

OR

2. (a) Explain Cohen – Sutherland clipping algorithm with region code details. (8)

   (b) Generate transformation matrix for all possible 2D reflections. (8)

UNIT - III

3. Implement depth buffer algorithm to display visible surfaces of a given polyhedron.

Is there any relation in definition of the object and storage requirements of the depth buffer? Explain. (16)

OR

3. Write a procedure to display 2D, cubic Bezier curves given a set of 4 control points in XY plane. (16)

UNIT - IV

4. Write a routine to convert RGB color model to HSV color model. (16)

OR

4. Explain phong and fast fast phong shading using a suitable object. (16)

UNIT - V

5. Write short notes on :
   (a) Difference between SCSI and IDE.
   (b) Authoring tools. (8×2)

OR

5. Write short notes on :
   (a) MPEG file format
   (b) Animation techniques. (8×2)

7E4241

Roll No. _____ [Total No. of Pages : 3

7E4241

B.Tech. VII Semester (Main/Back) Examination - 2013
Computer Engg.
7CS5 Computer Graphics & Multimedia Techniques
Common to CS & IT

Time : 3 Hours **Maximum Marks : 80**
Min. Passing Marks : 24

Instructions to Candidates:

*Attempt any **five** questions, selecting **one** question from each **unit**. All questions carry **equal** marks. (Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.)*

Unit - I

1. a) Explain the functions of display processor in raster scan display. Compare the merits and demerits of raster and vector devices **(10)**

   b) Explain the methods (any two) for producing color displays with the help of suitable diagrams **(6)**

OR

1. a) What is scan conversion? What are the major adverse side effects of scan conversion? **(4)**

   b) Show why the point-to-line error is always $\leq \frac{1}{2}$ for the midpoint line scan-conversion algorithm **(4)**

   c) What steps are required to scan convert a circle using bresenham's algorithm. Also, Derive the equation of decision variable with the help of neat diagram **(8)**

Unit - II

2. a) Use Cohen-Sutherland line clipping algorithm to find the visible portion of the line P(40,80), Q(120,30) inside the window, the window is defined as ABCD: A(20,20), B(60,20), C(60,40) and D(20,40) **(8)**

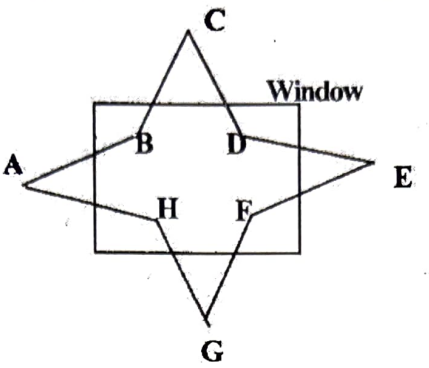
   b) What is homogeneous coordinate? Discuss the composite transformation matrices for two successive translation and scaling. **(8)**

[Contd....

OR

2. a) Reflect the triangle ΔABC about the line 3x-4y+8=0. The position vector of the coordinate ABC is given as A(4,1), B(5,2) and C(4,3) **(10)**

   b) Clip the given polygon using Sutherland. Hodgeman algorithm. The polygon is defined using set of vertices {A, B,C,D,E,F,G,H}. What will be the new set of vertices after clipping, show through a diagram. **(6)**



Unit - III

3. a) Prove that "The Sum of blending functions is unity for every value of parameter in Bezier curves". **(6)**

   b) Differentiate between image space and object space methods **(5)**

   c) Differentiate B-Splines with Bezier curves **(5)**

OR

3. (a) A cubic bezier curve segment is described by control points P_0 (2,2), P_1(4,8), P_2 (8,8) and P_3(9,5). Another curve segment is described by q_0(a,b), q_1(c,2), q_2(15,2) and q_3 (18,2). Determine the values of a,b and c so that the two curve segments Join smoothly. **(6)**

   (b) Explain Depth-Buffer method for visible surface detection. How is it different from scan-line method of visible surface detection? **(10)**

Unit - IV

4. a) Explain Gouraud shading and compare it with phong shading **(8)**

   b) Explain in brief about RGB, CMY and HSV color models. **(8)**

OR

4. (a) Explain how to simulate reflections from surfaces of different roughness using a reflection map. **(8)**

   (b) Write short note on simple recursive ray tracing without antialiasing **(8)**

b) Write short notes on:-

i) Animation Techniques

ii) Multimedia storage technologies (12)

7E 4

B. Tech. VII Semester (Main/Back) Examination - 2014

Computer Engg.

7CS5 Computer Graphics & Multimedia Techniques

(Common to CS & IT)

Time : 3 Hours **Maximum Marks : 80**

Min. Passing Marks : 24

Instructions to Candidates:

*Attempt any **five** questions, selecting **one** question from each **unit**. All questions carry **equal** marks. (Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.)*

Unit - I

1. a) What is the importance and utility of a display processor in a computer graphics system? **(8)**

   b) Highlight the features of a standard computer graphics system with an example? **(8)**

OR

1. a) What are the general application of computer graphics? **(8)**

   b) Explain Raster scan system. **(8)**

Unit - II

2. a) Prove that 2D rotation and scaling are commutative if $S_x = S_y$ or if $\theta = n\pi$ for integer and that otherwise they are not commutative i.e., $S(S_x, S_y).\ R(\theta) = R(\theta).\ S(S_x, S_y)$ only if $S_x = S_y$ *or* $\theta = n\pi$. **(8)**

   b) Write a polygon Clipping algorithm to Clip a polygon against rectangular Clipping area. **(8)**

OR

2. a) What is homogeneous Co-ordinates? Discuss the composite transformation matrices for two successive translations and scaling. **(8)**

   b) Explain perspective projection and vanishing point with example. **(8)**

Unit - III

3. During area filling one start with a point inside the program region and point it outwards towards boundary. Which fill algorithm is this? Explain it showing how 8-connected approach fills complex figures? **(16)**

OR

3. a) Describe Z buffer algorithm for visible surface detection. Also explain backface detection method. **(8)**

   b) What are different types of coherences which may be useful in visible surface determination? How can these be used? Explain. **(8)**

Unit - IV

(16)

4. Explain the following :
   a) Diffuse reflection and specular reflection
   b) Phong shading
   c) Ray Tracing
   d) RGB and CMY colour models

OR

4. Write short note on the following : **(16)**
   a) Binary ray tracing tree
   b) Antialiased ray tracing.

Unit - V

5. a) What is the use of compression technique in computer graphics? Explain JPEG. **(8)**

   b) Explain TIFF file format **(8)**

OR

5. What is Animation? What are the challenges faced in its implementation? Write the steps in generation of animation. **(16)**

6E

Computer Science

6CS4A Computer Graphics and Multimedia Techniques

Time : 3 Hours **Maximum Marks : 80**

Min. Passing Marks : 24

Instructions to Candidates:

Attempt any Five questions, selecting one question from each unit. All questions carry equal marks. (Schematic diagrams must be shown wherever necessary. any data you feel missing suitably be assumed and stated clearly.) Units of quantities used/ calculated must be stated clearly.

UNIT - I

1. a) What is scan conversion ? Explain Raster Scan system with the help of Block diagram? **(8)**

   b) Explain Basic principle to draw a circle also Explain mid-point circle Algorithm? **(8)**

(OR)

1. a) Write short note on : Anti aliasing technique? **(8)**

   b) Explain the interactive picture construction technique? **(8)**

UNIT - II

2. a) Explain Cohen-Sutherland line clipping Algorithm with region code details? **(8)**

   b) What do you mean by homogeneous co-ordinates? How these co-ordinates are useful in transformation? **(8)**

(OR)

2. a) What is the difference between scaling and Rotation? (8)

b) Write down flood fill Algorithm for Area filling? (8)

UNIT - III

3. a) Explain Depth-Buffer Algorithm to display visible surfaces of polygen? (8)

b) Short - Note on :

i) B-Spline curves

ii) Bezier Curve (4×2=8)

(OR)

3. a) Explain Scan line Algorithm? (8)

b) What is perspective representation? Explain various types of perspective projection? (8)

UNIT - IV

4. a) Write a short Note on the following

i) Gaurand shading

ii) Phong shading

iii) Ray - Tracing Algorithm (4×3=12)

b) Discuss about the difference between CMY and RGB color? (4)

(OR)

4. What are diffused and specular reflection? and write down the illumination model that incorporates both these reflections explain all the variables used in this model? (16)

UNIT - V

5. a) What are Multimedia authoring tools? (8)

b) Explain the different types of data compression technology? (8)

(OR)

5. Write a short Note on :

i) Animation techniques

ii) Architectural and telecommunication considerations. (8×2=16)

6E6024

Roll No. _____ Total No of Pages: 3

6E6024

B. Tech. VI-Sem. (Main/Back) Exam., April/May-2016

Computer Science

6CS4A Computer Graphics and Multimedia Techniques

Time: 3 Hours **Maximum Marks: 80**

Min. Passing Marks (Main & Back): 26

Instructions to Candidates:-

Attempt any five questions, selecting one question from each unit. All Questions carry equal marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly.

Units of quantities used/ calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL 2. NIL

UNIT-I

Q.1 (a) Explain the following terms in context of display devices:

(i) resolution [2]

(ii) flickering [2]

(iii) interlacing [2]

(iv) refreshing [2]

(b) Go through steps of Bresenham's line drawring algorithm for the line segment between end points (21, 12) to (29, 16). [8]

OR

Q.1 (a) Differentiate between Raster and random scan display devices. [6]

(b) Explain beam penetration method. [6]

(c) What is importance of 8 – way symmetry in scan conversion of circle? [4]

UNIT-II

Q.2 (a) Derive composite transformation matrix of translation followed by reflection. [8]

(b) Describe Cohen – Sutherland line clipping algorithm. [8]

OR

Q.2 (a) Differentiate between boundary fill and flood fill techniques. [6]

(b) Provide an example of inverse transformation in homogeneous coordinate system. [6]

(c) Discuss issues related to polygon clipping. [4]

UNIT-III

Q.3 (a) How is image space method different from object space method? [4]

(b) Discuss properties of Bezier curves. [8]

(c) What are the issues related to hidden surfaces? [4]

OR

Q.3 (a) Illustrate depth buffer method with diagrams. [8]

(b) Discuss properties of B-spline curves. [8]

UNIT-IV

Q.4 (a) Discuss following color models -

(i) RGB [4]

(ii) YIQ [4]

(iii) CMY [4]

(b) Describe Phong shading. [4]

OR

Q.4 (a) What are the various aspects of illumination of objects? [8]

(b) Describe Gourand shading. [4]

(c) What is HSV color model? [4]

UNIT-V

Q.5 Write short notes on any two - [8×2=16]

(a) Multimedia components

(b) Steps of animation

(c) Animation techniques

(d) Multimedia techniques

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3 Hours

Maximum Marks : 80
Min. Passing Marks : 26

ctions to Candidates:

*Attempt any **five questions**, selecting **one question** from **each unit**. All questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitable be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.*

Unit-I

a) Explain various application areas of computer graphics. Differentiate beam penetration method of colored CRT with shadow mask method. **(4+4=8)**

b) What steps are required to plot a line whose slope in between 0° and 45° using Bresenham's method? Indicate the raster locations would be chosen by Bresenham's algorithm when scan converting a line from screen coordinate (20,10) to (30,18). **(4+4=8)**

(OR)

1. a) If a TV screen has 525 scan lines and an aspect ratio of 3:4 and if each pixel contains 12 bits of intensity information, how many bits are required for refresh rate 30 frames per second? **(8)**

b) Give the advantages and disadvantages of DDA line algorithm. Explain mid point circle algorithm. **(2+6=8)**

Unit-II

2. a) Show rotation of a 2D Box represented by (5,5) to (10,15) with respect to (5,5) by 90° in anticlockwise direction. **(8)**

b) Explain flood fill algorithm. Differentiate it with Boundary fill algorithm. **(5+3=8)**

(OR)

2. a) Explain Cohen Sutherland line algorithm. **(8)**

b) Show that the composition of two rotations is additive by concatenating the matrix representation for $R(\theta_1)$, and $R(\theta_2)$ to obtain : **(8)**

$R(\theta_1).\ R(\theta_2) = R(\theta_1+\theta_2)$

Unit-III

3. a) Explain the scan line method for displaying the visible surface of a given polyhedron. **(8)**

b) Differentiate B-splines with Bezier curves. Briefly describe B-spline curve. **(3+5=8)**

(OR)

3. a) What is hidden surface problem? Write and explain Z-buffer algorithm for visible surface detection. **(2+6=8)**

b) What is parametric representation of a curve? Explain Bezier curve in detail. **(2+6=8)**

Unit-IV

4. a) Explain following terms : **(3×3=9)**

i) Diffuse reflection

ii) Specular reflection

iii) Illumination model

b) Explain phong shading. Compare it with Gouraud shading. **(4+3=7)**

(OR)

4. a) What is Ray Tracing? Explain Basic ray tracing algorithm. **(2+6=8)**

b) Explain color model RGB. Compare it with HSV. **(5+3=8)**

Unit-V

5. a) Define Animation. Explain principles of animation briefly. **(2+6=8)**

b) What is compression of data? Explain MPEG in detail. **(2+6=8)**

(OR)

5. a) Explain various presentation tools. **(8)**

b) Explain Authority tools with their uses. **(8)**

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5E1354

Roll No. _____ [Total No. of Pages : 2

5E1354

B.Tech. V- Semester (Main) Examination, Nov. - 2019
PCC/PEC Computer Sc. and Engg.
5CS4-04 Computer Graphics and Multimedia
(Common With CS,IT)

Time : 3 Hours **Maximum Marks : 120**
Min. Passing Marks : 42

Instructions to Candidates:

*Attempt **all ten** questions from **Part A**, **five** questions out of **Seven** from **Part B** and **Four** questions out of **Five** from **Part C**.*

Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly. Use of following supporting materials is permitted during examination. (No material is required)

PART - A

(Answer should be given up to **25** words only)

All questions are **compulsory** **(10×2=20)**

1. What is Pixel made of?
2. What is Scan Conversion?
3. Differentiate Plasma panel display and thin film Electroluminous Display.
4. Define Random Scan/Raster Scan display?
5. List out the merit and demerit of punctration technique.
6. Distinguish between convex and concave palygons.
7. What is translations.
8. Distinguish between uniform scaling and differential scaling.
9. List out the various text clipping.
10. Write all steps involved in 3-D Transformations.

PART - B

Attempt any **five** questions **(5×8=40)**

1. Explain scan conversion, write Bresenham's algorithm of line m >1.

2. Use Cohen sutherland line clipping algorithms to find the visible partion of the line P (40,80) Q(120,30) inside the window. The window is defined as ABCD : A(20,20), B(60,20), C(60,40) and D(20,40).
3. Explain in brief RGB, CMY and HSV colour models.
4. What is the use of compression technique in computer graphics? Explain JPEG.
5. Show Rotation of a 2D - Box represented by (5,5) to (10,15) with respect to (5,5) by 90° in anti clockwise direction.
6. Explain the document architecture and formating of files or documents in the multimedia systems.
7. Produce a sequence of transformation of refer on image in the line y = mx+c.

PART - C

Attempt any **Four** questions **(4×15=60)**

1. Explain the function of display processor in Raster scan display compare the merit and demerit of raster and vector devices.
2. Explain Beizer curve and Determine eleven points on a Beizer curve with equidistant parametric value having central points

   $(x_0, y_0) = (50,180), (x_1, y_1) = (250,100), (x_2, y_2) = (600,300), (x_3, y_3) = (500,50)$.
3. Describe different types of Parallel projection used in computer graphics.
4. Describe Z buffer algorithms for visible surface detection. Also explain backface detection method.
5. What is Animation? What are the challenges faced in its implementation? Write the steps in generation of animation.

5E1354

Roll No.

Total No of Pages: 2

5E1354

B. Tech. V - Sem. (Main / Back) Exam., Feb.-March - 2021

Computer Science & Engineering

5CS4 – 04 Computer Graphics & Multimedia

Common for CS, IT

Time: 2 Hours

Maximum Marks: 82

Min. Passing Marks: 29

Instructions to Candidates:

Attempt all ten questions from Part A, four questions out of seven questions from Part B and two questions out of five from Part C.

Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly. Units of quantities used /calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL

2. NIL

PART – A

(Answer should be given up to 25 words only) **[10×2=20]**

All questions are compulsory

Q.1 What is specular reflection?

Q.2 Define Gray Scale.

Q.3 What is Transformations Routine?

Q.4 Define Resolution.

Q.5 What does text clipping mean? Explain.

Q.6 What is morphing?

Q.7 What is Defuse reflection?

Q.8 Define surface rendering.

Q.9 Define Interlacing.

Q.10 What is Animation?

[4760]

PART – B

(Analytical/Problem solving questions) **[4×8=32]**

Attempt any four questions

Q.1 Write short note on: Anti-Aliasing technique?

Q.2 Explain Cohen – Sutherland line clipping Algorithm with region code in detail.

Q.3 Differentiate between boundary fill and flood fill techniques.

Q.4 Write a routine to convert RGB color model to HSV color model.

Q.5 Discuss properties of Bezier curves.

Q.6 Describe Phong Shading in detail.

Q.7 What is Ray Tracing? Explain basic ray tracing algorithm.

PART – C

(Descriptive/Analytical/Problem Solving/Design Questions) **[2×15=30]**

Attempt any two questions

Q.1 In a Raster System with resolution 2560 × 2048. How many pixels could be accessed per second by a display controller that refresh that Screen at a rate of 60 frames per second. Also calculate access time per pixel in the system.

Q.2 During area filling one start with a point inside the program region and point it outward towards boundary. Which fill algorithm is this? Explain it showing how 8 - connected approach fills complex figures.

Q.3 What is homogeneous coordinate? Discuss the composite transformation matrices for two successive translation and scaling.

Q.4 What is the use of compression technique in computer graphics? Explain JPEG and MPEG in detail.

Q.5 Explain Halftone patterns and Dithering techniques in detail.

5E1354

Roll No. _____ Total No. of Pages: 3

5E1354

B. Tech. V - Sem. (Main / Back) Exam., January - 2022
Computer Science & Engineering
5CS4 – 04 Computer Graphics & Multimedia
CS, IT

Time: 3 Hours **Maximum Marks: 120**
Min. Passing Marks: 42

Instructions to Candidates:

Attempt all ten questions from Part A, five questions out of seven questions from Part B and four questions out of five from Part C.

Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly. Units of quantities used /calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL 2. NIL

PART – A

(Answer should be given up to 25 words only) **[10×2=20]**

All questions are compulsory

Q.1 What is resolution in computer graphics?

Q.2 Explain Raster Scan System.

Q.3 Define Aspect ratio.

Q.4 What is the role of Scaling?

Q.5 What is point clipping?

Q.6 What does text clipping mean? Explain.

Q.7 What is Animation?

Q.8 What is Morphing?

Q.9 What is Translation?

Q.10 What is Scan conversion?

PART – B

[5×8=40]

(Analytical/Problem solving questions)

Attempt any five questions

Q.1 Discuss properties of Bezier curves.

Q.2 Describe Phong shading in detail.

Q.3 Explain scan conversion, write Bresenham's algorithm of line $m > 1$.

Q.4 Explain in brief RGB, CMY and HSV colour models.

Q.5 Draw a circle having radius $r = 10$, using mid-point circle generation algorithm.

Q.6 Write short note on –

(a) Cathode ray tube

(b) Anti-aliasing technique

Q.7 Write short note on –

(a) Shadow mask technique

(b) Beam penetration technique

PART – C

(Descriptive/Analytical/Problem Solving/Design Questions) [4×15=60]

Attempt any four questions

Q.1 What is Homogeneous Coordinate? Discuss the composite transformation matrices for two successive translation and scaling.

Q.2 Describe different types of parallel projection used in computer graphics.

Q.3 What is Animation? What are the challenges faced in its implementation? Write the steps in generation of animation.

Q.4 Use Cohen-Sutherland line clipping algorithm to find the visible portion of the line P(40, 80), Q(120, 30) inside the window, the window is defined as ABCD – A(20, 20), B(60, 20), C(60, 40) and D(20, 40)

Q.5 Explain the followings –

(a) Diffuse reflection and Specular reflection

(b) Phong shading

(c) Ray tracing

(d) RGB and CMY colour models

Outcome/Program Specific Outcome	Indicator	Competency
PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.	1.1.1	Apply mathematical techniques such as calculus, linear algebra, and statistics to solve problems
	1.1.2	Apply advanced mathematical techniques to model and solve computer science & engineering problems
	1.2.1	Apply laws of natural science to an engineering problem
	1.3.1	Apply fundamental engineering concepts to solve engineering problems
	1.4.1	Apply computer science & engineering concepts to solve engineering problems.
PO 2: Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2.1.1	Articulate problem statements and identify objectives
	2.1.2	Identify engineering systems, variables, and parameters to solve the problems
	2.1.3	Identify the mathematical, engineering and other relevant knowledge that applies to a given problem
	2.2.1	Reframe complex problems into interconnected sub-problems
	2.2.2	problems Identify, assemble and evaluate information
	2.2.3	Identify existing processes/solution methods for solving the problem, including forming justified approximations and assumptions
	2.2.4	Compare and contrast alternative solution processes to select the best process.
	2.3.1	Combine scientific principles and engineering concepts to formulate model/s (mathematical or otherwise) of a system or process that is appropriate in terms of applicability and required accuracy.
	2.3.2	Identify assumptions (mathematical and physical) necessary to allow modeling of a system at the level of accuracy required.
	2.4.1	Apply engineering mathematics and computations to solve mathematical models
	2.4.2	Produce and validate results through skilful use of contemporary engineering tools and models
	2.4.3	Identify sources of error in the solution process, and limitations of the solution.
	2.4.4	Extract desired understanding and conclusions consistent with objectives and limitations of the analysis
PO 3: Design/Development of Solutions:	3.1.1	Recognize that need analysis is key to good

Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.		**problem definition**
	3.1.2	**Elicit and document, engineering requirements from stakeholders**
	3.1.3	**Synthesize engineering requirements from a review of the state-of-the-art**
	3.1.4	**Extract engineering requirements from relevant engineering Codes and Standards such as IEEE, ACM, ISO etc.**
	3.1.5	**Explore and synthesize engineering requirements considering health, safety risks, environmental, cultural and societal issues**
	3.1.6	**Determine design objectives, functional requirements and arrive at specifications**
	3.2.1	**Apply formal idea generation tools to develop multiple engineering design solutions**
	3.2.2	**Build models/prototypes to develop diverse set of design solutions**
	3.2.3	**Identify suitable criteria for evaluation of alternate design solutions**
	3.3.1	**Apply formal decision making tools to select optimal engineering design solutions for further development**
	3.3.2	**Consult with domain experts and stakeholders to select candidate engineering design solution for further development**
	3.4.1	**Refine a conceptual design into a detailed design within the existing constraints (of the resources)**
	3.4.2	**Generate information through appropriate tests to improve or revise design**
PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	**4.1.1**	**Define a problem, its scope and importance for purposes of investigation**
	4.1.2	**Examine the relevant methods, tools and techniques of experiment design, system calibration, data acquisition, analysis and presentation**
	4.1.3	**Apply appropriate instrumentation and/or software tools to make measurements of physical quantities**
	4.1.4	**Establish a relationship between measured data and underlying physical principles.**
	4.2.1	**Design and develop experimental approach, specify appropriate equipment and procedures**
	4.2.2	**Understand the importance of statistical design of experiments and choose an appropriate experimental design plan based on the study objectives**
	4.3.1	**Use appropriate procedures, tools and**

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		techniques to conduct experiments and collect data
	4.3.2	Analyze data for trends and correlations, stating possible errors and limitations
	4.3.3	Represent data (in tabular and/or graphical forms) so as to facilitate analysis and explanation of the data, and drawing of conclusions
	4.3.4	Synthesize information and knowledge about the problem from the raw data to reach appropriate conclusions
PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	5.1.1	Identify modern engineering tools, techniques and resources for engineering activities
	5.1.2	Create/adapt/modify/extend tools and techniques to solve engineering problems
	5.2.1	Identify the strengths and limitations of tools for (i) acquiring information, (ii) modelling and simulating, (iii) monitoring system performance, and (iv) creating engineering designs.
	5.2.2	Demonstrate proficiency in using discipline specific tools
	5.3.1	Discuss limitations and validate tools, techniques and resources
	5.3.2	Verify the credibility of results from tool use with reference to the accuracy and limitations, and the assumptions inherent in their use.
PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	6.1.1	Identify and describe various engineering roles; particularly as pertains to protection of the public and public interest at global, regional and local level
	6.2.1	Interpret legislation, regulations, codes, and standards relevant to your discipline and explain its contribution to the protection of the public
PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	7.1.1	Identify risks/impacts in the life-cycle of an engineering product or activity
	7.1.2	Understand the relationship between the technical, socio economic and environmental dimensions of sustainability
	7.2.1	Describe management techniques for sustainable development
	7.2.2	Apply principles of preventive engineering and sustainable development to an engineering activity or product relevant to the discipline
PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	8.1.1	Identify situations of unethical professional conduct and propose ethical alternatives
	8.2.1	Identify tenets of the ASME professional code of ethics

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	8.2.2	Examine and apply moral & ethical principles to known case studies
PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	9.1.1	Recognize a variety of working and learning preferences; appreciate the value of diversity on a team
	9.1.2	Implement the norms of practice (e.g. rules, roles, charters, agendas, etc.) of effective team work, to accomplish a goal.
	9.2.1	Demonstrate effective communication, problem solving, conflict resolution and leadership skills
	9.2.2	Treat other team members respectfully
	9.2.3	Listen to other members
	9.2.4	Maintain composure in difficult situations
	9.3.1	Present results as a team, with smooth integration of contributions from all individual efforts
PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	10.1.1	Read, understand and interpret technical and non-technical information
	10.1.2	Produce clear, well-constructed, and well-supported written engineering documents
	10.1.3	Create flow in a document or presentation
	10.2.1	Listen to and comprehend information, instructions, and viewpoints of others
	10.2.2	Deliver effective oral presentations to technical and non- technical audiences
	10.3.1	Create engineering-standard figures, reports and drawings to complement writing and presentations
	10.3.2	Use a variety of media effectively to convey a message in a document or a presentation
PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	11.1.1	Describe various economic and financial costs/benefits of an engineering activity
	11.1.2	Analyze different forms of financial statements to evaluate the financial status of an engineering project
	11.2.1	Analyze and select the most appropriate proposal based on economic and financial considerations.
	11.3.1	Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks.
	11.3.2	Use project management tools to schedule an engineering project so it is completed on time and on budget.
PO 12: Life-long learning: Recognise the need for, and have the preparation and	12.1.1	Describe the rationale for requirement for continuing professional development

technological change.		demonstrate an ability to source information to close this gap
	12.2.1	Identify historic points of technological advance in engineering that required practitioners to seek education in order to stay current
	12.2.2	Recognize the need and be able to clearly explain why it is vitally important to keep current regarding new developments in your field
	12.3.1	Source and comprehend technical literature and other credible sources of information
	12.3.2	Analyze sourced technical and popular information for feasibility, viability, sustainability, etc.
PSO1: Core Engineering Skills: Exhibit fundamental concepts of Data Structures, Databases, Operating Systems, Computer Network, Theory of Computation, Advanced Programming and Software Engineering.	PSO1.1.1	Possess the concepts of Data Structure and Database Management System
	PSO1.1.2	Possess the concepts of core engineering subjects including Operating System, Computer Networks and Software Engineering.
	PSO1.1.3	Apply basic programming skills to solve real world problems
PSO2: Standard Software Engineering practices: Demonstrate an ability to design, develop, test, debug, deploy, analyze, troubleshoot, maintain, manage and secure a software.	PSO2.1.1	Apply fundamental software engineering concepts to solve real world problem
	PSO2.1.2	Possess conceptual knowledge for designing, analysing and testing a software
	PSO2.1.3	Estimate and evaluate the cost related to a Software
PSO3: Future Endeavors: Recognize the need to have knowledge of higher education institutions/ organizations/ companies related to computer science & engineering.	PSO3.1.1	Explore the need of current technology being practised by computer science industry/ institutions.
	PSO3.1.2	Identify the requirement of continuing education through postgraduation like M.Tech., MS, MBA etc.
	PSO3.1.3	List various higher education institutes and organizations related to computer science & engineering.

Course Outcomes Competency Level

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Course Code	Course Name		Course Outcomes	Bloom's Level	PO Indicators	PSO Indicators
5CAI-04	Computer Graphics & Multimedia		Upon successful completion of this course, students should be able to:			
		CO1	***Understand and apply*** basics about computer graphics along with graphics standards	2	2.2,2.3	PSO1.2, PSO1.3
		CO2	***Explain*** and ***analyse*** various algorithms to scan, convert the basic geometrical primitives,, Area filling	1,2,3	1.1,1.5,2.4, 2.7,2.12, 3. 4,3.13,3. 9	PSO1.2, PSO1.3
		CO3	***Explain,*** illustrate ***and design*** various algorithms for 2D transformations and clipping	1,2,3	1.1,1.2,1.5, 2.3,2.4,2.6, 2.10,3.6, 3. 8,3.9	PSO1.2, PSO1.3
		CO4	To ***understand*** the fundamentals concepts of parallel and perspective projections and evaluate various algorithms for 3D transformations	1,2,3	1.1,1.2,1.5, 2.2,2.3,2.6, 2.7,2.10, 3. 9	PSO1.2, PSO1.3
		CO5	***Understand*** various colour models in computer graphics system and develop animated motions through OpenGL	1,2,3	1.5,2.4,2.6, 2.7,2.10, 2. 11,3.4,	PSO1.2, PSO1.3

CO-PO/PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1		1											2		
CO2	2	1	1										2		
CO3	2	1	1										2		
CO4	2	2	1										2		
CO5	1	2	1										2		

Management & Gramothan, Jaipur

I Mid Term Examination, 2022

B.Tech./ Semester –V | **Branch: CS,AI & IT**

Subject: CG&M | **Subject Code : 5CS4-04/5IT4-04**

Time: 1½ Hours | **Maximum Marks : 20**

PART A (Note: All questions carry equal marks, and all are compulsory to attend)

Q 1: Answer the following questions:

A. If a TV screen has 525 scan lines and an aspect ratio of 3:4 and if each pixel contains 12 bits intensity information, how many bits are required for refresh rate 30 frames per second?

B. Compare Raster scan display and Random scan display.

C. What are Graphics software and standards **(3*2=6)**

PART B (Note: Attempt only 2 questions out of 3) **(2*4=8)**

Q 2: Define Computer Graphics. Briefly describe various application areas of Computer Graphics.

Q 3: Compute the pixels on the line from (2,2) to (12,10) using Bresenhams algorithm.

Q 4: State the Problems of Aliasing. Identify the processes used to solve the problem of Aliasing

PART C (Note: Attempt only 1 question out of 2) **(1*6=6)**

Q 5: Categorize the basic transformations in Computer Graphics with suitable example.

Q 6: Derive the various parameters to draw ellipse using mid-point ellipse algorithm? Calculate the intermediate pixels for ellipse having R_x=8 and R_y=6.

Swami Keshvanand Institute of Technology, Management & Gramothan, Ramnagaria, Jagatpura, Jaipur-302017

Analysis of Question Paper

I Mid-Term Examination, November - 2022

Branch/Semester: CS/CS(AI)/IT	**Subject: CGMT**	**Subject Code: 5CS4-04/5CAI4-04/5IT4-04**
Duration: 1.5 hours	**Session (I/II/III): I**	**Max Marks: 20**
Submitted By:		

A. Distribution of Course Outcome and Bloom's Taxonomy in Question Paper

Q. No	Questions	Marks	CO	BL
1(a)	If a TV screen has 525 scan lines and an aspect ratio of 3:4 and if each pixel contains 12 bits intensity information, how many bits are required for refresh rate 30 frames per second?	2	1	5
1(b)	Compare Raster scan display and Random scan display.	2	1	2
1(c)	What are Graphics software and standards	2	1	1
2	Define Computer Graphics. Briefly describe various application areas of Computer Graphics.	4	1	2
3	Compute the pixels on the line from (2,2) to (12,10) using Bresenhams algorithm	4	2	5
4	State the Problems of Aliasing. Identify the processes used to solve the problem of Aliasing	4	2	1
5	Categorize the basic transformations in Computer Graphics with suitable example	6	3	2
6	Derive the various parameters to draw ellipse using mid-point ellipse algorithm? Calculate the intermediate pixels for ellipse having Rx=8 and Ry=6	6	2	5

BL – Bloom's Taxonomy Level
(1- Remembering, 2- Understanding, 3 – Applying, 4 – Analyzing, 5 – Evaluating, 6 - Creating)
CO – Course Outcome

Analysis of Question Paper

I Mid-Term Examination, November - 2022

Branch/Semester: CS/CS(AI)/IT	Subject: CGMT	Subject Code: 5CS4-04/5CAI4-04/5IT4-04
Duration: 1.5 hours	Session (I/II/III): I	Max Marks: 20
Submitted By:		

B. Questions and Course Outcomes (COs) Mapping in terms of correlation

COs	Q1(a)	Q1(b)	Q1(c)	Q2	Q3	Q4	Q5	Q6
CO1	2	3	3	3	-	-	-	-
CO2	-	-	-	-	3	2	-	2
CO3	-	-	-	-	-	-	3	-
CO4	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

C. Mapping of Bloom's Level and Course Outcomes with Question Paper

Bloom's Level Mapping		CO Mapping	
Bloom's Level	Percentage	CO	Percentage
BL1	100%	CO1	100%
BL2	100%	CO2	100%
BL3	100%	CO3	50%
BL4	-	CO4	-
BL5	100%	CO5	-
BL6	-	CO6	-

Question Paper Solution

Branch: CS, CS (AI) and IT **Semester: V** **Subject: Computer Graphics and Multimedia**

Mid Term: I **Submitted By:Ms. Rashmi Dadhich, Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur**

Q 1: Answer the following questions:

A. If a TV screen has 525 scan lines and an aspect ratio of 3:4 and if each pixel contains 12 bits intensity information, how many bits are required for refresh rate 30 frames per second?

Answer: Given 525 scan lines

Vertical pixel = 525, horizontal pixels = 4*525/3 = 700

Resolution = 700 X 525

Number of bits per frame = 700 *525*12*30

B. Compare Raster scan display and Random scan display.

Answer: Differentiate between Random and Raster Scan Display:

Random Scan	Raster Scan
1. It has high Resolution	1. Its resolution is low.
2. It is more expensive	2. It is less expensive
3. Any modification if needed is easy	3.Modification is tough
4. Solid pattern is tough to fill	4.Solid pattern is easy to fill
5. Refresh rate depends or resolution	5. Refresh rate does not depend on the picture.
6. Only screen with view on an area is displayed.	6. Whole screen is scanned.
7. Beam Penetration technology come under it.	7. Shadow mark technology came under this.
8. It does not use interlacing method.	8. It uses interlacing
9. It is restricted to line drawing applications	9. It is suitable for realistic display.

C. What are Graphics software and standards

Answer: **General programming package**

Question Paper Solution

Branch: CS, CS (AI) and IT **Semester: V** **Subject: Computer Graphics and Multimedia** **Mid Term: I** **Submitted By:Ms. Rashmi Dadhich, Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur**

-A general programming package provides an extensive set of graphics function that can be used in high level programming language such as C or FORTRAN.

-It includes basic drawing element shape like line, curves, polygon, color of element transformation etc.

-Example: - GL (Graphics Library).

Special-purpose application package

-Special-purpose application package are customize for particular application which implement required facility and provides interface so that user need not to vary about how it will work (programming). User can simply use it by interfacing with application.

-Example: - CAD, medical and business systems.

Software Standard

-Primary goal of standardize graphics software is portability so that it can be used in any hardware systems & avoid rewriting of software program for different system

Some of these standards are discuss below

Graphical Kernel System (GKS)

-This system was adopted as a first graphics software standard by the international standard organization (ISO) and various national standard organizations including ANSI.

-GKS was originally designed as the two dimensional graphics package and then later extension was developed for three dimensions.

PHIGS (Programmer's Hierarchical Interactive Graphic Standard)

-PHIGS is extension of GKS. Increased capability for object modeling, color specifications, surface rendering, and picture manipulation are provided in PHIGS.

-Extension of PHIGS called **"PHIGS+"** was developed to provide three dimensional surface shading capabilities not available in PHIGS.

PART B (Note: Attempt only 2 questions out of 3) **(2*4=8)**

Q 2: Define Computer Graphics. Briefly describe various application areas of Computer Graphics.

Answer: **Computer Graphics:** Computer Graphics is a branch of Computer Science that deals with generating images with the

aid of computers, using specialized graphical hardware and software

• Broadly, the term Computer Graphics refers to

1. Representation and manipulation of image data by a computer
2. Various technologies used to create and manipulate the images
3. Methods for digitally synthesizing and manipulating visual content

The 3 main tasks of Computer Graphics are:

1. Modelling: Creating and Representing geometry of objects in 3D world
2. Rendering: Generating 2D images of the objects
3. Animation: Describing how objects change in time

Question Paper Solution

Branch: CS, CS (AI) and IT **Semester: V** **Subject: Computer Graphics and Multimedia** **Mid Term: I** **Submitted By:Ms. Rashmi Dadhich, Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur**

Applications of Computer Graphics:

There are various application areas of Computer Graphics in real world, majorly which include:

1. Computer Aided Design
2. Computer Simulation
3. Digital Art
4. Graphics Design
5. Special Effects (Entertainment Industry)
6. Presentation Graphics
7. Education and Training
8. Visualization
9. Image Processing
10. Graphical User Interface

Q 3: Compute the pixels on the linefrom (2,2) to (12,10) using Bresenhams algorithm.

Answer: **Answer: (x1,y1) = (2,2), (x2,y2) = (12,10)**

$\Delta x = 12-2=10$

$\Delta y=10-2=8$

ImI=8/10 <1

P0 = 2Δx-Δx=2x8-10=6, p0 > 0

So the point is (3,3) and p1=p0+2Δy-2Δx=6+2x8-2x10=2

P1>0, so the next point to the plot is (4,4) and

P2 =p1 +2Δy – 2Δx = 2+16 – 20 = -2 so the next point to the plot is (5,4) and

P3=p2+2Δy= -2 + 2x8 = 14

P3>0, so the next point to the plot is (6,5) and

P4=p3+2Δy – 2Δx = 14+ 16 -20 = 10 , so the next point to the plot is (7,6) and

P5=p4 +2Δy-2Δx= 10+ 16 – 20 = 6

P5>0, so the next point to the plot is (8,7) and

P6=p5+2Δy – 2Δx = 6 + 16 - 20 = 2 and

so the next point to the plot is (9,8) and

p7 = p6 +2Δy-2Δx = 2+16 – 20 = -2

p7<0, so the next point to the plot is (10,8) and

p8 = p7 + 2dely = -2 +16 = 14

so the next point to the plot is (11,9) and

p9 = p8 + 2Δy – 2Δx = 14+ 16 – 20 = 10

so the next point to the plot is (12,10)

thus , the pixels on the line are

(2,2) (3,3) (4,4) (5,4) (6,5) (7,6) (8,7) (9,8) (10,8) (11,9) and (12,10)

(3,3)
(4,4)
(5,4)
(6,5)
(7,6)
(8,7)
(9,8)
(10,8)
(11,9)
(12,10)

Question Paper Solution

Branch: CS, CS (AI) and IT **Semester: V** **Subject: Computer Graphics and Multimedia** **Mid Term: I** **Submitted By:Ms. Rashmi Dadhich, Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur**

Q 4: State the Problems of Aliasing. Identify the processes used to solve the problem of Aliasing

Answer: Antialiasing is a technique used in computer graphics to remove the aliasing effect. The aliasing effect is the appearance of jagged edges or "jaggies" in a rasterized image (an image rendered using pixels). The problem of jagged edges technically occurs due to distortion of the image when scan conversion is done with sampling at a low frequency, which is also known as Undersampling. Aliasing occurs when real-world objects which comprise of smooth, continuous curves are rasterized using pixels.

Cause of anti-aliasing is Undersampling. Undersampling results in loss of information of the picture. Undersampling occurs when sampling is done at a frequency lower than Nyquist sampling frequency. To avoid this loss, we need to have our sampling frequency atleast twice that of highest frequency occurring in the object.

This minimum required frequency is referred to as Nyquist sampling frequency (fs):

$f_s = 2 * f_{max}$

This can also be stated as that our sampling interval should be no larger than half the cycle interval. This maximum required the sampling interval is called Nyquist sampling interval Δx_s:

$\Delta x_s = \Delta x_{cycle}/2$

Where $\Delta x_{cycle} = 1/f_{max}$

Methods of Antialiasing (AA) –

Aliasing is removed using four methods: Using high-resolution display, Post filtering (Supersampling), Pre-filtering (Area Sampling), Pixel phasing. These are explained as following below.

1. Using high-resolution display:

   One way to reduce aliasing effect and increase sampling rate is to simply display objects at a higher resolution. Using high resolution, the jaggies become so small that they become indistinguishable by the human eye. Hence, jagged edges get blurred out and edges appear smooth.

   Practical applications:

   For example retina displays in Apple devices, OLED displays have high pixel density due to which jaggies formed are so small that they blurred and indistinguishable by our eyes.

2. Post filtering (Supersampling):In this method, we are increasing the sampling resolution by treating the screen as if it's made of a much more fine grid, due to which the effective pixel size is reduced. But the screen resolution remains the same. Now, intensity from each subpixel is calculated and average intensity of the pixel is found from the average of intensities of subpixels. Thus we do sampling at higher resolution and display the image at lower resolution or resolution of the screen; hence this technique is called supersampling. This method is also known as post filtration as this procedure is done after generating the rasterized image.

   Practical applications:In gaming, SSAA (Supersample Antialiasing) or FSAA (full-scene antialiasing) is used to create best image quality. It is often called the pure AA and hence is very slow and has a very high computational cost. This technique was widely used in early days when better AA techniques were not

available. Different modes of SSAA available are: 2X, 4X, 8X, etc. denoting that sampling is done x times (more than) the current resolution.

A better style of AA is MSAA (multisampling Antialiasing) which is a faster and approximate style of supersampling AA.It has lesser computational cost. Better and sophisticated supersampling techniques are developed by graphics card companies like CSAA by NVIDIA and CFAA by AMD.

3. Pre-filtering (Area Sampling):In area sampling, pixel intensities are calculated proportional to areas of overlap of each pixel with objects to be displayed. Here pixel color is computed based on the overlap of scene's objects with a pixel area.
For example: Suppose, a line passes through two pixels. The pixel covering bigger portion(90%) of line displays 90% intensity while less area(10%) covering pixel displays 10-15% intensity. If pixel area overlaps with different color areas, then the final pixel color is taken as an average of colors of the overlap area. This method is also known as pre-filtering as this procedure is done BEFORE generating the rasterized image. It's done using some graphics primitive algorithms.
4. Pixel phasing:It's a technique to remove aliasing. Here pixel positions are shifted to nearly approximate positions near object geometry. Some systems allow the size of individual pixels to be adjusted for distributing intensities which is helpful in pixel phasing.

PART C (Note: Attempt only 1 question out of 2) **(1*8=8)**

Q 5: Catagorize the basic transformations in Computer Graphics with suitable example.

Answer: Basic Transformation

- Basic transformation includes three transformations **Translation**, **Rotation**, and**Scaling**.
- These three transformations are known as basic transformation because with combination of these three transformations we can obtain anytransformation.

Translation

Question Paper Solution

Branch: CS, CS (AI) and IT **Semester: V** **Subject: Computer Graphics and Multimedia** **Mid Term: I** **Submitted By:Ms. Rashmi Dadhich, Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur**

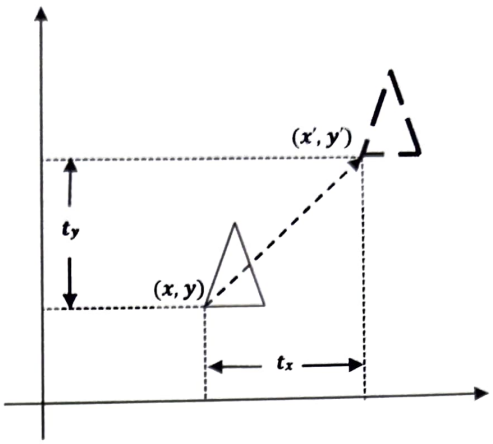

Fig. 3.1: - Translation.

It is a transformation that used to reposition the object along the straight line path from one coordinate location to another.

It is rigid body transformation so we need to translate wholeobject.

We translate two dimensional point by adding translation distance $t_x$and $t_y$to the original coordinate position (x, y) to move at new position (x', y')as:

$x' = x+$ & $y' = y + t_y$

Translation distance pair $(t_x,)$ is called a **Translation Vector** or **ShiftVector**.

We can represent it into single matrix equation in column vectoras;

$P' = P + T$

$[_{y'}] =$

$x\,[_{y}]+$

$t_x\,[t_y]$

We can also represent it in row vector formas:

$P' = P + T$

$[x' \quad y'] = [x \quad y] + [t_x \quad t_y]$

Since column vector representation is standard mathematical notation and since many graphics package like **GKS** and **PHIGS** uses column vector we will also follow column vectorrepresentation.

Example: - Translate the triangle [A (10, 10), B (15, 15), C (20, 10)] 2 unit in x direction and 1 unit in y direction.

We know that

Question Paper Solution

Branch: CS, CS (AI) and IT **Semester: V** **Subject: Computer Graphics and Multimedia** **Mid Term: I** **Submitted By:Ms. Rashmi Dadhich, Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur**

$P' = P + T$

$P' = [P] +$

$t_x [t_y]$

For point (10, 10)

$A' = [^{10}] + [^{2}]$

10 1

$A' = [^{12}]$

11

For point (15, 15)

$B' = [^{15}] + [^{2}]$

15 1

$B' = [^{17}]$

16

For point (10, 10)

$C' = [^{20}] + [^{2}]$

10 1

$C' = [^{22}]$

11

Final coordinates after translation are [A' (12, 11), B' (17, 16), C' (22,11)].

Rotation

- It is a transformation that used to reposition the object along the circular path in the XY -plane.
- To generate a rotation we specify a rotation angle $\theta$and the position of the **Rotation Point (Pivot Point)** $(x_r y_r)$ about which the object is to berotated.
- Positive value of rotation angle defines counter clockwise rotation and negative value of rotation angle defines clockwiserotation.
- We first find the equation of rotation when pivot point is at coordinate origin(**0,0**).

Question Paper Solution

Branch: CS, CS (AI) and IT **Semester: V** **Subject: Computer Graphics and Multimedia** **Mid Term: I** **Submitted By:Ms. Rashmi Dadhich, Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur**

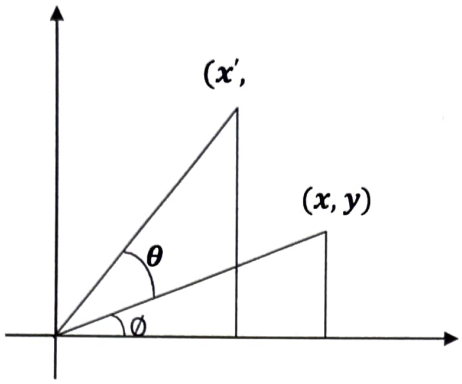

Fig. 3.2: - Rotation.

From figure we canwrite.

$x = r\cos\phi$

$y = r\sin\phi$

and

$x' = r\cos(\theta+\phi) = r\cos\phi\cos\theta - r\sin\phi\sin\theta$

$y' = r\sin(\phi+\theta) = r\cos\phi\sin\theta + r\sin\phi\cos\theta$

Nowreplace$r\cos\phi$with$x$and$r\sin\phi$with$y$inaboveequation.

$x' = x\cos\theta - y\sin\theta$

$y' = x\sin\theta + y\cos\theta$

We can write it in the form of column vector matrix equationas;

$P' = R \cdot P$

Rotation about arbitrary point is illustrated in belowfigure.

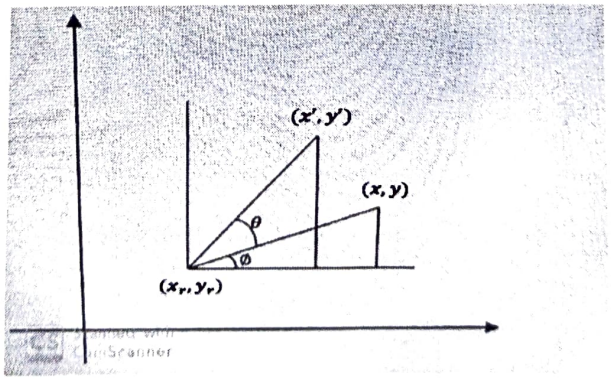

Fig. 3.3: - Rotation about pivot point.

Transformation equation for rotation of a point about pivot point $(x_r, y_r)$is:

$$x' = x_r + (x - x_r)\cos\theta - (y - y_r)\sin\theta$$

$$y' = y_r + (x - x_r)\sin\theta + (y - y_r)\cos\theta$$

These equations are differing from rotation about origin and its matrix representation is alsodifferent.

Its matrix equation can be obtained by simple method that we will discuss later in thischapter.

Rotation is also rigid body transformation so we need to rotate each point ofobject.

Example: - Locate the new position of the triangle [A (5, 4), B (8, 3), C (8, 8)] after its rotation by 90° clockwise about theorigin.

As rotation is clockwise we will take $\theta = -90^\circ$.

Final coordinates after rotation are [A' (4, -5), B' (3, -8), C' (8,-8)].

Scaling

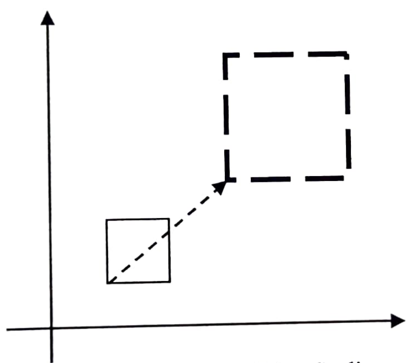

Fig. 3.4: - Scaling.

It is a transformation that used to alter the size of anobject.

This operation is carried out by multiplying coordinate value (x, y) with scaling factor(s_x, s_y) respectively.

So equation for scaling is givenby:

$$x' = x \cdot s_x$$

$$y' = y \cdot s_y$$

These equation can be represented in column vector matrix equationas:

$$P' = S \cdot P$$

Any positive value can be assigned to(s_x, s_y).

- Values less than 1 reduce the size while values greater than 1 enlarge the size of object, and object remains unchanged when values of both factor is1.
- Same values of $s_x$and $s_y$will produce **Uniform Scaling**. And different values of $s_x$and $s_y$will produce *Differential Scaling.*
- Objects transformed with above equation are both scale and repositioned.
- Scaling factor with value less than 1 will move object closer to origin, while scaling factor with value greater than 1 will move object away fromorigin.
- We can control the position of object after scaling by keeping one position fixed called **Fix point** (x_f, y_f) that point will remain unchanged after the scaling transformation.

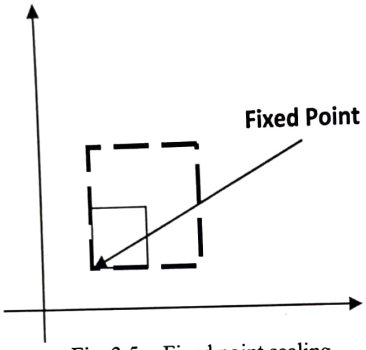

Fig. 3.5: - Fixed point scaling.

Equation for scaling with fixed point position as $(x_f, y_f)$is:

$$x' = x_f + (x - x_f)s_x \qquad y' = y_f + (y - y_f)s_y$$

$$x' = x_f + xs_x - x_f s_x \qquad y' = y_f + ys_y - y_f s_y$$

$$x' = xs_x + x_f(1 - s_x) \qquad y' = ys_y + y_f(1 - s_y)$$

$$\begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Matrix equation for the same will discuss in later section.

Polygons are scaled by applying scaling at coordinates and redrawing while other body like circle and ellipse will scale using its defining parameters. For example ellipse will scale using its semi major axis, semi minor axis and center point scaling and redrawing at thatposition.

Example: - Consider square with left-bottom corner at (2, 2) and right-top corner at (6, 6) apply the transformation which makes its size half.

As we want size half so value of scale factor are s_x= 0.5, s_y= 0.5 and Coordinates of square are [A (2, 2), B (6, 2), C (6, 6), D (2,6)].

$P' = S \cdot P$

Final coordinate after scaling are [A'(1, 1), B' (3, 1), C' (3, 3), D' (1, 3)].

Q 6: Derive the various parameters to draw ellipse using mid-point ellipse algorithm? Calculate the

Question Paper Solution

Branch: CS, CS (AI) and IT Semester: V Subject: Computer Graphics and Multimedia Mid Term: I

Submitted By:Ms. Rashmi Dadhich, Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur

intermediate pixels for ellipse having R_x=8 and R_y=6.

Answer:Mid-Point Ellipse Algorithm :

1. Take input radius along x axis and y axis and obtain center of ellipse.
2. Initially, we assume ellipse to be centered at origin and the first point as : $(x, y_0)= (0, r_y)$.
3. Obtain the initial decision parameter for region 1 as: $p1_0=r_y^2+1/4r_x^2-r_x^2r_y$
4. For every x_k position in region 1 :

   If $p1_k<0$ then the next point along the is (x_{k+1}, y_k) and $p1_{k+1}=p1_k+2r_y^2x_{k+1}+r_y^2$

   Else, the next point is (x_{k+1}, y_{k-1})

   And $p1_{k+1}=p1_k+2r_y^2x_{k+1} - 2r_x^2y_{k+1}+r_y^2$
5. Obtain the initial value in region 2 using the last point (x_0, y_0) of region 1 as: $p2_0=r_y^2(x_0+1/2)^2+r_x^2(y_0-1)^2-r_x^2r_y^2$
6. At each y_k in region 2 starting at k =0 perform the following task.

   If $p2_k<0$ the next point is (x_k, y_{k+1}) and $p2_{k+1}=p2_k-2r_x^2y_{k+1}+r_x^2$
7. Else, the next point is (x_{k+1}, y_{k-1}) and $p2_{k+1}=p2_k+2r_y^2x_{k+1} -2r_x^2y_{k+1}+r_x^2$
8. Now obtain the symmetric points in the three quadrants and plot the coordinate value as: x=x+xc, y=y+yc
9. Repeat the steps for region 1 until $2r_y^2x&gt=2r_x^2y$

Question Paper Solution

Branch: CS, CS (AI) and IT Semester: V Subject: Computer Graphics and Multimedia

Mid Term: I Submitted By:Ms. Rashmi Dadhich, Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur

Given input ellipse parameters $r_x = 8$ and $r_y = 6$, we illustrate the steps in the midpoint ellipse algorithm by determining raster positions along the ellipse path in the first quadrant. Initial values and increments for the decision parameter calculations are

$$2r_y^2 x = 0 \quad \text{(with increment } 2r_y^2 = 72\text{)}$$

$$2r_x^2 y = 2r_x^2 r_y \quad \text{(with increment } -2r_x^2 = -128\text{)}$$

For region 1: The initial point for the ellipse centered on the origin is $(x_0, y_0) = (0, 6)$, and the initial decision parameter value is

$$p1_0 = r_y^2 - r_x^2 r_y + \frac{1}{4} r_x^2 = -332$$

Successive decision parameter values and positions along the ellipse path are calculated using the midpoint method as

k	$p1_k$	(x_{k+1}, y_{k+1})	$2r_y^2 x_{k+1}$	$2r_x^2 y_{k+1}$
0	−332	(1, 6)	72	768
1	−224	(2, 6)	144	768
2	−44	(3, 6)	216	768
3	208	(4, 5)	288	640
4	−108	(5, 5)	360	640
5	288	(6, 4)	432	512
6	244	(7, 3)	504	384

We now move out of region 1, since $2r_y^2 x > 2r_x^2 y$.

For region 2, the initial point is $(x_0, y_0) = (7, 3)$ and the initial decision parameter is

$$p2_0 = f\left(7 + \frac{1}{2}, 2\right) = -151$$

The remaining positions along the ellipse path in the first quadrant are then calculated as

k	$p2_k$	(x_{k+1}, y_{k+1})	$2r_y^2 x_{k+1}$	$2r_x^2 y_{k+1}$
0	−151	(8, 2)	576	256
1	233	(8, 1)	576	128
2	745	(8, 0)	—	—

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Analysis of Question Paper

II Mid-Term Examination, January - 2022

Branch/Semester: CSE/AI/IT	Subject: CGMT	Subject Code: 5CS4-04/5CAI4-04/5IT4-04
Duration: 1.5 hours	Session (I/II/III): I	Max Marks: 20
Submitted By:		

A. Distribution of Course Outcome and Bloom's Taxonomy in Question Paper

Q. No	Questions	Marks	CO	BL
1(a)	Differentiate between parallel and perspective projection.	2	4	1
1(b)	What do you mean by clipping? Write down the condition for point clipping.	2	3	2
1(c)	What is Animation? Write the steps in generation of Animation	2	5	2
2	Explain in brief RGB and HSV color models.	4	5	2
3	Discuss Halftone patterns and Dithering techniques in detail.	4	5	2
4	Discuss Gourand Shading in detail by taking example of polygon and find intensity at any point on edge.	4	4	3
5	Write Cohen-Sutherland line clipping algorithm and find the visible portion of the line P(40,80), Q (120,30) inside the window, the window is defined as ABCD – A (20,20), B (60,20), C (60,40), D (20,40)	6	3	4
6	Given a bezier curve with 4 control points- $B_0[1\ 0]$, $B_1[3\ 3]$, $B_2[6\ 3]$, $B_3[8\ 1]$ Determine any 5 points lying on the curve. Also, draw a rough sketch of the curve.	6	4	5

BL – Bloom's Taxonomy Level
(1- Remembering, 2- Understanding, 3 – Applying, 4 – Analyzing, 5 – Evaluating, 6 - Creating)
CO – Course Outcome

Duration: 1.5 hours	Session (I/II/III): I	Max Marks: 20
Submitted By:		

B. Questions and Course Outcomes (COs) Mapping in terms of correlation

COs	Q1(a)	Q1(b)	Q1(c)	Q2	Q3	Q4	Q5	Q6
CO1	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-
CO3	-	3	-	-	-	-	3	-
CO4	3	-	-	-	-	2	-	2
CO5	-	-	3	3	2	-	-	-

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

C. Mapping of Bloom's Level and Course Outcomes with Question Paper

Bloom's Level Mapping		CO Mapping	
Bloom's Level	Percentage	CO	Percentage
BL1	100%	CO1	-
BL2	100%	CO2	-
BL3	100%	CO3	50%
BL4	100%	CO4	100%
BL5	100%	CO5	100%
BL6	-	CO6	-

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Solution of Question Paper

II Mid-Term Examination, Jan. -2023

Semester: V CSE/V IT.	Subject: CGM	Subject Code: 5CS4-04
: 1.5 hours	Date:07/01/2023 Session (I/II/III):I	Max Marks:20
By: Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur		

Q 1: Answer the following questions:

A. Differentiate between parallel and perspective projection.

SR.NO	Parallel Projection	Perspective Projection
1	Parallel projection represents the object in a different way like telescope.	Perspective projection represents the object in three dimensional way.
2	In parallel projection, these effects are not created.	In perspective projection, objects that are far away appear smaller, and objects that are near appear bigger.
3	The distance of the object from the center of projection is infinite.	The distance of the object from the center of projection is finite.
4	Parallel projection can give the accurate view of object.	Perspective projection cannot give the accurate view of object.
5	The lines of parallel projection are parallel.	The lines of perspective projection are not parallel.
6	Projector in parallel projection is parallel.	Projector in perspective projection is not parallel.
7	Two types of parallel projection : 1.Orthographic, 2.Oblique	Three types of perspective projection: 1.one point perspective, 2.Two point perspective, 3. Three point persp...

8	It does not form realistic view of object.	It forms a realistic view of object.

B. What do you mean by clipping? Write down the condition for point clipping.

clipping is a procedure that identifies those portions of a picture that are either inside or outside of our viewing pane.

In case of point clipping, we only show/print points on our window which are in range of our viewing pane, others points which are outside the range are discarded.

Point Clipping is used to determining, whether the point is inside the window or not. For this following conditions are checked.

1. $x \leq x_{max}$
2. $x \geq x_{min}$
3. $y \leq y_{max}$
4. $y \geq y_{min}$

C. What is Animation? Write the steps in generation of Animation.

The term computer animation generally refers to any time sequence of visual changes in a scene.

In addition to changing object position with translations or rotations, a computer-generated animation could display time variations in object size, color, transparency, or surface texture. Computer animations can be generated by changing camera parameters, such as position, orientation, and

Solution of Question Paper

II Mid-Term Examination, Jan. -2023

nch/Semester: V CSE/V IT.	Subject: CGM	Subject Code: 5CS4-04
ration: 1.5 hours	Date:07/01/2023 Session (I/II/III):I	Max Marks:20
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focal length. Computer animations can also be produced by changing lighting effects.

DESIGN OF ANIMATION SEQUENCES

An animation sequence is designed with the following steps:

- Storyboard layout
- Object definitions
- Key-frame specifications
- Generation of in-between frames

Q 2: Explain in brief RGB and HSV color models.

RGB Model

- The red, green, and blue (RGB) color space is widely used throughout computer graphics.

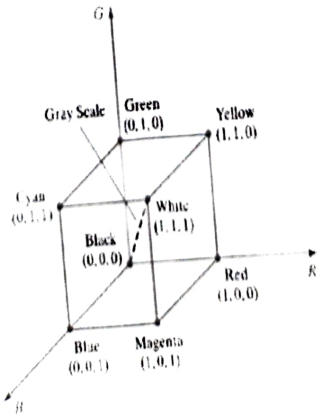
  - Additive Color Model.
  - Unit Cube defined on R, G & B axes.

- The Origin (0,0,0) represents black and thediagonally opposite vertex (1,1,1) is White.

- Vertices of the cube on the axes represent primary colors, and the remaining vertices are the complementary color points for each of theprimary colors.

- Shades of gray are represented along the 16 main diagonal.

Each color point within the unit cube can be represented asw weighted vector



sum of the primary colors, using unit vectors **R**,**G** and **B**.

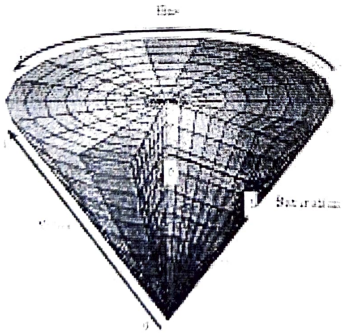
$$C(\lambda) = (R,G,B) = RR + GG + BB$$

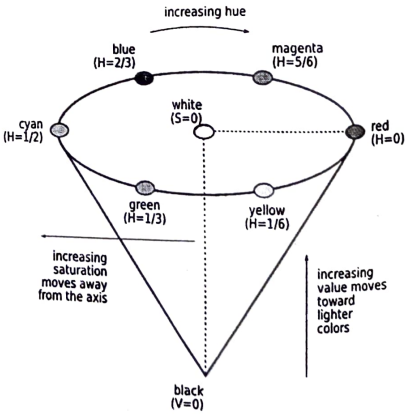
Where R,G, and B are assigned values in the range from 0to 1.0.

For example , the magenta vertex is obtained by adding the maximum red and blue values to produce : (1,0,1)

HSV Model

Every color is represented by three components Hue (H), Saturation (S) and Value (V)





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Solution of Question Paper

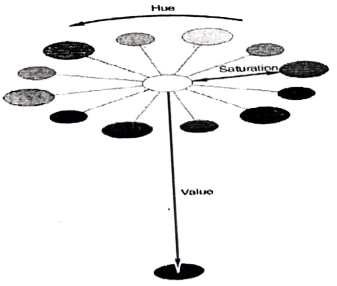
II Mid-Term Examination, Jan. -2023

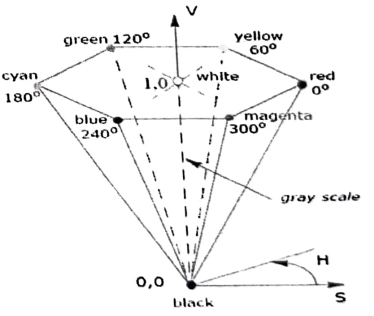
Branch/Semester: V CSE/V IT.	**Subject: CGM**	**Subject Code: 5CS4-04**
Duration: 1.5 hours	**Date:07/01/2023 Session (I/II/III):I**	**Max Marks:20**
Submitted By: Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur		

HSV Model

The **Hue (H)** of a color refers to which pure color it resembles.All tints, tones and shades of red have the same hue. (simply the color we see)

SV Model





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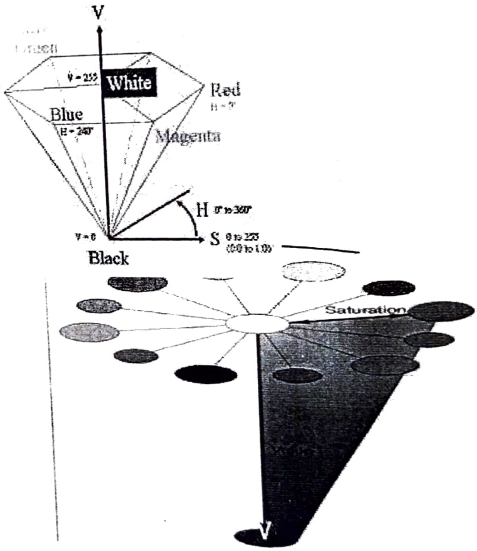
Solution of Question Paper

II Mid-Term Examination, Jan. -2023

Branch/Semester: V CSE/V IT.	Subject: CGM	Subject Code: 5CS4
Duration: 1.5 hours	Date:07/01/2023 Session (I/II/III):I	Max Marks:20
Submitted By: Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur		

The **Saturation (S)** of a color describes how white the color is.Or the amount of white added to the color. A pure red is fully saturated (S=1) means no white added

The **Value (V)** of a color, also called its lightness, describeshow dark the color is. A value of 0 is black, with increasing lightness moving away from bla-1.



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Solution of Question Paper

II Mid-Term Examination, Jan. -2023

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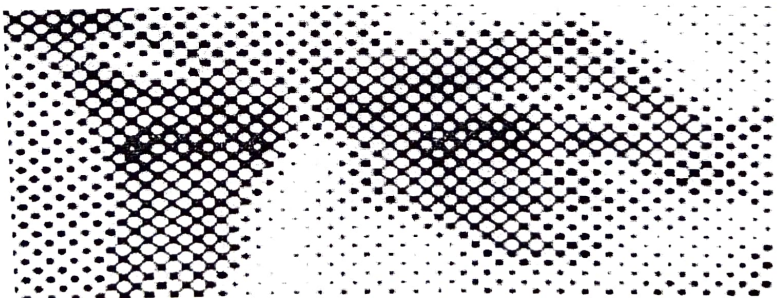
Submitted By: Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur		

Q 3: Discuss Halftone patterns and Dithering techniques in detail.

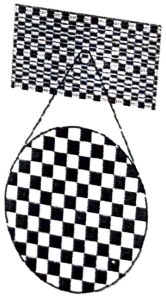
Halftone

A technique used in newspaper printing Only two intensities are possible, blob of ink and no blob ofink. But, the size of the blob can be varied



Dithering

The process of approximating colors you don't have bymixing colors you do have.



Half toning is the reproduction of grayscale images using dots but with varying size.

Typical Application Laser printer.

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Solution of Question Paper

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If a monitor can't show a certain color, dithering approximates the color by placing close together pixels in colors that the computer can display.

Typical Application Web graphic designers often limit their images to 256 colors and use dithering to imply other colors.

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Solution of Question Paper

II Mid-Term Examination, Jan. -2023

Branch/Semester: V CSE/V IT.	Subject: CGM	Subject Cod
Duration: 1.5 hours	Date:07/01/2023 Session (I/II/III):I	Max Marks:2
Submitted By: Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur		

Half tonning Technique:

1. Newspaper, photographs simulate a grey-scale image that can printed using only black ink.
2. A newspaper picture is, in fact, made up of a pattern of tiny black dots of varying size.
3. The human visual system has a tendency to average brightness over small areas, so the black dots and their white background merge and are perceived as an intermediate shade of grey.
4. The process of generating a binary pattern of black and white dots from an image is termed half toning.
5. In traditional newspaper and magazine production, this process is carried out photographically by projection of a transparency through a 'halftone screen' onto film.
6. The screen is a glass plate with a grid etched into it.
7. Different screens can be used to control the size and shape of the dots in the half toned image.
8. In computer graphics, half toning reproductions are approximated using rectangular pixel region say 2 x 2 pixels or 3 x 3 pixels.
9. These regions are called as “Halftone Patters” or “Pixel Patterns”.
10. 2 x 2 pixel patterns for creating five intensity levels are shown in figure 43.

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Solution of Question Paper

II Mid-Term Examination, Jan. -2023

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ubmitted By: Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur		Max Marks:20

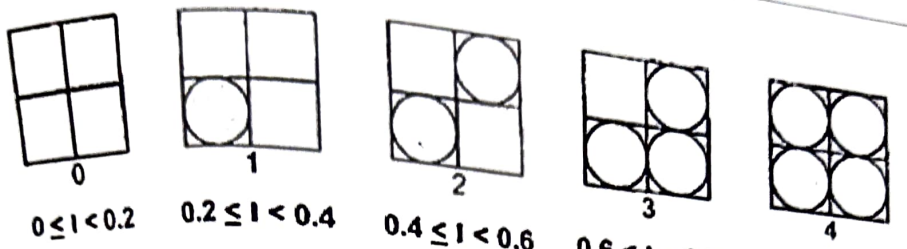


Figure 43

3 x 3 pixel patterns for creating ten intensity levels are shown in figure 44.

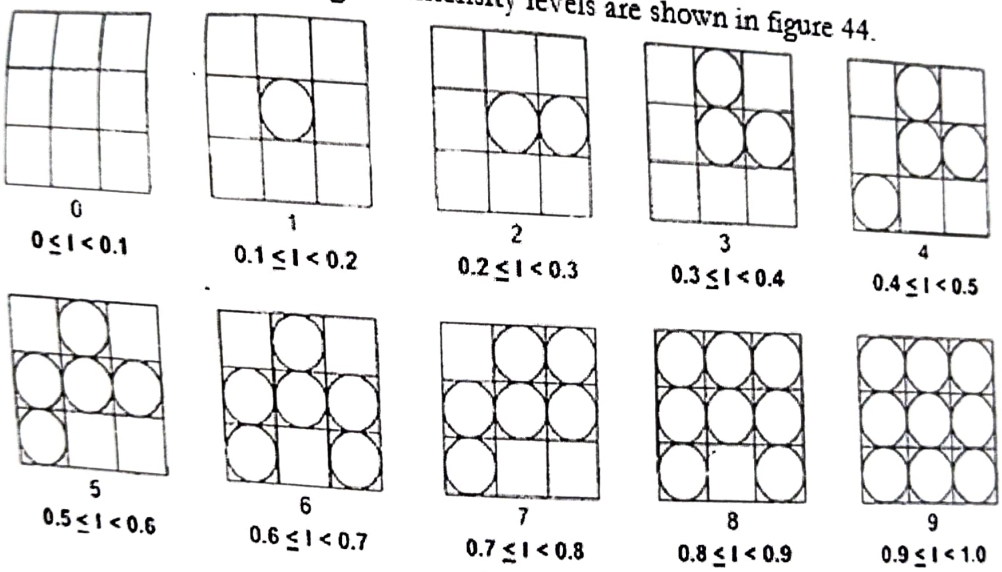


Figure 44

Dithering technique:

1. Another technique for digital half toning is dithering.
2. It is the technique for approximating halftones without reducing resolution, as pixel grid patterns do.
3. Dithering can be accomplished by Thresholding the image against a dither matrix.
4. To obtain n2 intensity levels, it is necessary to setup an n x n dither matrix Dn whose elements are distinct positive integers in the range of 0 to n2 – 1.
5. Matrix for 4 intensity level and 9 intensity level is shown below.

Solution of Question Paper

II Mid-Term Examination, Jan. -2023

Branch/Semester: V CSE/V IT.	Subject: CGM	Subject Code: 5C
Duration: 1.5 hours	Date:07/01/2023 Session (I/II/III):I	Max Marks:20
Submitted By: Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur		

$$D2 = \begin{bmatrix} 3 & 1 \\ 0 & 2 \end{bmatrix} \qquad D3 = \begin{bmatrix} 7 & 2 & 6 \\ 4 & 0 & 1 \\ 3 & 8 & 5 \end{bmatrix}$$

1. The elements of a dither matrix are thresholds.
2. The matrix is laid like a tile over the entire image and each pixel value is compared with the corresponding threshold from the matrix.
3. The pixel becomes white if its value exceeds the threshold or black otherwise.
4. This approach produces an output image with the same dimensions as the input image, but with less detail visible.
5. High order dither matrices can be obtained from lower order matrices with the recurrence relation.

$$D_n = \begin{bmatrix} 4D_{n/2} + D_2(1,1)u_{n/2} & 4D_{n/2} + D_2(1,2)u_{n/2} \\ 4D_{n/2} + D_2(2,1)u_{n/2} & 4D_{n/2} + D_2(2,2)u_{n/2} \end{bmatrix}$$

Algorithm to halftone an image using a dither matrix

```
For all x & y do
    if f(x,y) > m(x,y) then
        g(x,y) = white
    else
        g(x,y) = black
    end if
End for
```

Step3:If the OR operation gives 0000

Then

line is considered to be visible

else

Perform AND operation on both endpoints

If And ≠ 0000

then the line is invisible

else

And=0000

Line is considered the clipped case.

Step4:If a line is clipped case, find an intersection with boundaries of the window

m=(y2-y1)(x2-x1)

(a) If bit 1 is "1" line intersects with left boundary of rectangle window

y3=y1+m(x-X1)

where X = Xwmin

where Xwminis the minimum value of X co-ordinate of window

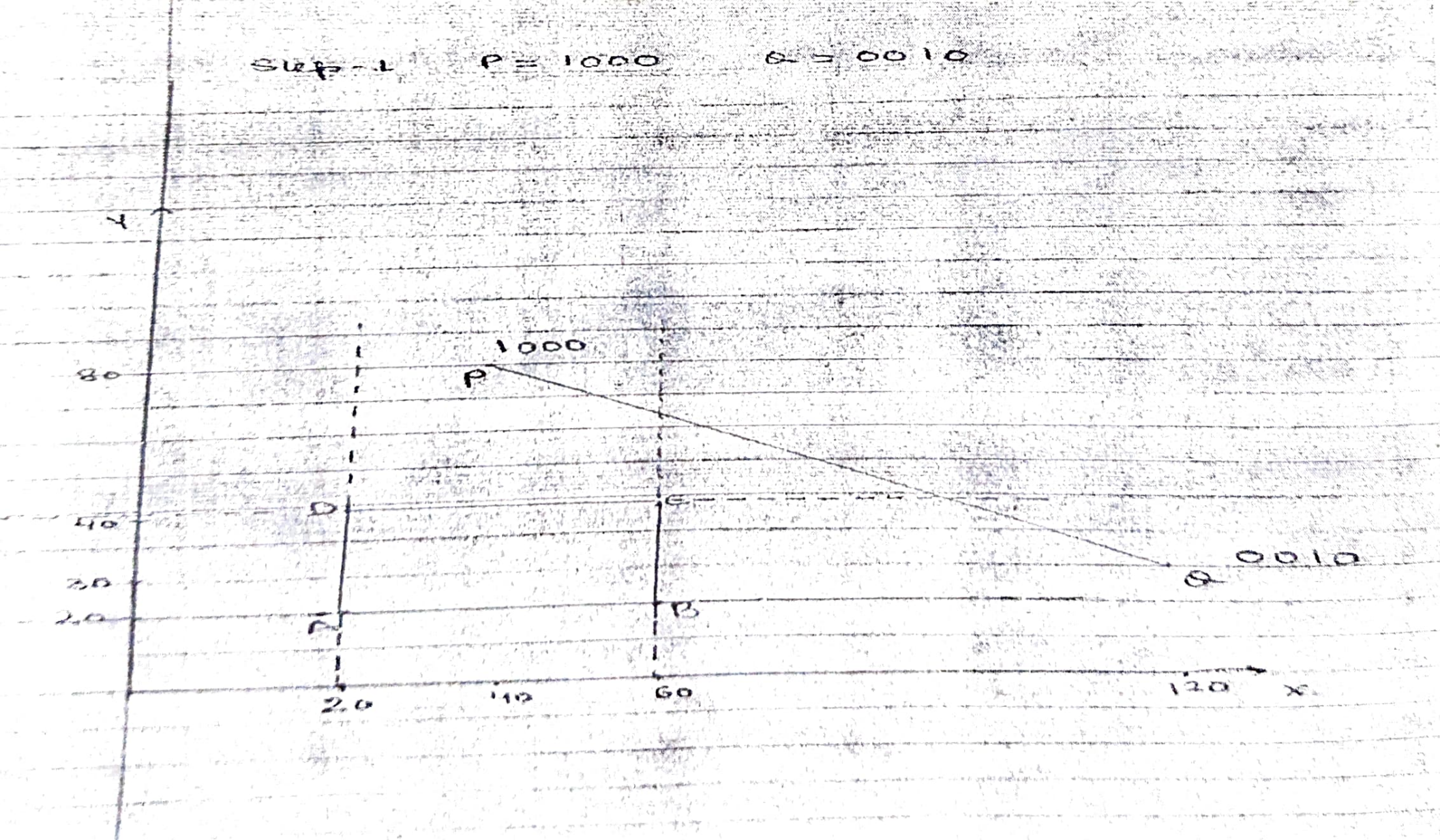
(b) If bit 2 is "1" line intersect with right boundary

y3=y1+m(X-X1)

where X = Xwmax

where X more is maximum value of X co-ordinate of the window

Step - 1 P = 1000 Q = 0010



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...ion: 1.5 hours	Date:07/01/2023 Session (I/II/III):I	Max Marks:20
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...have-

The given curve is defined by 4 control points.
So, the given curve is a cubic bezier curve.

...he parametric equation for a cubic bezier curve is-

$$P(t) = B_0(1-t)^3 + B_1 3t(1-t)^2 + B_2 3t^2(1-t) + B_3 t^3$$

Substituting the control points B_0, B_1, B_2 and B_3, we get-

$P(t) = [1\ 0](1-t)^3 + [3\ 3]3t(1-t)^2 + [6\ 3]3t^2(1-t) + [8\ 1]t^3$ .....(1)

Now,

To get 5 points lying on the curve, assume any 5 values of t lying in the range $0 <= t <= 1$.

Let 5 values of t are 0, 0.2, 0.5, 0.7, 1

For t = 0:

Substituting t=0 in (1), we get-

$P(0) = [1\ 0](1-0)^3 + [3\ 3]3(0)(1-t)^2 + [6\ 3]3(0)^2(1-0) + [8\ 1](0)^3$

$P(0) = [1\ 0] + 0 + 0 + 0$

$P(0) = [1\ 0]$

For t = 0.2:

Substituting t=0.2 in (1), we get-

$P(0.2) = [1\ 0](1-0.2)^3 + [3\ 3]3(0.2)(1-0.2)^2 + [6\ 3]3(0.2)^2(1-0.2) + [8\ 1](0.2)^3$

$P(0.2) = [1\ 0](0.8)^3 + [3\ 3]3(0.2)(0.8)^2 + [6\ 3]3(0.2)^2(0.8) + [8\ 1](0.2)^3$

$P(0.2) = [1\ 0] \times 0.512 + [3\ 3] \times 3 \times 0.2 \times 0.64 + [6\ 3] \times 3 \times 0.04 \times 0.8 + [8\ 1] \times 0.008$

$P(0.2) = [1\ 0] \times 0.512 + [3\ 3] \times 0.384 + [6\ 3] \times 0.096 + [8\ 1] \times 0.008$

$P(0.2) = [0.512\ 0] + [1.152\ 1.152] + [0.576\ 0.288] + [0.064\ 0.008]$

$P(0.2) = [2.304\ 1.448]$

For t = 0.5:

Substituting t=0.5 in (1), we get-

$P(0.5) = [1\ 0](1-0.5)^3 + [3\ 3]3(0.5)(1-0.5)^2 + [6\ 3]3(0.5)^2(1-0.5) + [8\ 1](0.5)^3$

$P(0.5) = [1\ 0](0.5)^3 + [3\ 3]3(0.5)(0.5)^2 + [6\ 3]3(0.5)^2(0.5) + [8\ 1](0.5)^3$

$P(0.5) = [1\ 0] \times 0.125 + [3\ 3] \times 3 \times 0.5 \times 0.25 + [6\ 3] \times 3 \times 0.25 \times 0.5 + [8\ 1] \times 0.125$

$P(0.5) = [1\ 0] \times 0.125 + [3\ 3] \times 0.375 + [6\ 3] \times 0.375 + [8\ 1] \times 0.125$

$P(0.5) = [0.125\ 0] + [1.125\ 1.125] + [2.25\ 1.125] + [1\ 0.125]$

$P(0.5) = [4.5\ 2.375]$

For t = 0.7:

Substituting t=0.7 in (1), we get-

$P(t) = [1\ 0](1-t)^3 + [3\ 3]3t(1-t)^2 + [6\ 3]3t^2(1-t) + [8\ 1]t^3$

$P(0.7) = [1\ 0](1-0.7)^3 + [3\ 3]3(0.7)(1-0.7)^2 + [6\ 3]3(0.7)^2(1-0.7) + [8\ 1](0.7)^3$

$P(0.7) = [1\ 0](0.3)^3 + [3\ 3]3(0.7)(0.3)^2 + [6\ 3]3(0.7)^2(0.3) + [8\ 1](0.7)^3$

$P(0.7) = [1\ 0] \times 0.027 + [3\ 3] \times 3 \times 0.7 \times 0.09 + [6\ 3] \times 3 \times 0.49 \times 0.3 + [8\ 1] \times 0.343$

$P(0.7) = [1\ 0] \times 0.027 + [3\ 3] \times 0.189 + [6\ 3] \times 0.441 + [8\ 1] \times 0.343$

$P(0.7) = [0.027\ 0] + [0.567\ 0.567] + [2.646\ 1.323] + [2.744\ 0.343]$

$P(0.7) = [5.984\ 2.233]$

For t = 1:

Substituting t=1 in (1), we get-

Solution of Question Paper

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By: Mr. Harpreet Singh Gill, Mr. Manish Bhardwaj, Dr. S.R. Dogiwal, Mr Sumit Mathur		Max Marks:20

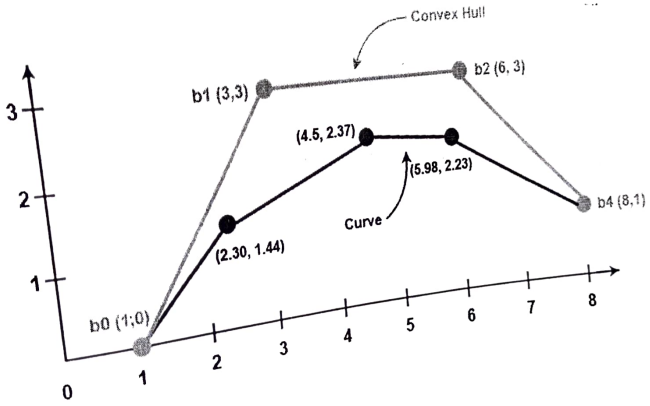
$0](1-1)^3 + [3\ 3]3(1)(1-1)^2 + [6\ 3]3(1)^2(1-1) + [8\ 1](1)^3$

$1\ 0] \times 0 + [3\ 3] \times 3 \times 1 \times 0 + [6\ 3] \times 3 \times 1 \times 0 + [8\ 1] \times 1$

$) + 0 + 0 + [8\ 1]$

$8\ 1]$

ing is the required rough sketch of the curve-



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Session 2022-23

Assignment 1 for students debarred in MidTerm-01

Branch: CSE **Semester: V** **Subject: CGMT (5CS21-04)**

(All questions are compulsory)

PART A

Q 1: Answer the following questions:

A. If a TV screen has 525 scan lines and an aspect ratio of 3:4 and if each pixel contains 12 bits intensity information, how many bits are required for refresh rate 30 frames per second?

B. Compare Raster scan display and Random scan display.

C. What are Graphics software and standards

PART B

Q 2: Define Computer Graphics. Briefly describe various application areas of Computer Graphics.

Q 3: Compute the pixels on the line from (2,2) to (12,10) using Bresenham's algorithm.

Q 4: State the Problems of Aliasing. Identify the processes used to solve the problem of Aliasing

PART C

Q 5: Categorize the basic transformations in Computer Graphics with suitable example.

Q 6: Derive the various parameters to draw ellipse using mid-point ellipse algorithm? Calculate the intermediate pixels for ellipse having R_x=8 and R_y=6.

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Assignment-1

Part – A

1. Write down application areas of computer graphics.
2. Define random scan system.
3. Define Raster scan system.
4. Draw conceptual diagram of DVST.
5. Write down drawbacks of DVST.
6. Write down computer graphics standards and software's.
7. Aliasing and Anti-aliasing.
8. Scaling vs rotation.
9. Transformation matrix for reflection and translation.
10. Homogenous coordinates.

Part – B

1. Explain mid-point line algorithm.
2. Explain mid-point circle algorithm.
3. Explain mid-point ellipse algorithm.
4. Write down the steps for Cohen-Sutherland line clipping algorithm.
5. Write down the steps for Cyrus Beck line clipping algorithm.

Part – C

1. Consider the line from (5,5) to (13,9). Use Bresenham's line algorithm to draw this line.
2. Draw a line using DDA from points (0,0) to (6,6).
3. Draw line from (1,1) to (8,7) using Bresenham's line algorithm.
4. Consider a point (4,3) is rotated counterclockwise by an angle of 45°. find the rotation matrix and resultant point.

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Assignment-2

Part – A

1. What do you mean by clipping? Write down the condition for point clipping.
2. Differentiate between parallel and perspective projection.
3. What do you mean by 3D translation?
4. Cube representation of RGB color model
5. Differentiate between HSV and HLS color model
6. Various curve representation techniques
7. What do you mean by spline representation?
8. Inside outside test for polygon clipping.
9. Write short notes on Koch curve and C Curve
10. Write short notes on morphing and Tweening.

Part – B

1. Explain Bezier and B-spline curve with its definition, diagram, equation and properties.
2. Explain cubic spline interpolation.
3. Define animation and its type. Explain principles of animation.
4. Define projection and its types.
5. Write short notes on:
   a. Ambient light
   b. Specular reflection
   c. Diffuse reflection
   d. Differences between Phong shading and Gouroud shading.

Part – C

1. Construct the Bezier curve of order 3 and with 4 polygon vertices A(1,1), B(2,3) , C(4,3) and D(6,4)
2. A triangle is defined by 3 vertices A(0,2,1), B(2,3,0) and C(1,2,1) find the final coordinates after it is rotated by 45^{O} around a line joining the points (2,2,2) and (1,1,1).
3. Find the clipping coordinates for a line p1 p2 where p1=(10,10) and p2 = (60,30), against window with (X_{min}, Y_{min}) = (15,15) and (X_{max}, Y_{max}) = (25,25) using Liang Barsky algorithm.
4. Use Cohen-Sutherland algorithm to clip two lines p1(40,15) , p2(75,45), p3(70,20) and p4(100,10) against the window A(50,10), B(80,10), C(80,40) and D(50,40).
5. Complete the position of Bezier curve P(t) at the times t=0.2, 0.5 and 0.9 when 4 control points are (2,3), (6,6), (8,1) and (4,-3).

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Syllabus:-

Unit-1

Basic of Computer Graphics: Basic of Computer Graphics, Applications of computer graphics, Display devices, Random and Raster scan systems, Graphics input devices, Graphics software and standards

DEFINITION OF COMPUTER GRAPHICS

Computer Graphics is principally concerned with the generation of images, with wide ranging applications from entertainment to scientific visualization.

OR

computer graphics is a rendering tool for the generation and manipulation of images.

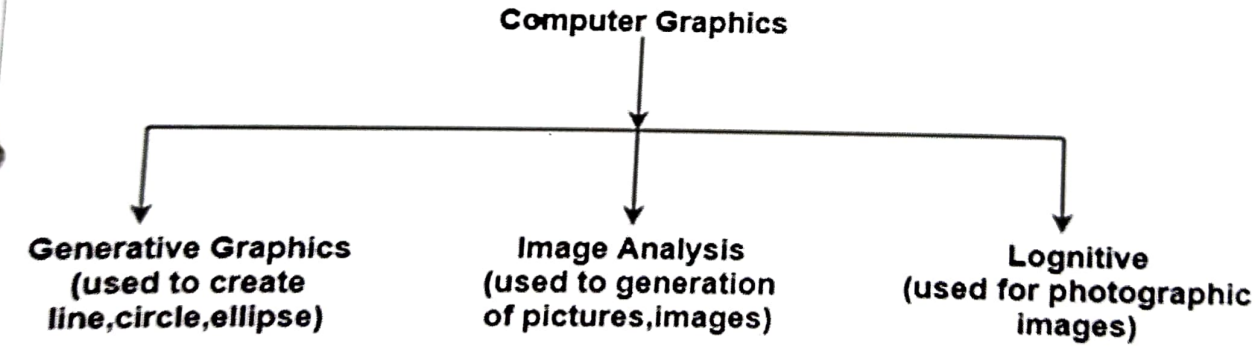
OR

by using a computer as a rendering tool for the generation and manipulation of images is called computer graphics.

Computer graphics is an art of drawing pictures on computer screens with the help of programming. It involves computations, creation, and manipulation of data.

The end product of the computer graphics is a picture it may be a business graph, drawing, and engineering.

In computer graphics, two or three-dimensional pictures can be created that are used for research. Many hardware devices algorithm has been developing for improving the speed of picture generation with the passes of time.



Why computer graphics used?

Suppose a shoe manufacturing company want to show the sale of shoes for five years. For this vast amount of information is to store. So a lot of time and memory will be needed. This method will be tough to understand by a common man. In this situation graphics is a better alternative. Graphics tools are charts and graphs. Using graphs, data can be represented in pictorial form. A picture can be understood easily just with a single look.

Application of Computer Graphics

1. Education and Training: Computer-generated model of the physical, financial and economic system is

often used as educational aids. Model of physical systems, physiological system, population trends or equipment can help trainees to understand the operation of the system.
For some training applications, particular systems are designed. For example Flight Simulator.
Flight Simulator: It helps in giving training to the pilots of airplanes. These pilots spend much of their training not in a real aircraft but on the ground at the controls of a Flight Simulator.

Advantages:

1. Fuel Saving
2. Safety
3. Ability to familiarize the training with a large number of the world's airports.

2. Use in Biology: Molecular biologist can display a picture of molecules and gain insight into their structure with the help of computer graphics.
3. Computer-Generated Maps: Town planners and transportation engineers can use computer-generated maps which display data useful to them in their planning work.
4. Architect: Architect can explore an alternative solution to design problems at an interactive graphics terminal. In this way, they can test many more solutions that would not be possible without the computer.
5. Presentation Graphics: Example of presentation Graphics are bar charts, line graphs, pie charts and other displays showing relationships between multiple parameters. Presentation Graphics is commonly used to summarize

- Financial Reports
- Statistical Reports
- Mathematical Reports
- Scientific Reports
- Economic Data for research reports
- Managerial Reports
- Consumer Information Bulletins
- And other types of reports

6. Computer Art: Computer Graphics are also used in the field of commercial arts. It is used to generate television and advertising commercial.
7. Entertainment: Computer Graphics are now commonly used in making motion pictures, music videos and television shows.
8. Visualization: It is used for visualization of scientists, engineers, medical personnel, business analysts for the study of a large amount of information.
9. Educational Software: Computer Graphics is used in the development of educational software for making computer-aided instruction.
10. Printing Technology: Computer Graphics is used for printing technology and textile design.

Example of Computer Graphics Packages:

COREL DRAW
AUTO CAD

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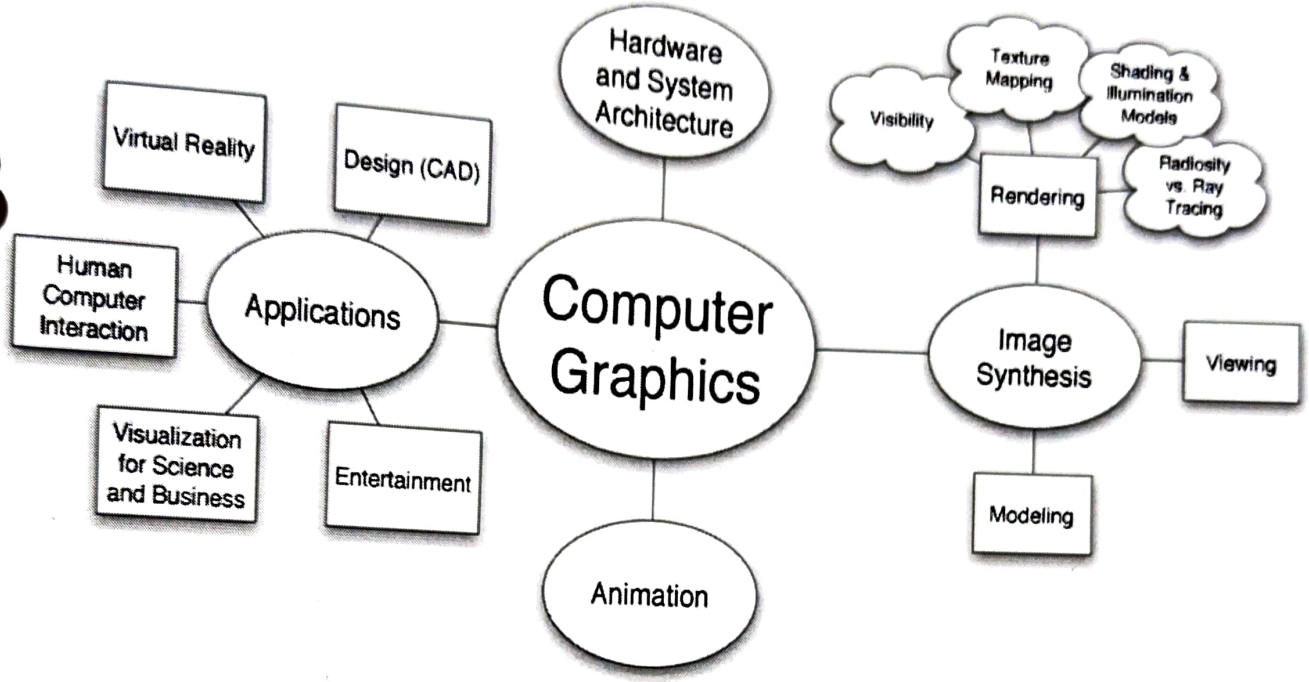
What Is Computer Graphics?



© Torsten Möller

Display Devices:

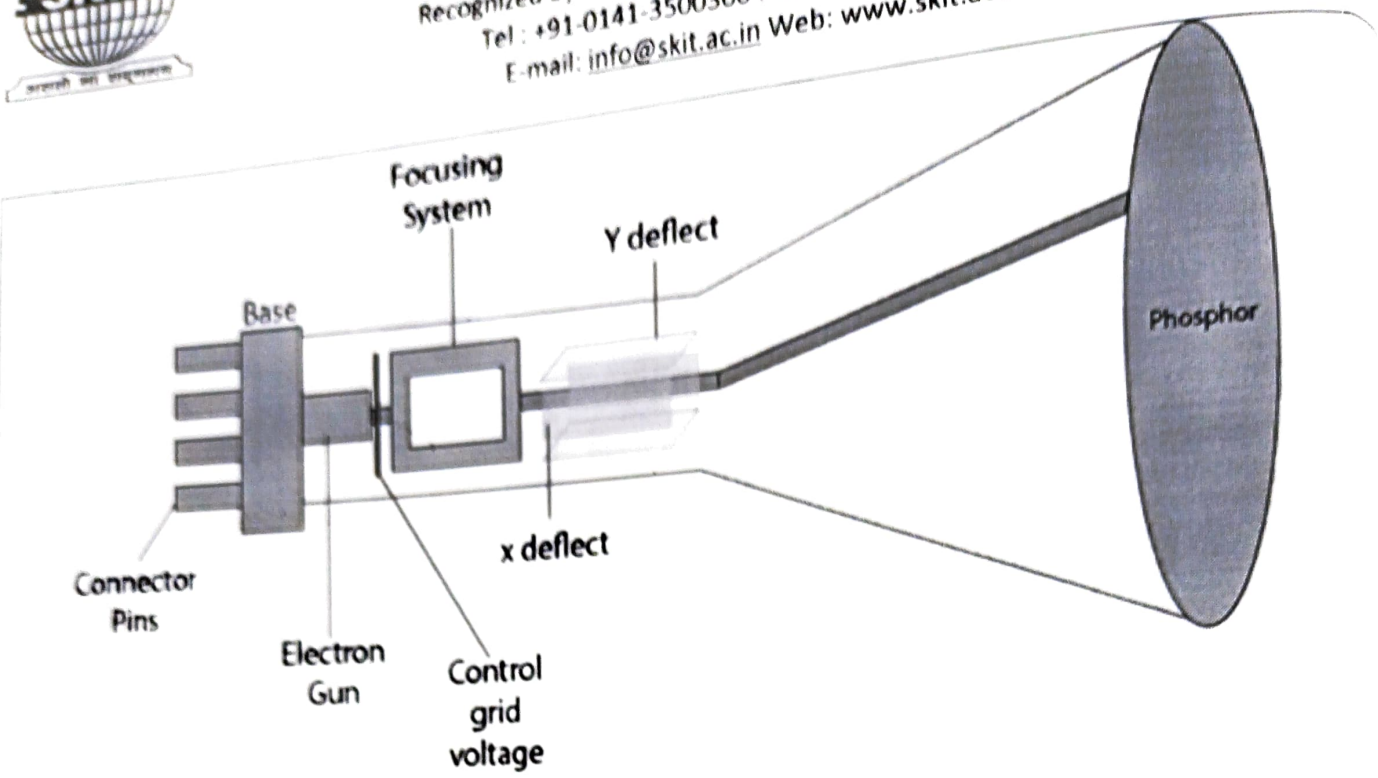
The most commonly used display device is a video monitor. The operation of most video monitors based on CRT (Cathode Ray Tube). The following display devices are used:

1. Refresh Cathode Ray Tube
2. Random Scan and Raster Scan
3. Color CRT Monitors
4. Direct View Storage Tubes
5. Flat Panel Display
6. Lookup Table

Cathode Ray Tube (CRT):

CRT stands for Cathode Ray Tube. CRT is a technology used in traditional computer monitors and televisions. The image on CRT display is created by firing electrons from the back of the tube of phosphorus located towards the front of the screen.

Once the electron heats the phosphorus, they light up, and they are projected on a screen. The color you view on the screen is produced by a blend of red, blue and green light.



Cathode Ray Tube

Components **of CRT:**

Main Components of CRT are:

1. **Electron Gun:** Electron gun consisting of a series of elements, primarily a heating filament (heater) and a cathode. The electron gun creates a source of electrons which are focused into a narrow beam directed at the face of the CRT.
2. **Control Electrode:** It is used to turn the electron beam on and off.
3. **Focusing system:** It is used to create a clear picture by focusing the electrons into a narrow beam.
4. **Deflection Yoke:** It is used to control the direction of the electron beam. It creates an electric or magnetic field which will bend the electron beam as it passes through the area. In a conventional CRT, the yoke is linked to a sweep or scan generator. The deflection yoke which is connected to the sweep generator creates a fluctuating electric or magnetic potential.
5. Phosphorus-coated **screen:** The inside front surface of every CRT is coated with phosphors. Phosphors glow when a high-energy electron beam hits them. Phosphorescence is the term used to characterize the light given off by a phosphor after it has been exposed to an electron beam.

Random Scan and Raster Scan Display:

Random Scan Display:

Random Scan System uses an electron beam which operates like a pencil to create a line image on the CRT screen. The picture is constructed out of a sequence of straight-line segments. Each line segment is drawn on the screen by directing the beam to move from one point on the screen to the next, where its x & y coordinates define each point. After drawing the picture. The system cycles back to the first line and design all the lines of the image 30 to 60 time each second. The process is shown in fig:

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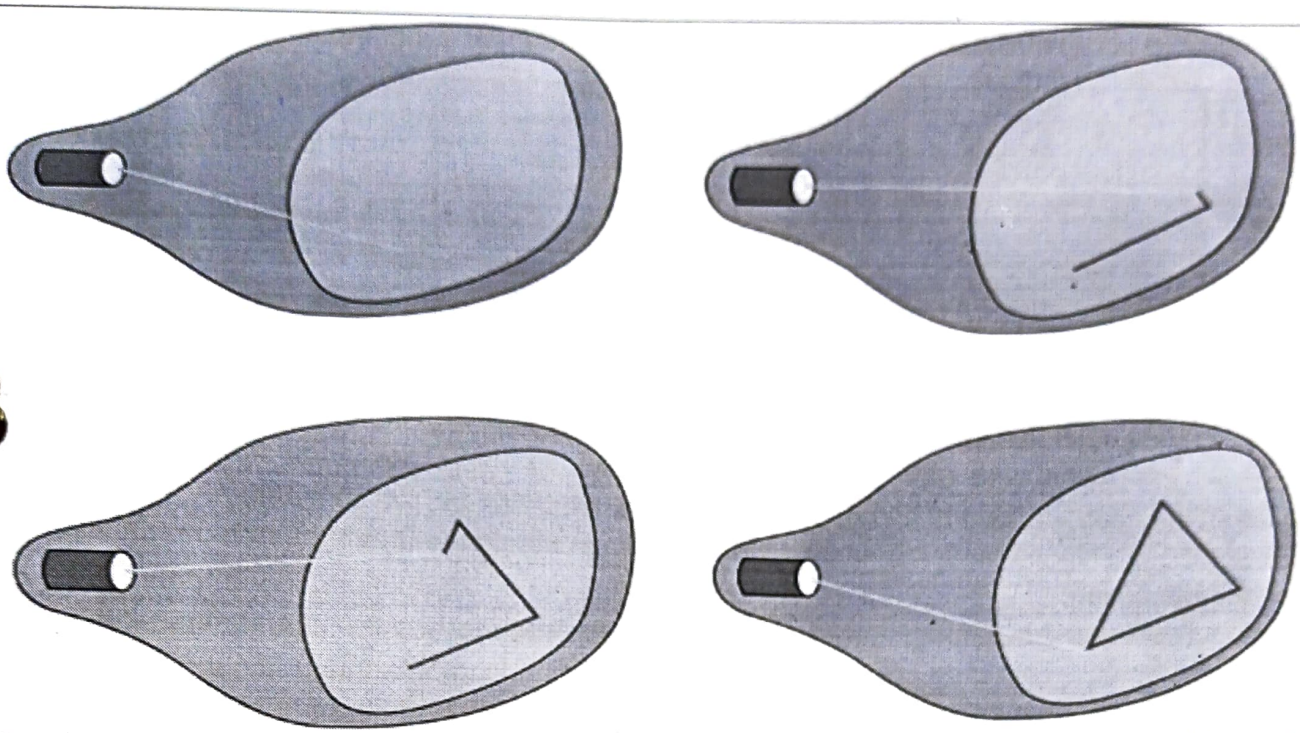

Random-scan monitors are also known as vector displays or stroke-writing displays or calligraphic displays.

Advantages:

1. A CRT has the electron beam directed only to the parts of the screen where an image is to be drawn.
2. Produce smooth line drawings.
3. High Resolution

Disadvantages:

1. Random-Scan monitors cannot display realistic shades scenes.

Raster Scan Display:

A Raster Scan Display is based on intensity control of pixels in the form of a rectangular box called Raster on the screen. Information of on and off pixels is stored in refresh buffer or Frame buffer. Televisions in our house are based on Raster Scan Method. The raster scan system can store information of each pixel position, so it is suitable for realistic display of objects. Raster Scan provides a refresh rate of 60 to 80 frames per second.

Frame Buffer is also known as Raster or bit map. In Frame Buffer the positions are called picture elements or pixels. Beam refreshing is of two types. First is horizontal retracing and second is vertical retracing. When the beam starts from the top left corner and reaches the bottom right scale, it will again return to the top left side called at vertical retrace. Then it will again more horizontally from top to bottom call as horizontal retracing shown in fig:

2. Non-interlaced

In Interlaced scanning, each horizontal line of display of object may occur. This problem can be solved by Non-interlaced odd numbered lines are traced or visited by an electron beam, then in the next circle, even number of are located.

For non-interlaced display refresh rate of 30 frames per second used. But it gives flickers. For interla display refresh rate of 60 frames per second is used.

Advantages:

1. Realistic image
2. Million Different colors to be generated
3. Shadow Scenes are possible.

Disadvantages:

1. Low Resolution
2. Expensive

Differentiate between Random and Raster Scan Display:

Differentiate between Random and Raster Scan Display:

Random Scan	Raster Scan
1. It has high Resolution	1. Its resolution is low.
2. It is more expensive	2. It is less expensive
3. Any modification if needed is easy	3.Modification is tough
4. Solid pattern is tough to fill	4.Solid pattern is easy to fill
5. Refresh rate depends or resolution	5. Refresh rate does not depend on the picture.
6. Only screen with view on an area is displayed.	6. Whole screen is scanned.
7. Beam Penetration technology come under it.	7. Shadow mark technology came under this.
8. It does not use interlacing method.	8. It uses interlacing

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9. It is restricted to line drawing applications	9. It is suitable for realistic display.

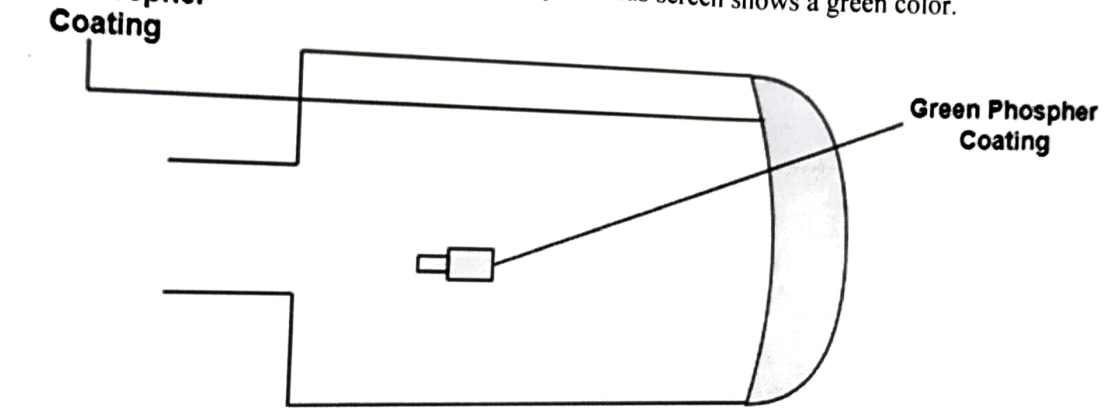
Color CRT Monitors:

The CRT Monitor display by using a combination of phosphors. The phosphors are different colors. There are two popular approaches for producing color displays with a CRT are:

1. Beam Penetration Method
2. Shadow-Mask Method

1. Beam Penetration Method:

The Beam-Penetration method has been used with random-scan monitors. In this method, the CRT screen is coated with two layers of phosphor, red and green and the displayed color depends on how far the electron beam penetrates the phosphor layers. This method produces four colors only, red, green, orange and yellow. A beam of slow electrons excites the outer red layer only; hence screen shows red color only. A beam of high-speed electrons excites the inner green layer. Thus screen shows a green color.



Advantages:

1. Inexpensive

Disadvantages:

1. Only four colors are possible
2. Quality of pictures is not as good as with another method.

2. Shadow-Mask Method:

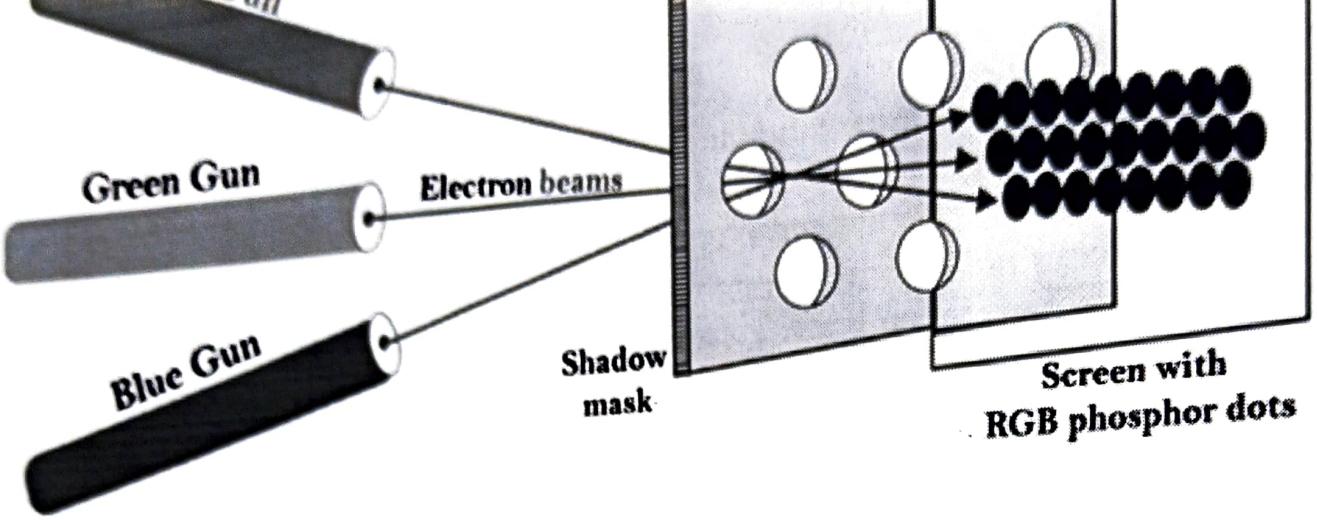
- Shadow Mask Method is commonly used in Raster-Scan System because they produce a much wider range of colors than the beam-penetration method.
- It is used in the majority of color TV sets and monitors.

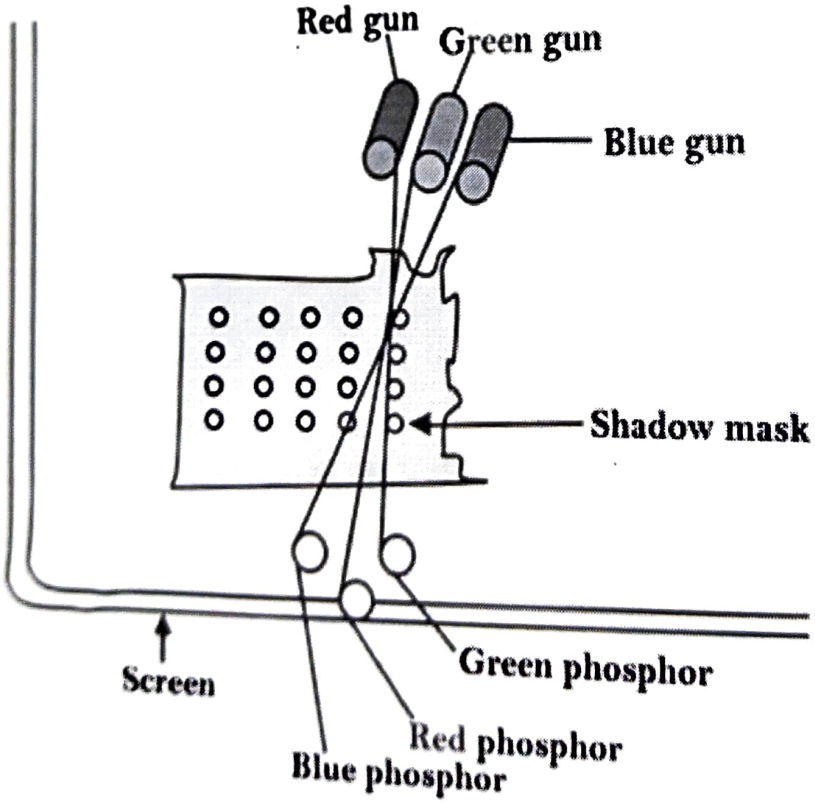
Construction: A shadow mask CRT has 3 phosphor color dots at each pixel position.

- One phosphor dot emits: red light
- Another emits: green light
- Third emits: blue light

This type of CRT has 3 electron guns, one for each color dot and a shadow mask grid just behind the phosphor coated screen.

Shadow mask grid is pierced with small round holes in a triangular pattern.





The Shadow mask CRT

Working: Triad arrangement of red, green, and blue guns.
The deflection system of the CRT operates on all 3 electron beams simultaneously; the 3 electron beams are deflected and focused as a group onto the shadow mask, which contains a sequence of holes aligned with the

phosphor- dot patterns.
When the three beams pass through a hole in the shadow mask, they activate a dotted triangle, which occurs as a small color spot on the screen.
The phosphor dots in the triangles are organized so that each electron beam can activate only its corresponding color dot when it passes through the shadow mask.
Inline arrangement: Another configuration for the 3 electron guns is an Inline arrangement in which the 3 electron guns and the corresponding red-green-blue color dots on the screen, are aligned along one scan line rather of in a triangular pattern.

This inline arrangement of electron guns in easier to keep in alignment and is commonly used in high-resolution color CRT's.

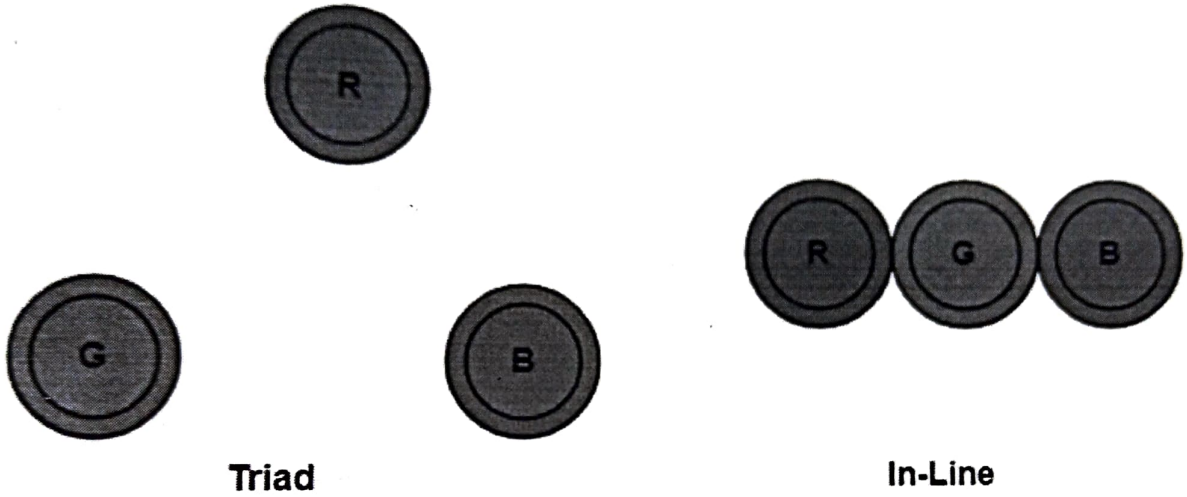


Fig: Triad-and -in-line arrangements of red, green and blue electron guns of CRT for color monitors.

Advantage:
1. Realistic image
2. Million different colors to be generated
3. Shadow scenes are possible

Disadvantage:
1. Relatively expensive compared with the monochrome CRT.
2. Relatively poor resolution
3. Convergence Problem

Direct View Storage Tubes:
DVST terminals also use the random scan approach to generate the image on the CRT screen. The term "storage tube" refers to the ability of the screen to retain the image which has been projected against it, thus avoiding the need to rewrite the image constantly.
Function of guns: Two guns are used in DVST
1. **Primary guns:** It is used to store the picture pattern.

2. **Flood gun or Secondary gun:** It is used to maintain picture display.

computer-graphics-direct-view-storage-tubes.png

Advantage:

1. No refreshing is needed.
2. High Resolution
3. Cost is very less

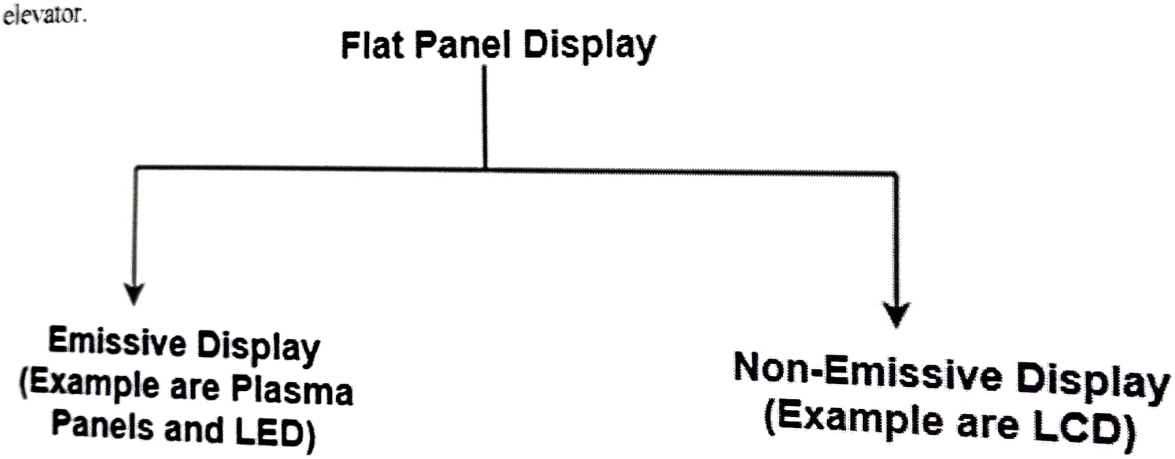
Disadvantage:

1. It is not possible to erase the selected part of a picture.
2. It is not suitable for dynamic graphics applications.
3. If a part of picture is to modify, then time is consumed.

Flat Panel Display:

The Flat-Panel display refers to a class of video devices that have reduced volume, weight and power requirement compare to CRT.

Example: Small T.V. monitor, calculator, pocket video games, laptop computers, an advertisement board in elevator.



1. **Emissive Display:** The emissive displays are devices that convert electrical energy into light. Examples are Plasma Panel, thin film electroluminescent display and LED (Light Emitting Diodes).
2. **Non-Emissive Display:** The Non-Emissive displays use optical effects to convert sunlight or light from some other source into graphics patterns. Examples are LCD (Liquid Crystal Device).

Plasma Panel Display:

Plasma-Panels are also called as Gas-Discharge Display. It consists of an array of small lights. Lights are fluorescent in nature. The essential components of the plasma-panel display are:

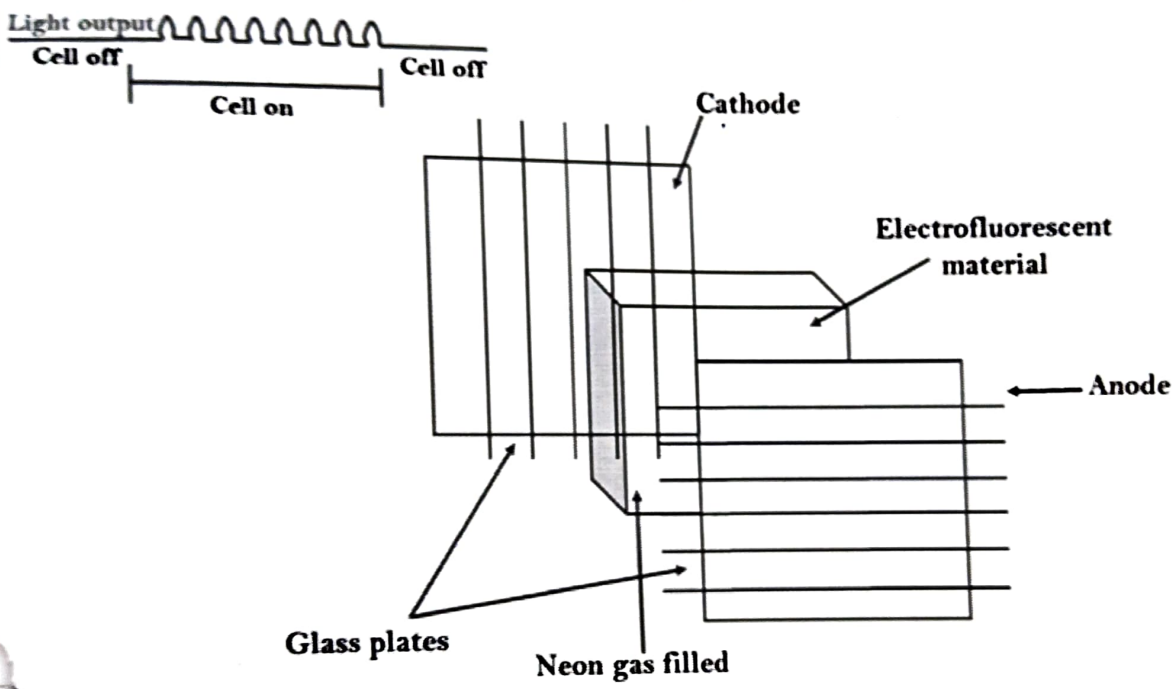
1. **Cathode:** It consists of fine wires. It delivers negative voltage to gas cells. The voltage is released along with the negative axis.
2. **Anode:** It also consists of line wires. It delivers positive voltage. The voltage is supplied along positive axis.
3. **Fluorescent cells:** It consists of small pockets of gas liquids when the voltage is applied to this liquid (neon gas) it emits light.

4. **Glass Plates:** These plates act as capacitors. The voltage will be applied, the cell will glow continuously.

The gas will slow when there is a significant voltage difference between horizontal and vertical wires. The voltage level is kept between 90 volts to 120 volts. Plasma level does not require refreshing. Erasing is done by reducing the voltage to 90 volts.

Each cell of plasma has two states, so cell is said to be stable. Displayable point in plasma panel is made by the crossing of the horizontal and vertical grid. The resolution of the plasma panel can be up to 512 * 512 pixels.

Figure shows the state of cell in plasma panel display:



Advantage:

1. High Resolution
2. Large screen size is also possible.
3. Less Volume
4. Less weight
5. Flicker Free Display

Disadvantage:

1. Poor Resolution
2. Wiring requirement anode and the cathode is complex.
3. Its addressing is also complex.

LED (Light Emitting Diode):

In an LED, a matrix of diodes is organized to form the pixel positions in the display and picture definition is stored in a refresh buffer. Data is read from the refresh buffer and converted to voltage levels that are applied to the diodes to produce the light pattern in the display.

LCD (Liquid Crystal Display):

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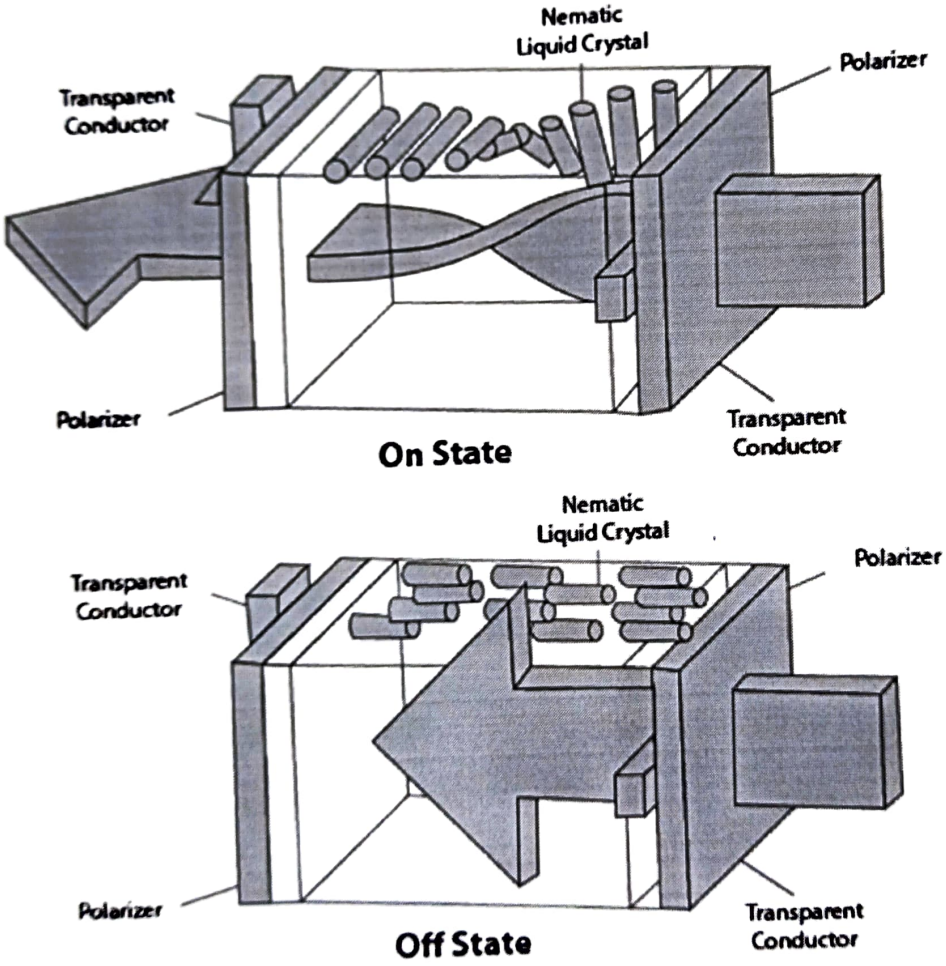
Liquid Crystal Displays are the devices that produce a picture by passing polarized light from the surroundings or from an internal light source through a liquid-crystal material that transmits the light. LCD uses the liquid-crystal material between two glass plates; each plate is the right angle to each other between plates liquid is filled. One glass plate consists of rows of conductors arranged in vertical direction. Another glass plate is consisting of a row of conductors arranged in horizontal direction. The pixel position is determined by the intersection of the vertical & horizontal conductor. This position is an active part of the screen.

Liquid crystal display is temperature dependent. It is between zero to seventy degree Celsius. It is flat and requires very little power to operate.



Liquid Crystal Display

Advantage:

1. Low power consumption.
2. Small Size

Low Cost

Disadvantage:

1. LCDs are temperature-dependent (0-70°C)
2. LCDs do not emit light; as a result, the image has very little contrast.
3. LCDs have no color capability.
4. The resolution is not as good as that of a CRT.

Input Devices

The Input Devices are the hardware that is used to transfer transfers input to the computer. The data can be the form of text, graphics, sound, and text. Output device display data from the memory of the compute Output can be text, numeric data, line, polygon, and other objects.

computer-graphics-input-devices.jpg ¬

input-devices.jpg ¬

These Devices include:

1. Keyboard
2. Mouse
3. Trackball
4. Spaceball
5. Joystick
6. Light Pen
7. Digitizer
8. Touch Panels
9. Voice Recognition
10. Image Scanner

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Graphics Software

Two general classes of graphics software:-

1) General programming packages

- It provides an extensive set of graphics functions that can be used in a high-level programming language, such as C or FORTRAN.

Ex → Graphics library system on Silicon Graphics equipment.

- Basic function in a general packages include those for generating picture components (straight line, polygons, ~~circle~~ circles), setting color and intensity values, selecting views and applying transformations.

2) Application Graphics package:-

- It is designed for nonprogrammers, so that users can generate displays without worrying about how graphics operations work.
- The interface to the graphics routines in such packages allows users to communicate with the programs in their own terms.
- Ex— various business, medical and CAD System.

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Graphics Standards

- The primary goal of standardized graphics S/w is portability.
- When packages are designed with standard graphics functions, software can be moved easily from one h/w system to another and used in different implementations and applications.
- Without standards, programs designed for one h/w system often cannot be transferred to another system without extensive rewriting of the program.

Two general standards have been developed
. GKS . PHIGS

And overall there all 9 Standard developed

1. IGES (Initial Graphics Exchange Specification)
2. DXF (Drawing / Data exchange Format)
3. STEP (Standard for the exchange of product model data)
4. CALS (Computer Aided Acquisition & logistic Support)
5. GKS (Graphics Kernel System)
6. PHIGS (Programmer's Hierarchical Interactive Graphics System)
7. VDI (Virtual Device ~~metafile~~ Interface)
8. VDM (Virtual Device metafile)
9. NAPLPS (North American Presentation-Level Protocol Sy

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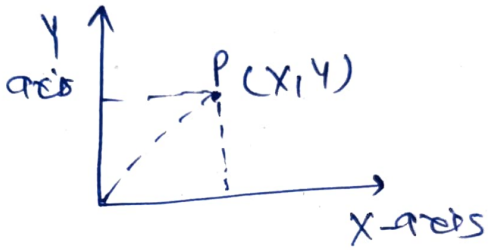
Point

The point is a most basic graphical element which is defined by a pair of user coordinates (x, y). where x, y are the distance of the point from the x-axis, Y-axis ~~and Z-axis~~ respectively.



Line

A line connects two end points.

→ Line drawing is done by calculating intermediate positions ~~between~~ along the path between two specified endpoint positions.

↳ The output device is then directed to fill in those positions between the endpoints with some color

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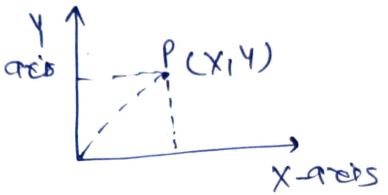

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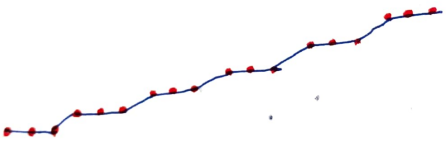
- Digital devices display a straight line segment by plotting discrete point between the two points.
  - Discrete coordinate positions calculated by line equation.

- Screen locations are referenced with integer value, so plotted position may only approximate actual line positions between two specified end points

  for eg. (12.36, 23.87) converted into (12, 24)



Stair Step effect

The S.S. effect is noticeable in low resolution system and we can improve their appearance somewhat by displaying them on high resolution system.

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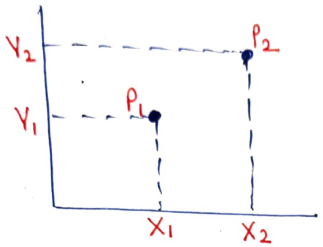
Line Drawing Algorithm



$y = mx + b$ (b: intercept, m: slop)

$$m = \frac{Y_2 - Y_1}{X_2 - X_1}$$

$$b = Y_1 - m * X_1$$

$$\Delta Y = m * \Delta X$$

$$\Delta X = \frac{\Delta y}{m}$$

Digital Differential Analyzer (DDA)

DDA is a scan conversion line drawing algorithm based on calculating either Δy or Δx using above equation.

Procedure :-

Given Starting coordinate = (X_0, Y_0)
Ending coordinate = (X_n, Y_n)

Step 1 calculate Δx, Δy and m from given input

$\Delta X = X_n - X_0$
$\Delta y = Y_n - Y_0$
$m = \Delta y / \Delta X$

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Step2 find the no. of steps or point in between the starting and ending coordinates.

```
if (absolute (Δx) > absolute (Δy))
  - steps = absolute (Δx);
else
  - step = absolute (Δy);
```

Step3

Suppose the current point is (x_p, y_p) and the next point is (x_{p+1}, y_{p+1})

Find the next point by following ~~two~~ three cases.

$$m = \begin{cases} < 1 & x_{p+1} = \text{round off}(1 + x_p) \\ & y_{p+1} = \text{round off}(m + y_p) \\ = 1 & x_{p+1} = \text{round off}(1 + x_p) \\ & y_{p+1} = \text{round off}(1 + y_p) \\ > 1 & x_{p+1} = \text{round off}\left(\frac{1}{m} + x_p\right) \\ & y_{p+1} = \text{round off}(1 + y_p) \end{cases}$$

Step4 Keep repeating (Step-3) until end point reache or the no. of generated new points (including start & ending point) equal to the step count.

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Ex. $(X_0, Y_0) = (5, 6)$
$(X_n, Y_n) = (8, 12)$

Step-1 $\Delta X = 8 - 5 = 3$
$\Delta Y = 12 - 6 = 6$
$m = \frac{6}{3} = 2$

Step-2 As. $|\Delta X| < |\Delta Y|$
So Steps = $\Delta X = 6$

Step-3 $m > 1$ so follow case-3

X_p	Y_p	X_{p+1}	Y_{p+1}	(X_{p+1}, Y_{p+1})	round (X_{p+1}, Y_{p+1})
5	6	$\frac{1}{2} + 5 = 5.5$	7	(5.5, 7)	(6, 7)
		$\frac{1}{2} + 5.5 = 6$	8	(6, 8)	(6, 8)
		$\frac{1}{2} + 6 = 6.5$	9	(6.5, 9)	(7, 9)
		$\frac{1}{2} + 6.5 = 7$	10	(7, 10)	(7, 10)
		$\frac{1}{2} + 7 = 7.5$	11	(7.5, 11)	(8, 11)
		$\frac{1}{2} + 7.5 = 8$	12	(8, 12)	(8, 12)

Q. Draw a line using DDA from points (0,0) to (6,6)

Bresenham's Line algorithm

It determine the pts of an n-dimensional raster that should be selected in order to form a close approximation to a straight line b/w 2 pts

Procedure:-

Start coordinates (X_0, Y_0)
End coordinates (X_n, Y_n)

Step 1

Calculate Δx & Δy

$\Delta x = x_2 - x_1$
$\Delta y = y_2 - y_1$

Step 2 Calculate decision parameter → used to find exact pt to draw line

$P_k = 2\Delta y - \Delta x$

Step 3 Suppose current pt (x_k, y_k), next pt (x_{k+1}, y_{k+1})

find next pt values depending upon decision parameter P_k.

Case:-1 if $P_k < 0$

$P_{k+1} = P_k + 2\Delta y$
$x_{k+1} = x_k + 1$
$y_{k+1} = y_k$

Case:-2 if $P_k \geq 0$

$P_{k+1} = P_k + 2\Delta y - 2\Delta x$
$x_{k+1} = x_k + 1$
$y_{k+1} = y_k + 1$

Step 4 repeat **Step (3)** until end pt is reached

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Ex $(x_0, y_0) = (9, 18)$
$(x_n, y_n) = (14, 22)$

Step1 $\Delta x = 14 - 9 = 5$
$\Delta y = 22 - 18 = 4$

Step2 calculate decision para.

$P_k = 2\Delta y - \Delta x$
$8 - 5 = 3$
$P_k = 3$

Step3 $P_k > 0$ so case 2

$P_{k+1} = P_k + 2\Delta y - 2\Delta x = 1$
$x_{k+1} = x_{k+1} = 9 + 1 = 10$
$y_{k+1} = y_k + 1 = 18 + 1 = 19$

P_k	P_{k+1}	x_{k+1}	y_{k+1}
		9	18
3	1	10	19
1	-1	11	20
-1	7	12	20
7	5	13	21
5	3	14	22

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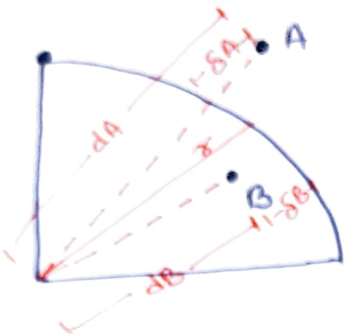

A point outside circle

B point inside circle

δA – distance of point A from circle boundary

δB – distance of point B from circle boundary.

r – radius

dA – distance of point A from circle centre (0, 0)

dB – distance of point B from circle centre (0,0)

$A = (x_k + 1, y_k)$

$B = (x_k + 1, y_k - 1)$

(distance) $dA = \sqrt{(x_k + 1 - 0)^2 + (y_k - 0)^2}$

(distance) $dB = \sqrt{(x_k + 1 - 0)^2 + (y_k - 1 - 0)^2}$

$dA = r + \delta A$ (always +ve)

$dB = r - \delta B$

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$\delta A = dA - r$ (+ve) (dA > r) $\delta B = dB - r$ (-ve) (Always)

(Always) ↳ because r will always r > dB

↳ modify co2 of square root

$\delta A' = dA^2 - r^2$ $\delta B' = dB^2 - r^2$

↳ these are new terms

Derive decision parameter (D) = $\delta A' + \delta B'$

Value of D = { +ve → if $\delta A'$ is bigger than $\delta B'$ ($\delta A' > \delta B'$)
-ve → if $\delta B'$ is bigger than $\delta A'$ ($\delta A' < \delta B'$)

Case #1 +ve — means point A is far from boundary of circle in comparison to point B
↳ so choose point (B)

Case #2 -ve — means point A is near to circle boundary in comparison to point B
↳ so choose point (A)

calculation of decision parameter

$D = \delta A' + \delta B'$
$= (dA^2 - r^2) + (dB^2 - r^2)$

$= [(x_k+1)^2 + y_k^2 - r^2] + [(x_k+1)^2 + (y_k-1)^2 - r^2]$

$D_k = 2(x_k+1)^2 + (y_k-1)^2 + y_k^2 - 2r^2$ ——— (1)

$D_{k+1} = 2(x_{k+1}+1)^2 + (y_{k+1}-1)^2 + y_{k+1}^2 - 2r^2$ ——— (2)

$D_{k+1} - D_k = 2(x_{k+1}+1)^2 + (y_{k+1}-1)^2 + y_{k+1}^2 - 2r^2$
$- 2(x_k+1)^2 - (y_k-1)^2 - y_k^2 + 2r^2$

$D_{k+1} - D_k =$ put $x_{k+1} = x_k + 1$

$= 2(x_k+2)^2 + (y_{k+1}-1)^2 + y_{k+1}^2 - 2(x_k+1)^2 - (y_k-1)^2$

$= 2[x_k^2 + 4 + 4x_k] + [y_{k+1}^2 + 1 - 2y_{k+1}] + y_{k+1}^2$
$- 2[x_k + 1 + 2x_k] - [y_k^2 + 1 - 2y_k] - y_k^2$

$= 2x_k^2 + 8 + 8x_k + y_{k+1}^2 + 1 - 2y_{k+1} + y_{k+1}^2 - 2x_k^2 - 2$
$- 4x_k - y_k^2 - 1 + 2y_k - y_k^2$

$D_{k+1} = D_k + 4x_k + 6 + 2y_{k+1}^2 - 2y_k^2 + 2y_k - 2y_{k+1}$

$= D_k + 4x_k + 2(-y_k^2 + y_{k+1}^2) - 2(y_k - y_{k+1}) + 6$

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if $D_K < 0 \Rightarrow$ Point A is chosen $\Rightarrow y_{K+1} = y_K$

$$D_{K+1} = D_K + 4x_K + 2(y_K^2 - y_K^2) - 2(y_K - y_K) + 6$$

$$\boxed{D_{K+1} = D_K + 4x_K + 6} \quad \text{---(3)}$$

if $D_K > 0 \Rightarrow$ Point B is chosen $\Rightarrow y_{K+1} = y_K - 1$

$$D_{K+1} = D_K + 4x_K + 2((y_K-1)^2 - y_K^2) + 2(y_K - (y_K-1)) + 6$$

$$D_{K+1} = D_K + 4x_K + 2(y_K^2 + 1 - 2y_K) - 2y_K^2 + 2 + 6$$

$$= D_K + 4x_K + 2y_K^2 + 2 - 4y_K - 2y_K^2 + 8$$

$$\boxed{D_{K+1} = D_K + 4x_K - 4y_K + 10} \quad \text{---(4)}$$

Initial decision Parameter D_0

put $(0, r)$ in eq-(1)

$$D_0 = 2(0+1)^2 + (r-1)^2 - r^2 - 2r^2$$

$$= 2 + r^2 + 1 - 2r + r^2 - 2r^2$$

$$\boxed{D_K = 3 - 2r}$$

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Algo

1. Determine the radius 'r' of the circle from the given information.
2. Centre the centre of the circle lies at ORIGIN i.e (0,0)
3. Plot the first pixel of first octant as $(0, r)$
4. Calculate initial decision parameter as $d = 3 - 2r$
5. Repeat till $x \leq y$:
   (i) If $d_k < 0$ then
   $\hookrightarrow d_{k+1} = d_k + 4x_k + 6$
   $x_{k+1} = x_k + 1 \; ; \; y_{k+1} = y_k$

   (ii) If $d_k \geq 0$
   $\hookrightarrow d_{k+1} = d_k + 4(x_k - y_k) + 10$
   $\hookrightarrow x_{k+1} = x_k + 1$
   $\hookrightarrow y_{k+1} = y_k - 1$
6. Plot (x_{k+1}, y_{k+1})
7. Determine and plot symmetric points in other octants as well.
8. Plot a circle using Bresenham's algo. using radius

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Iteration	x	y
0	0	10
1	1	10
2	2	10
3	3	10
4	4	9
5	5	9
6	6	8
7	7	7

Decision Parameter

$d_0 = 3 - 2(r)$

$d_0 = -17$

$d_1 = d_0 + 4x_0 + 6 \Rightarrow d_1 = -11$

$d_2 = d_1 + 4x_1 + 6 \Rightarrow d_1 = -1$

$d_3 = 13$

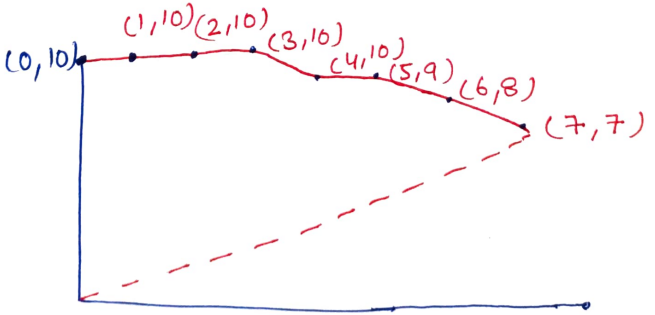
$d_4 = d_3 + 4(x_3 - y_3) + 10$

$d_4 = -5$

$d_5 = -5 + 16 + 6 \Rightarrow$ ~~$d_5 = 5$~~ $d_5 = 17$

$d_6 = 17 + (-16) + 10 \Rightarrow 11$

$d_7 = 11 - 8 + 10 \Rightarrow d_7 = 13$



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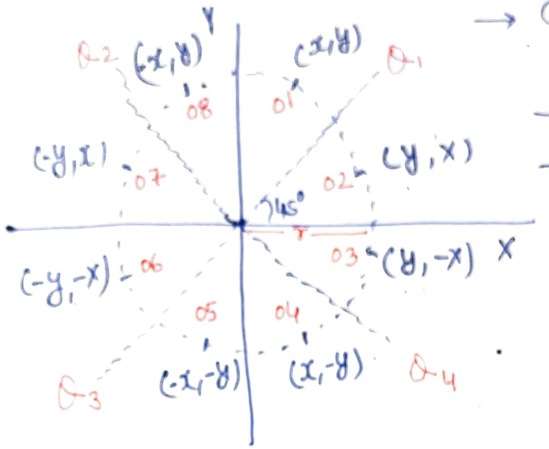
Midpoint Circle Algorithm

A circle is a set of all point that lie at an equal distance from a fixed point called centre.



→ Circle is a symmetric figure

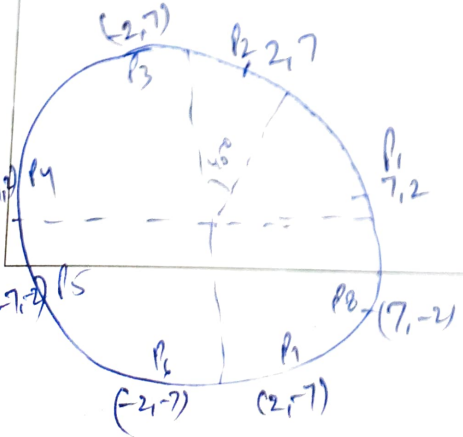
→ 4 way symmetry

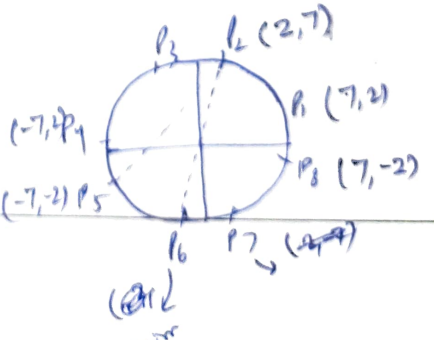
→ 8 way symmetry

→ If we reflect through 45° line than x & y coordinate will interchange but sign will presarved

→ If we reflect a point through x axis than y coordinate will change. if previously +ve than after reflection -ve

- Circle Equation :- $x^2+y^2=r^2$ { centre at origin (0,0)





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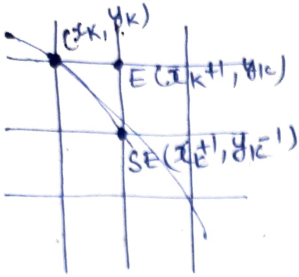
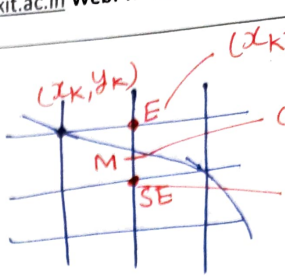




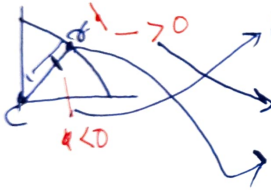
if (x', y') is a point than using circle equation

~~result~~ 3 results will be evaluated.

$(x')^2 + (y')^2 - r^2 = 0$ — point (x', y') lies on Circle

> 0 — point lies Outside Circle

< 0 — point lies inside Circle

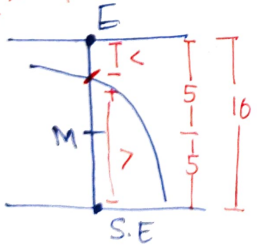


$(x')^2 + (y')^2 < r^2$

$(x')^2 + (y')^2 > r^2$

$(x')^2 + (y')^2 = r^2$

Case# point lies inside — select (E) point



→ Midpoin m is having distance 5 from both E and S.E.

→ because m lies inside circle, so E point is near to circle boundary and S.E. point is far from circle boundary.

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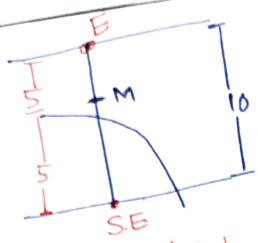
Case 2



(E) point is having distance more in comparision to S.E point from circle boundary

If point outside to circle than (S.E) point selected

Calculation of mid point

E (x_k+1, y_k) S.E (x_k+1, y_k-1)

midpoint: $\left(\frac{x_{k+1}+x_{k+1}}{2}, \frac{y_k+y_k-1}{2}\right)$

$: \left(x_k+1, y_k-\frac{1}{2}\right)$

x_m y_m

$P_k = x_m^2 + y_m^2 - r^2$

$P_k = (x_k+1)^2 + \left(y_k-\frac{1}{2}\right)^2 - r^2$ — decision parameter of current iteration (1)

P_{k+1} → iteration → Successive decision parameter are obtained using incremental calculations.

~~$P_{K+1} = [(x_k+1)+1]^2 + [$~~

→ We obtain a recursive expression for the next decision parameter by evaluating the circle function at sampling position $x_{k+1}+1 = x_k+2$

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$$P_{k+1} = [(x_k+1)+1]^2 + \left(y_{k+1} - \frac{1}{2}\right)^2 - r^2$$

Now $P_{k+1} - P_k$

$$= [(x_k+1)+1]^2 - (x_k+1)^2 + \left(y_{k+1} - \frac{1}{2}\right)^2 - \left(y_k - \frac{1}{2}\right)^2 - r^2 + r^2$$

$$= (x_k+1)^2 + 1 + 2(x_k+1) - x_k^2 - 1 - 2x_k + (y_{k+1})^2 + \frac{1}{4} - y_{k+1} - y_k^2 + \frac{1}{4} + y_k$$

$$= x_k^2 + 1 + 2x_k + 1 + 2x_k + 2 - x_k^2 - 1 - 2x_k + y_{k+1}^2 + \frac{1}{4} - y_{k+1} - y_k^2 + \frac{1}{4} + y_k$$

$$= 4x_k + 3 - 2x_k + y_{k+1}^2 - y_{k+1} - y_k^2 + y_k$$

$$P_{k+1} = P_k + 2x_k + 3 + y_{k+1}^2 - y_{k+1} - y_k^2 + y_k \quad \text{— (2)}$$

if $P_k < 0$ than ~~P_{k+1}~~ $= y_{k+1} = y_k$

because East point selected

$$P_{k+1} = P_k + 2x_k + 3 + y_k^2 - y_k - y_k^2 + y_k$$

$$\boxed{P_{k+1} = P_k + 2x_k + 3} \quad \text{— (3)}$$

if $P_k > 0$ than $y_{k+1} = y_{k-1}$

$$P_{k+1} = P_k + 2x_k + 3 + (y_k - 1)^2 - (y_k - 1) - y_k^2 + y_k$$

$$= P_k + \text{''} + \text{''} + y_k^2 + 1 - 2y_k - y_k + 1 - y_k^2 + y_k$$

$$P_{k+1} = P_k + 2x_k + 3 - 2y_k + 2$$

$$\boxed{P_{k+1} = P_k + 2(x_k - y_k) + 5} \quad \text{— (4)}$$

$$P_{k+1} = P_k + 2(x_k - y_k) + 5$$

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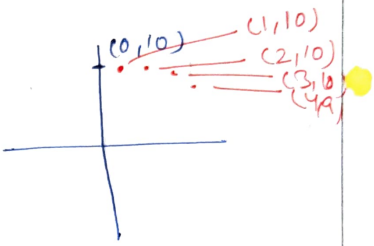
(5) Repeat step 3, 4 until x become equal or greater than to y

(6) Q. Plot 1st octant of a circle centered at origin, having radius 10 units. Use $P_0 = 1 - r$

$(x_0, y_0) = (0, 10)$ $\quad P_0 = 1 - 10 = -9$



(1) $P_0 < 0$

~~$P_{k+1} = P_k + 2x_{k+1} + 1$~~

$= -9 +$

$P_{k+1} = P_k + 2x_k + 3$ $\quad x_{k+1} = x_k + 1$, $x_1 = 1$

$P_1 = P_0 + 2x_k + 3$ $\quad y_{k+1} = y_k$, $y_1 = 10$

$P_1 = -9 + 2(0) + 3$

$P_1 = -6$

$P_1 < 0$

(2) $P_2 = -6 + 2 + 3$ $\quad x_2 = 2$, $y_2 = 10$

$P_2 = -1$; $P_2 < 0$

(3) $P_3 = -1 + 4 + 3$ $\quad x_3 = 3$

$P_3 = 6$; $P_3 > 0$ $\quad y_3 = 10$

$P_4 = 6 - 14 + 5$ $\quad x_4 = 4$

$P_4 = -3$ $\quad P_4 < 0$ $\quad y_4 = 9$

$P_5 = 8 \quad x_5 = 5 \quad y_5 = 9$

$P_6 = 5 \quad x_6 = 6 \quad y_6 = 8$

$P_7 = 6 \quad x_7 = 7 \quad y_7 = 7$

k	P_k	P_{k+1}	x_{k+1}	y_{k+1}
0	-9	-6	1	10
1	-6	-1	2	10
2	-1	6	3	10
3	6	-3	4	9
4	-3	8	5	9
5	8	5	6	8
6	5	6	7	7

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Find initial decision parameter P_0

$x_k = 0$; $y_k = r$

so $x^2 + y^2 - r^2$;

Put value in eq (1)

$$P_0 = (0+1)^2 + (r - \tfrac{1}{2})^2 - r^2$$
$$= 1 + r^2 + \tfrac{1}{4} - r - r^2$$

$$\boxed{P_0 = \frac{5}{4} - r}$$

Algo

- Input radius r and circle center (x_c, y_c) ~~and~~ to plot first OCTANT of circle, do the following:

(1) Plot the initial point (x_0, y_0) such that

$x_0 = 0$; $y_0 = r$

(2) Find initial decision parameter

$$p_0 = \frac{5}{4} - r$$

(3) If $P_k < 0$ then

$x_{k+1} = x_k + 1$

$y_{k+1} = y_k$ $\Rightarrow P_{k+1} = P_k + 2x_k + 3$

(4) if $P_k \geq 0$ then

$x_{k+1} = x_k + 1$

$y_{k+1} = y_k - 1$ $\Rightarrow P_{k+1} = P_k + 2(x_k - y_k) + 5$

Mid Point Circle Algorithm →

In this approach test is done to identify the halfway position position between two pixels to determine if this point is either inside or outside the circle boundary.

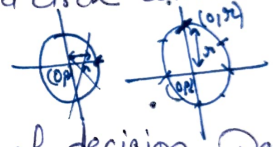
$$f_{circle}(x,y) = x^2+y^2-r^2$$

$$f_{circle}(x,y) \begin{cases} <0 & \text{if } (x,y) \text{ is inside the circle boundary} \\ =0 & \text{if } (x,y) \text{ is on the circle boundary} \\ >0 & \text{if } (x,y) \text{ is outside} \end{cases}$$

Algorithm

① I/P radius r and circle center (x_c, y_c) and obtain the first point on the circumference of a circle centered on the origin as

$$(x_0, y_0) = (0, r)$$



② Calculate the initial value of decision parameter is

$$P_0 = \frac{5}{4} - r \quad | \quad P_0 = 1 - r \text{ (for integers)}$$

③ At each x_k position, starting at $k=0$ perform the follow test: if $P_k < 0$, the next point along the circle centered (0,0) is (x_{k+1}, y_k) and

$$P_{k+1} = P_k + 2x_{k+1} + 1$$

Otherwise, the next point along the circle is (x_k+1, y_k-1) and

$$P_{k+1} = P_k + 2x_{k+1} + 1 - 2y_{k+1}$$

where $2x_{k+1} = 2x_k + 2$ and $2y_{k+1} = 2y_k - 2$

4. Determine symmetry points in other seven octants.
5. Move each calculated pixel position (x, y) onto the circular path centered on (x_c, y_c) and plot the co-ordinate values

$$x = x + x_c \quad , y = y + y_c$$

6. Repeat steps 3 to 5 until $x \geq y$

Ex

$r = 10$

$P_0 = 1 - r = -9$

$(x_0, y_0) = (0, 10)$

$r = 10$

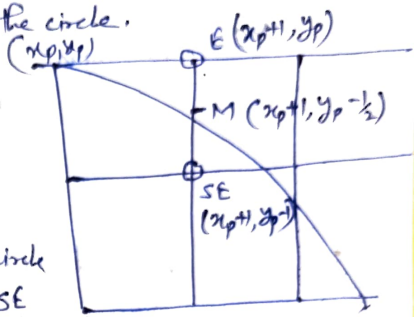
$P < 0$	$P > 0$
(x_k+1, y)	(x_k+1, y_k-1)
$P_{k+1} = P_k + 2x_{k+1} + 1$	$P_{k+1} = P_k + 2x_{k+1} + 1 - 2y_{k+1}$

$2x_0 = 0, \quad 2y_0 = 20$

k	P_k	(x_{k+1}, y_{k+1})	$2x_{k+1}$	$2y_{k+1}$
0	-9	(1,10)	2	20
1	-6	(2,10)	4	20
2	-1	(3,10)	6	20
3	6	(4,9)	8	18
4	-3	(5,9)	10	18
5	8	(6,8)	12	16
6	5	(7,7)	14	14

Midpoint Circle Algo

[We assume that we are working in 1st octant.
A midpoint M lies between two points and we have to decide if M lies inside or outside the circle.



Next position at which pixel is to be plotted would be either E or SE.

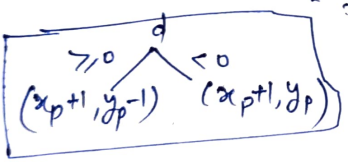
Eq^n of circle $f(x,y) = x^2+y^2-r^2=0$

if $f(x,y)>0$ ⟶ m outside the circle ⟶ choose SE

$f(x,y)<0$ ⟶ m inside the circle ⟶ choose E

decision variable $d = f(m)$

$= f(x_p+1, y_p-\frac{1}{2}) = (x_p+1)^2+(y_p-\frac{1}{2})^2-r^2$



if $d \geq 0$ SE will be choosen and new value of d would be incremented by 1 in x and decremented by 1 in y.

So $d_{new} = f(x_p+2, y_p-\frac{3}{2})$

$d_{old} = d$

So $d_{new} - d = (x_p+2)^2+(y_p-\frac{3}{2})^2-r^2-(x_p+1)^2-(y_p-\frac{1}{2})^2+r^2$

$= 2x_p-2y_p+5$

This is the increment we will make in the value of decision variable d at each successive step. $x_{new} = x_{old}+1$ & $y_{new} = y_{old}-1$

if $d<0$ E will be choosen & increment in x & no change in y.

So $d_{new} = f(x_p+2, y_p-\frac{1}{2})$

$= (x_p+2)^2+(y_p-\frac{1}{2})^2-r^2-(x_p+1)^2-(y_p-\frac{1}{2})^2+r^2$

$= 2x_p + 3$

This is the increment we will make in d at each successive step

$x_{new} = x_{old} + 1$, $y_{new} = y_{old}$

now for dstart. $x = 0$, $y = r$

$d_{start} = f(x_0 + 1, y_0 - \frac{1}{2})$

$= f(1, r - \frac{1}{2}) = 1 + (r - \frac{1}{2})^2 - r^2 = -r + \frac{5}{4}$

floating point

so let $h = d - \frac{1}{4}$

or $h = 1 - r$

now if $d = 0$ $h < -\frac{1}{4}$ or $h < 0$

if $h < 0$

$h = h + 2x + 3$

$h > 0$ $h = h + 2x - 2y + 5$

$y = y - 1$

Mid point circle Algo

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Polygon Area Filling Algorithm

This Algo. fill any shape with color

Topics ① what is polygon, types of polygon, representation of poly. + details

② Inside test
- even odd method
- Winding Number method

③ Polygon Filling :-

Seed fill Algo.
- Boundary fill
- Flood fill

line scan algo.
OR
line scan polygon area filling

Two approaches to fill
- 4 connected approach
- 8 connected

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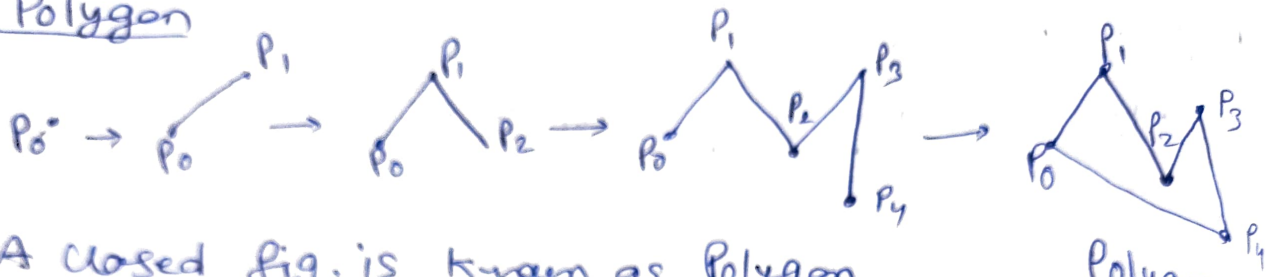
Polygon



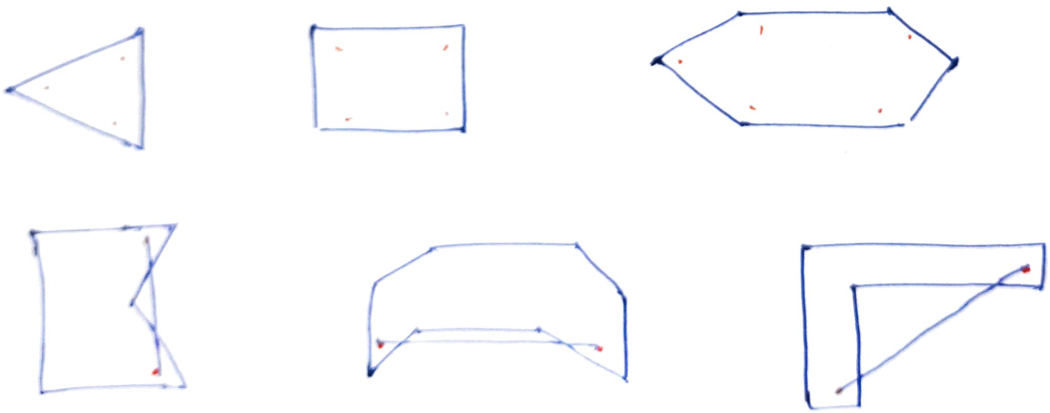
A closed fig. is known as Polygon.

Polygon

Types of Polygon

Convex:- Line segment joining any two points within the polygon lies completly inside the polygon.

Concave:- Line segment outside the Polygon.



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An Inside Test

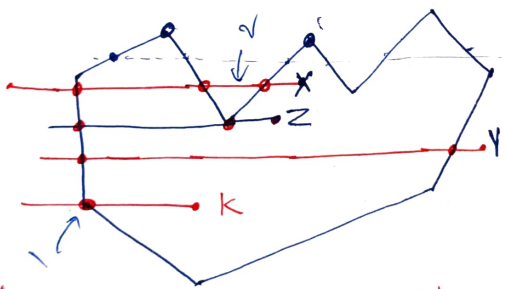
ODD Even Method :- Even ODD method - ODD parity Rule

(1) Construct a line segment b/w the point in Question & a point known to be outside Polygon.

(2) count the intersection of line with Polygon boundaries

Inside — ODD. No. of interaction

Outside — Even " " "



x — inside
y — outside
z — inside
k — inside

Special case If intersection point is Vertex then look at other points of line segment.

#1 If points are on same side of constructed line then Even no of interaction for only that interaction

#2 If diffent side then odd no. of intersection for only that intersection

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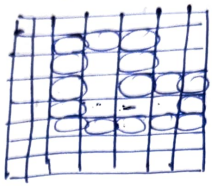
SEED fill – Boundary fill Algo.



(x, y)
(x+1, y) R
(x-1, y) L
(x, y+1) T
(x, y-1) B

4 - Connected

(x, y)
(x+1, y)
(x-1, y)
(x, y+1)
(x, y-1)
(x+1, y+1)
(x-1, y+1)
(x-1, y-1)
(x+1, y-1)

Algo. bounda

```
bound_fill (x, y, F_col, b_col)
{ if
  (getpixel(x,y) != b_col && getpixel(x,y) != F_col)
  {
    Putpixel(x, y, F_col)
  bound_fill (x+1, y, F_col, b_col)
          (x-1, yy, F, ....)
          .
          .
  }
```

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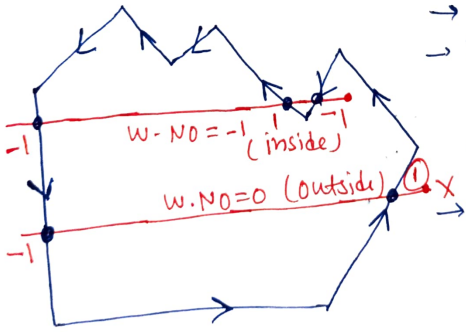
Flood Fill Algo.

```
Flood_fill (x, y, Old_c, New_c)
{
  if (getpixel (x,y) = Old_c)
  {
    putpixel (x,y, New_c)
    Floodfill (x+1, y, old_c, New_c);
    .
    .
    .
```

Inside Test - Winding - No - Method



→ initial W.No = 0
→ If Line crosses an edge directed bottom to top then Add 1 to W.No.
→ If top to bottom then -1
Bottom to top = +1

Point outside if W.No. = 0
Point inside if W.No. = ~~+1~~ non zero (including -ve)

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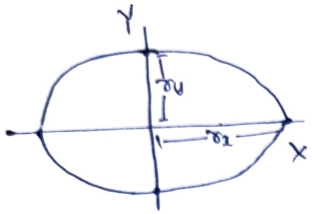
Midpoint Ellipse Drawing



Equation of ellipse centred at (0,0)

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

$a^2 \to r_x$, $b^2 \to r_y$

Major Axis $= 2a = 2r_x$
Minor Axis $= 2b = 2r_y$
Semi Major " $= a = r_x$
" Minor " $= b = r_y$

$$\Rightarrow x^2b^2 + y^2a^2 = a^2b^2$$
$$\Rightarrow b^2x^2 + a^2y^2 - a^2b^2 = 0$$
$$\Rightarrow r_y^2x^2 + r_x^2y^2 - r_x^2r_y^2 = 0 \quad (1)$$

If we put any point in eq. (1)

- $= 0$ → Point lies ON ellipse
- < 0 → Inside the ellipse
- > 0 → Outside the ellipse

→ Ellipse has 4-way symmetry.

→ In " we need to plot (2) octants to plot entire ellipse.

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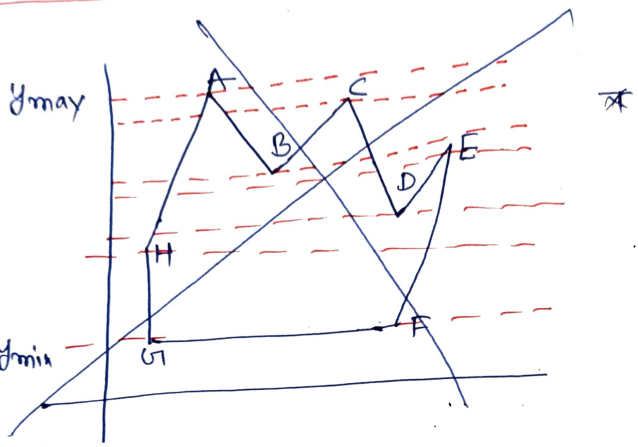
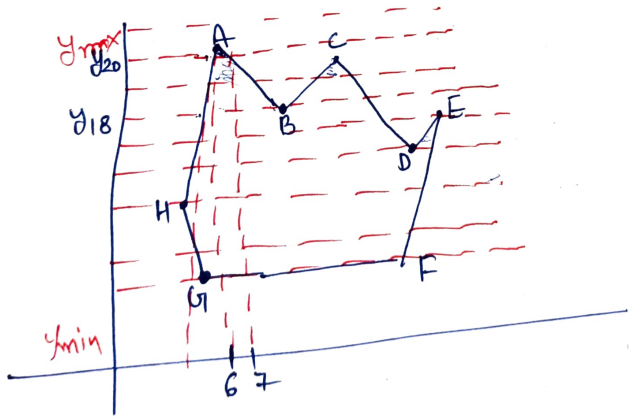
Polygon Area Filling (Scan Line Algorithm)



This algo. works by intersecting scanline with polygon edges and fills the polygon blw pairs of intersection.



Steps

1) Locate the intersection point of the Scan Line with the Polygon Edges.
2) Pairing Intersection Points
3) Move down side as per Scan line & sort all pairs.
4) All pairs are sorted from y_{max} to y_{min}
5) Sides get sorted on intersection point bases.
6) Area filling starts Now.

Coherence Property

- Relating Property of one scene to another part of scene.

Slop of line is 'm'

$$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta y}{\Delta x}$$ here $\Delta y = 1$ always

put $x_2 = x_{k+1}$ & $x_1 = x_k$

$$m = \frac{1}{(x_{k+1}) - (x_k)} \Rightarrow m = \frac{1}{x_{k+1}} - \frac{1}{x_k}$$

$$\Rightarrow \frac{1}{x_{k+1}} = m + \frac{1}{x_k} \Rightarrow \boxed{x_{k+1} = \frac{1}{m} + x_k}$$

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Fill Type - integer-value attribute

Fill_Type_NONE — for fill OFF

Fill_Type_SOLID — fill by a single color (by default)

Fill_Type_GRADIENT — for fill by a color gradient

Fill_Type_PAINT — for fill by a paint object. This is usually a TexturePaint object

Gradient - It is a color array-value attribute that fills a region with a gradient color.

→ It is an array of four colors. These colors at the four corners of a shape. — Order - lower-left, lower-right, upper-right and upper left

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Aliasing and Antialiasing

The process by which smooth curves and other lines become jagged because the resolution of the graphics device – is Aliasing.

The aliasing effect can be reduced by adjusting intensities of the pixel along the line. The process of adjusting intensities of pixel along the line to minimize the effect of aliasing is called antialiasing.

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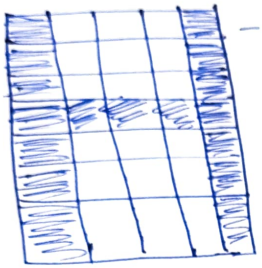
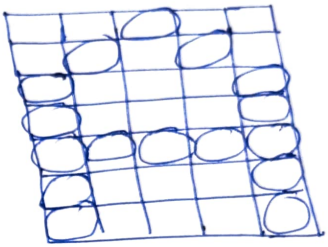
Bit map method

bitmap is an array of binary data representing the values of pixel in an image or display.

- use of pixel array to display character
- font of character can be increased by increasing pixel array size.





5x7

Line Attributes

1) line width — SetLineWidthScaleFactor (lw)
2) line color
3) line Type

- Line width depends on capacity of the device to display
- Standard width line is drawn with one pixel at each sample position
- To draw thicker line another parallel line is drawn adjacent to the first one.

Line color – setPolylineColorIndex(LC).

- default line color is black
- no. of color choice depends on the no. of bits available per pixel in the frame buffer

Line types –

1) Solid line → default
2) Dashed line
3) Dotted line — setLinetype(Lt)

Fill Area Attributes

FillOutline Type – It is an integer value attribute that turns on or off the drawing of an outline around filled areas.

FILL_TYPE_NONE — for outline off
FILL_TYPE_SOLID — for outline on

default is SOLID

FILLOutLine Color – it is a color valued attribute that determine the color to be used to outline the filled regions.

→ active only when FILL_TYPE_SOLID is active

— default is black

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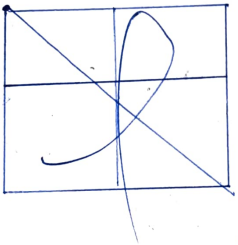
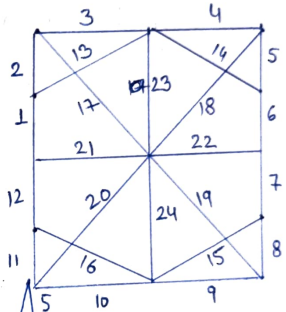
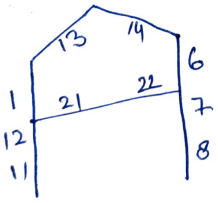
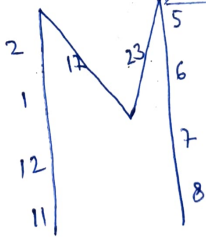
Starburst Method

- In this method a fixed pattern of line is used to generate the character
- We use a combination of 24 bit line segment
- In 24-bit line segment code each bit represent a single line.
- To highlight a line – put bit (1) in 24 bit line segment code and (0) otherwise.









Char A: 0 0 1 1 0 0 0 0 0 0 1 1 1 1 0 0 1 1 1 0 0 0 0 1

Char M:

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Characters Generation in CG

In C.G. Character can be generated using software.

Three method

- Stroke method
- Vector method or bitmap method
- Star burst method.

(1) **Stroke method**:- It use a sequence of line drawing function and arc functions to generate characters

- We can generate a sequence of character by assigning starting and and point of line or arc
- By using this method various faces of character can be generated by changing the values in line and arc function.

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Step2

Pairing $\{(6,20),(7,20)\}, \{(5,19),(8,19)\}, \{(12,19),(14,19)\}$

if Scan line intersecting a vertex than use inside test

Property – same side take 2
– diffent side take 1

So lets see vertex B (y_{18} – line)

Points are $\{(4,18),(10,18)\}$ $\{(10,18),(13,18)\}$

Do calculation accordingly

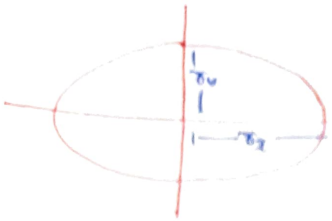
Step-5

edges

Edge list

AH
AB
BC
CD
DE
EF
HG
GF

Midpoint Ellipse Algo:



major axis : r_x

minor axis : r_y

equation of ellipse centred at (0,0)

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

$a = r_x$

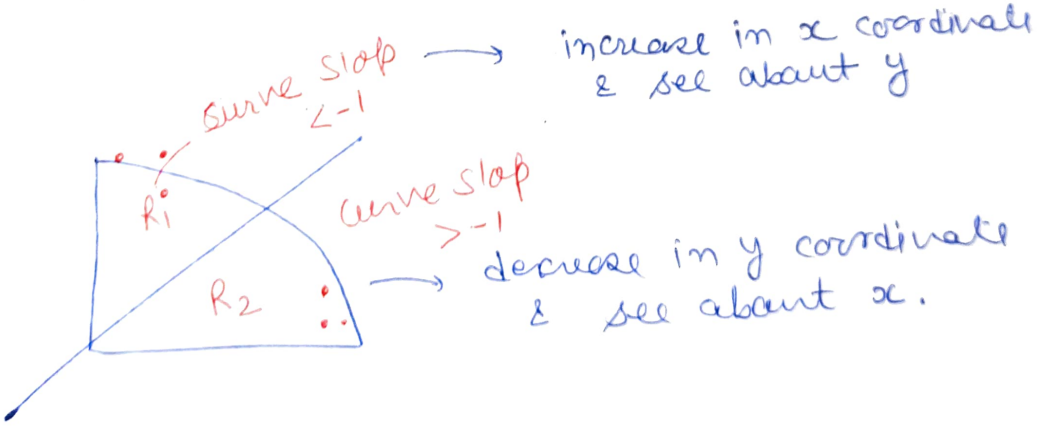
$b = r_y$

$$b^2x^2 + a^2y^2 - a^2b^2 = 0$$

$$r_y^2x^2 + r_x^2y^2 - r_x^2r_y^2 = 0 \quad \text{---(1)}$$

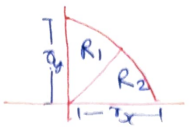
If we put any point in eq (1)

- $= 0$: point lies on ellipse
- < 0 : Inside the ellipse
- > 0 : Outside the ellipse



Quadrant 1 → Region 1

- Start point : $(0, r_y)$
- Slop of curve < -1
- ~~take~~ in every iteration increase x and do till touch region 2 boundary.



Region - 2

- Slop of curve > -1

  in every iteration decrease y and do till end of quadrant

- at boundary of Region-2 & quadrant **Slop = -1**

Slop of curve

$$\frac{dy}{dx} = \{ r_y^2 x^2 + r_x^2 y^2 - r_x^2 r_y^2)$$

$$\frac{dy}{dx}(y^2) = \frac{dy}{dx}\left(\frac{-r_y^2 x^2 + r_x^2 r_y^2}{r_x^2}\right)$$

$$\frac{dy}{dx}(y^2) = \frac{dy}{dx}\left(\frac{r_x^2 r_y^2}{r_x^2}\right) - \frac{dy}{dx}\left(\frac{r_y^2 x^2}{r_x^2}\right)$$

$$\frac{dy}{dx} \cdot 2y = \frac{-2r_y^2 x}{r_x^2}$$

$$\boxed{\frac{dy}{dx} = \frac{-2r_y^2 x}{2r_x^2 y}}$$

if $\frac{-2r_y^2 x}{2r_x^2 y} = -1$ than point lies on boundary b/w R1 & R2

Derivation Region-1

(x_{k+1}, y_k) , $(x_{k+1}, y_k - 1)$

↓

Midpoint = $(x_{k+1}, y_k - \frac{1}{2})$

Eq. of ellipse $r_y^2 x^2 + r_x^2 y^2 - r_x^2 r_y^2 = 0$

put value of midpoint

$\Rightarrow r_y^2 (x_{k+1})^2 + r_x^2 (y_k - \frac{1}{2}) - r_x^2 r_y^2 = p'_k$ — (2)

for k+1 iteration

$r_y^2 (x_k + 2)^2 + r_x^2 (y_{k+1} - \frac{1}{2}) - r_x^2 r_y^2 = p'_{k+1}$ — (3)

(3) − (2)

$p'_{k+1} - p'_k = r_y^2 \{ 2(x_k + 1) + 1 \} + r_x^2 \{ y_{k+1}^2 - y_k^2 - y_{k+1} + y_k \}$ — (4)

two caseee :-

if $p'_k < 0$ than $y_{k+1} = y_k$

&

$p'_k \geq 0$ than $y_{k+1} = y_k - 1$

] in eq. (4)

$p'_{k+1} = p'_k + r_y^2 \cdot 2x_{k+1} + r_y^2$ — (5)

$p'_{k+1} = p'_k + 2x_{k+1} \cdot r_y^2 + r_y^2 - 2y_{k+1} r_x^2$ — (6)

initial decision parameter :- put $(0, r_y)$ in p'_k — eq (3)

$p'_0 = r_y^2 + r_x^2/4 - r_y r_x^2$ — (7)

Derivation Region - 2

$(x_k, y_k - 1)$ $(x_k + 1, y_k - 1)$

midpoint

$(x_k + \frac{1}{2}, y_k - 1)$

Eq. $= r_y^2 x^2 + r_x^2 y^2 - r_x^2 r_y^2$

So $$p_k^2 = r_y^2 \left(x_k + \frac{1}{2}\right)^2 + r_x^2 (y_k - 1)^2 - r_x^2 r_y^2 \quad (2)$$

$$p_{k+1}^2 = r_y^2 \left(x_{k+1} + \frac{1}{2}\right)^2 + r_x^2 ((y_k - 1) - 1)^2 - r_x^2 r_y^2 \quad (3)$$

(3) − (2)

$$p_{k+1}^2 - p_k^2 = r_y^2 \{x_{k+1}^2 + x_{k+1} - x_k^2 - x_k\} + r_x^2 \{1 - 2y_{k+1}\} \quad (4)$$

if $p_k^2 > 0 \longrightarrow x_{k+1} = x_k$

if $p_k^2 \leq 0 \longrightarrow x_{k+1} = x_k + 1$

$$p_{k+1}^2 = p_k^2 - 2y_{k+1} r_x^2 + r_x^2 \quad (5)$$

$$p_{k+1}^2 = p_k^2 + r_y^2 (2x_{k+1}) - 2y_{k+1} r_x^2 + r_x^2 \quad (6)$$

Initial decision parameter

Obtained by putting last point of Region 1 in (2)

Eq. (2)

$$p_k^2 = r_y^2 \left(x + \frac{1}{2}\right)^2 + r_x^2 (y - 1)^2 - r_x^2 r_y^2$$

Algo.

- Read radius r_x & r_y
- Initialise $(x, y) = (0, r_y)$
- Calculate $P_0^1 = r_y^2 - r_x^2 r_y + \frac{1}{4} r_x^2$
- Calculate $dx = 2r_y^2 x$; $dy = 2r_x^2 y$

Repeat while $(dx < dy)$ Region 1

- Plot(x, y)
- if $(P^1 < 0)$

{
$x = x+1$
update dx
$(dx = \text{old}\,dx + 2r_y^2)$
$P^1 = P^1 + \underbrace{2r_y^2 x}_{dx} + r_y^2$
}

else $(P^1 \geq 0)$
{
$x = x+1$, $y = y-1$
update dx
$(dx = \text{old}\,dx + 2r_y^2)$
update dy
$(dy = \text{old}\,dy - 2r_x^2)$
$P^1 = P^1 + dx - dy + r_y^2$
}

When $(dx \geq dy)$ Plot region 2

- Find $P_0^2 = r_y^2 (x+\frac{1}{2})^2 + r_x^2 (y-1)^2 - r_x^2 r_y^2$

- Repeat till $(y > 0)$
- Plot(x, y)

if $(P2 > 0)$
{
$x = x$
$y = y-1$
update dy
$(dy = 2r_x^2 y)$
$P2 = P2 - dy + r_x^2$
}

else $P2 \leq 0$
{
$x = x+1$
$y = y-1$
$dy = dy - 2r_x^2$
$dx = dx + 2r_y^2$
$P2 = P2 + dx - dy + r_x^2$
}

P1

(x_k, y_k)	Decision Parameter: p^1 or p^2	(x_{k+1}, y_{k+1})	$2r_y^2 x_{k+1}$	$2r_x^2 y_{k+1}$
(0,6)	$p_0^1 = -332$	(1,6)	2(1)(36) = 72	2(6)(64) = 768
(1,6)	$p_1^1 = -332 + 72 + 36 = -224$	(2,6)	4(36) = 144	768
(2,6)	$p_2^1 = -224 + 144 + 36 = -44$	3,6	6(36) = 216	768
(3,6)	$p_3^1 = -44 + 216 + 36 = 208$	4,5	8(36) = 288	640
(4,5)	$p_4^1 = 208 + 288 + 36 - 640 = -108$	5,5	10(36) = 360	640
(5,5)	$p_5^1 = -108 + 360 + 36 = 288$	6,4	12(36) = 432	8(64) = 512
(6,4)	$p_6^1 = 288 + 432 + 36 - 512 = 244$	7,3	504	384
(7,3)	$p_0^2 = 36\left(7+\frac{1}{2}\right)^2 + 64(2)^2 - 36(64) = -23$	8,2	16(36) = 576	256
(8,2)	$p_1^2 = -23 + 576 + 64 - 256 = 361$	(8,1)	576	2(64) = 128
(8,1)	$p_1^2 = 361 - 128 + 64 = 297$	(8,0)	-	—
(8,0)				

$r_x = 8$ $r_y = 6$

$d_x = 2(8)^2 = 128$

$= 0$

$d_y = 2(6)^2 = 72$

$= 72$

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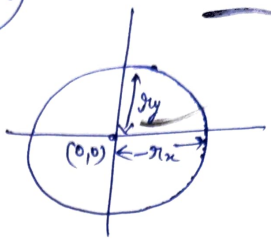
Ellipse is an elongated form of circle or circle is a special case of ellipse where the two radii of circle are equal.

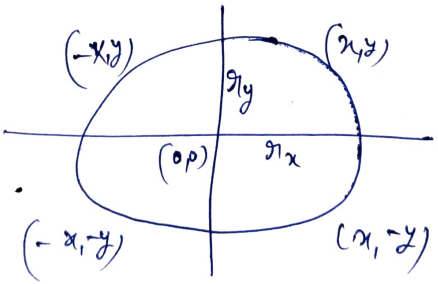
Ellipse has a semi major axis and a semi minor axis named as r_x & r_y respectively



The eqn of ellipse would be

$$\left(\frac{x-x_c}{r_x}\right)^2 + \left(\frac{y-y_c}{r_y}\right)^2 = 1 \quad \text{where } (x_c, y_c) = (0,0)$$

Then for successive value of x, we can calculate the corresponding values of y. It is to be calculated for first quadrant and by symmetry can be calculated for rest of the three quadrants.



ellipse is not symmetric in octants like circle.

eqn of ellipse can also be written in form of Polar Coordinates

$x = x_c + r_x \cos\theta$, $y = y_c + r_y \sin\theta$

This form reduces square root calculations but involves lot of computations

Midpoint Ellipse Algorithm

1. I/P r_x, r_y and ellipse center (x_c, y_c) and obtain the first point on an ellipse centered on the origin as $(x_0, y_0) = (0, r_y)$
2. Calculate the initial value of decision parameter in region 1 as

$$P1_0 = r_y^2 - r_x^2 r_y + \frac{1}{4} r_x^2$$

3. At each x_k position in region 1, starting at k=0 perform the following test. if $P1_k < 0$, the next point along the ellipse centered on (0,0) is (x_{k+1}, y_k) and

$$P1_{k+1} = P1_k + 2r_y^2 x_{k+1} + r_y^2$$

otherwise the next point along the circle is (x_k+1, y_k-1) and

$$P1_{k+1} = P1_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_y^2$$

with

$$2r_y^2 x_{k+1} = 2r_y^2 x_k + 2r_y^2, \quad 2r_x^2 y_{k+1} = 2r_x^2 y_k - 2r_x$$

and continue until $2r_y^2 x \geq 2r_x^2 y$

4. Calculate the initial value of the decision parameter in region 2 using the last point (x_0, y_0) calculated in region 1 as

$$P2_0 = r_y^2 \left(x_0 + \frac{1}{2}\right)^2 + r_x^2 (y_0 - 1)^2 - r_x^2 r_y^2$$

5. At each y_k position in region 2, starting at k=0, perform the following test: If $P2_k > 0$, the next point along the ellipse centered on (0,0) is $(x_k, y_k - 1)$ and

$$P2_{k+1} = P2_k - 2r_x^2 y_{k+1} + r_x^2$$

otherwise, the next point along the

$$p2_{k+1} = p2_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_x^2$$

Using the same incremental calculations for x & y as in Reg

6. Determine symmetry points in the other three quadrants.
7. Move each calculated pixel position (x, y) onto the elliptical path centered on (x_c, y_c) and plot the coordinate values:

$$x = x + x_c \;,\; y = y + y_c$$

8. Repeat the steps for region 1 until $2r_y^2 x \geq 2r_x^2 y$

Ex

$r_x = 8,\ r_y = 6$

$2r_y^2 x = 0$

$2r_x^2 r_y$

$2r_y^2 = 72$

$-2r_x^2 = -128$

for Region 1

$(x_0, y_0) = (0, 6)$, and the initial decision parameter value

$$p1_0 = r_y^2 - r_x^2 r_y + \frac{1}{4} r_x^2 = -332$$

k	$p1_k$	(x_{k+1}, y_{k+1})	$2r_y^2 x_{k+1}$	$2r_x^2 y_{k+1}$
0	-332	(1,6)	72	768
1	-224	(2,6)	144	768
2	-44	(3,6)	216	768
3	208	(4,5)	288	640
4	-108	(5,5)	360	640
5	288	(6,4)	432	512
6	244	(7,3)	504	384

we now move out of region 1, since

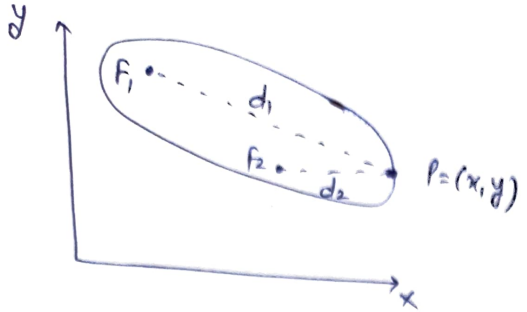
$2r_y^2 x > 2r_x^2 y$

for region 2. $(x_0, y_0) = (7, 3)$ & decision parameter is

$$p2_0 = f\left(7 + \tfrac{1}{2}, 2\right) = -151.23$$

k	$p2_k$	(x_{k+1}, y_{k+1})	$2r_y^2 x_{k+1}$	$2r_x^2 y_{k+1}$
0	-151	(8,2)	576	256
1	233	(8,1)	576	128
2	745	(8,0)	—	—

Ellipse - Generating Algorithm



$d_1 + d_2 = \text{Constant}$

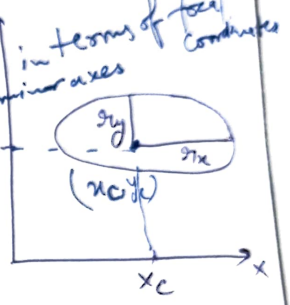
$F_1 = (x_1, y_1)$ & $F_2 = (x_2, y_2)$

$$\sqrt{(x-x_1)^2+(y-y_1)^2} + \sqrt{(x-x_2)^2+(y-y_2)^2} = \text{Constant}$$

general ellipse equation

$$Ax^2 + By^2 + Cxy + Dx + Ey + F = 0$$

A, B, C, D, E & F are evaluated in terms of focal coordinates and dimensions of major and minor axes



equation of ellipse

$$\left(\frac{x-x_c}{r_x}\right)^2 + \left(\frac{y-y_c}{r_y}\right)^2 = 1$$

Using polar coordinates r & θ

$$x = x_c + r_x \cos\theta$$

$$y = y_c + r_y \sin\theta$$

$(x_c, y_c) = (0, 0)$

$f_{ellipse}(x,y) = r_y^2 x^2 + r_x^2 y^2 - r_x^2 r_y^2$

which has the following properties:

$$f_{ellipse}(x,y) \begin{cases} < 0 & \text{if } (x,y) \text{ is inside the ellipse} \\ = 0 & \text{if } (x,y) \text{ is on the ellipse boundary} \\ > 0 & \text{if } (x,y) \text{ is outside the ellipse} \end{cases}$$

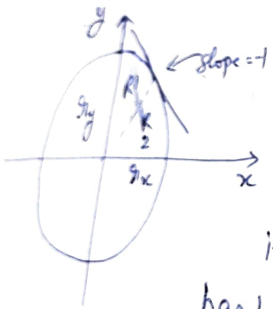
slope of ellipse $\frac{dy}{dx} = -\frac{2r_y^2 x}{2r_x^2 y}$

At the boundary between region 1 & region 2, $dy/dx = -1$ and

$$2r_y^2 x = 2r_x^2 y$$

We move out of region 1 whenever

$$2r_y^2 x \geq 2r_x^2 y$$



← Figure shows the midpoint between the two candidate pixels at sampling position x_{k+1} in the first region. Assuming position (x_k, y_k) has been selected at the previous step, we determine the next position along the ellipse path by evaluating the decision parameter at this midpoint:

$$P1_k = f_{ellipse}(x_k + 1, y_k - \tfrac{1}{2})$$

$$= r_y^2 (x_k + 1)^2 + r_x^2 (y_k - \tfrac{1}{2})^2 - r_x^2 r_y^2$$

if $P1_k < 0$, the midpoint is inside the ellipse and the pixel on scanline y_k is closer to the ellipse boundary. Otherwise the midposition is outside or on the ellipse boundary and we select the pixel on scan line $y_k - 1$

At the next sampling position $(x_{k+1} + 1 = x_k + 2)$ the decision parameter for region 1 is evaluated as

$$P1_{k+1} = f_{ellipse}(x_{k+1}+1, y_{k+1} - \tfrac{1}{2})$$
$$= r_y^2[(x_k+1)+1)^2 + r_x^2 (y_{k+1} - \tfrac{1}{2})^2 - r_x^2 r_y^2$$

or

$$P1_{k+1} = P1_k + 2r_y^2 (x_k+1) + r_y^2 + r_x^2\left[(y_{k+1} - \tfrac{1}{2})^2 - (y_k - \tfrac{1}{2})^2\right]$$

where y_{k+1} is either y_k or $y_k - 1$, depending on the sign of $P1_k$.

Decision parameters are incremented by

$$\text{increment} = \begin{cases} 2r_y^2 x_{k+1} + r_y^2 & \text{if } P1_k < 0 \\ 2r_y^2 x_{k+1} + r_y^2 - 2r_x^2 y_{k+1} & \text{if } P1_k \geq 0 \end{cases}$$

At the initial position $(0, r_y)$, the two terms evaluate to

$$2r_y^2 x = 0$$
$$2r_x^2 y = 2r_x^2 r_y$$

As x & y are incremented, updated values are obtained by adding $2r_y^2$ to $2r_y^2 x = 0$ & subtracting $2r_x^2$ from $2r_x^2 y = 2r_x^2 r_y$

In region 1, the initial value of the decision parameter is obtained by evaluating the ellipse function at start position, $(x_0, y_0) = (0, r_y)$

$$P1_0 = f_{ellipse}(1, r_y - \tfrac{1}{2})$$
$$= r_y^2 + r_x^2 (r_y - \tfrac{1}{2})^2 - r_x^2 r_y^2$$

$$P1_0 = r_y^2 - r_x^2 r_y + \tfrac{1}{4} r_x^2$$

over region 2, we sample at unit steps in the negative y direction, and the midpoint is now taken b/n horizontal pixels at each step. for this region, the decesion parameter is evaluated as

$$P2_k = f_{ellipse}\left(x_k + \frac{1}{2}, y_k - 1\right)$$

$$= r_y^2\left(x_k + \frac{1}{2}\right)^2 + r_x^2(y_k - 1)^2 - r_x^2 r_y^2$$

If $P2_k > 0$ the midpoint is outside the ellipse boundary, and we select the pixel at x_k.

If $P_{2k} \le 0$, the midpoint is inside or on the ellipse boundary and we select pixel position x_{k+1}.

To determine the relationship b/n successive decision parameters in region 2, we evaluate the ellipse function at the next sampling step $y_{k+1} - 1 = y_k - 2$

$$P2_{k+1} = f_{ellipse}\left(x_{k+1} + \frac{1}{2}, y_{k+1} - 1\right)$$

$$= r_y^2\left(x_{k+1} + \frac{1}{2}\right)^2 + r_x^2\left[(y_k - 1) - 1\right]^2 - r_x^2 r_y^2$$

or

$$P2_{k+1} = P2_k - 2r_x^2(y_k - 1) + r_x^2 + r_y^2\left[\left(x_{k+1} + \frac{1}{2}\right)^2 - \left(x_k + \frac{1}{2}\right)^2\right]$$

with x_{k+1} set either to x_k or to $x_k + 1$, depending on the sign of $P2_k$.

When we enter region 2, the initial position (x_0, y_0) is taken as the last position selected in region 1 and the initial decision parameter in region 2 is then

$$P2_0 = f_{ellipse}\left(x_0 + \frac{1}{2}, y_0 - 1\right)$$

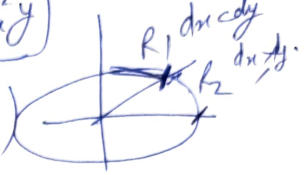
$$= r_y^2\left(x_0 + \frac{1}{2}\right)^2 + r_x^2(y_0 - 1)^2 - r_x^2 r_y^2$$

(1) Read radii r_x & r_y

(2) Initialize starting point of region 1 as $x=0$, $y=r_y$ $(0, r_y)$

(3) Calculate $P1_0 = r_y^2 - r_x^2 r_y + \frac{1}{4} r_x^2$ — (i)

(4) Calculate $dx = 2r_y^2 x$, $dy = 2r_x^2 y$



Repeat while $(dx < dy)$ (region 1)

→ plot (x, y)

if $(P1 < 0)$

{ $x = x+1$

update $dx \rightarrow 2r_y^2 x = \text{old } dx + 2r_y^2$

$P1_{k+1} = P1_k + 2r_y^2 x + r_y^2$

}

Until $dx > dy$

else { $P1_{k+1} = P1_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_y^2$

$x = x+1$, $y = y-1$

update $dx \rightarrow 2r_y^2 x$ { old $dx + 2r_y^2$)

update $dy \rightarrow 2r_x^2 y$ (old $dy - 2r_x^2$)

when $(dx \geq dy)$ plot region 2 as

Find $P2_0 = r_y^2 (x+\frac{1}{2})^2 + r_x^2 (y-1)^2 - r_x^2 r_y^2$

$y = 0$

Repeat till $(y > 0)$

→ plot (x, y)

if $(P2 > 0)$ {

$P2_{k+1} = P2_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_x^2$

$x = x$

$y = y-1$

update $dy: 2r_x^2 y$

$P2 = P2 - dy + r_x^2$

$P2_{k+1} = P2_k - 2r_x^2 y_{k+1} + r_x^2$

else { $x = x+1$

$y = y-1$

$dy = dy - 2r_x^2$

$dx = dx + 2r_y^2$

$P2 = P2 + dx - dy + r_x^2$

$\partial_x = 8$, $\partial_y = 6$ $\frac{dx}{dx}$

(x_k, y_k)	P_1 or P_2	(x_{k+1}, y_{k+1})	$2x_{k+1}\partial_y^2$	$2y_{k+1}\partial_x^2$
y^0 $(0,6)$	~~$P_1 = (6)^2 - (8)^2(6)^2 + \frac{1}{4}(8)^2$~~ ~~$= 36 - 384 + 16$~~ $P_0 = \partial_y^2 - \partial_x^2\partial_y + \frac{1}{4}\partial_x^2$ $= (6)^2 - (8)^2(6) + \frac{1}{4}(8)^2$ $= 36 - 64(6) + 16$ $= 36 - 384 + 16$ $= -332$	$(1,6)$	$2(1)(36)$ $= 72$	$2(6)(64)$ $12(64) = 768$
P_1 $(1,6)$	$P_1 = P_0 + 2\partial_y^2 x + \partial_y^2$ $= -332 + 72 + 36$ $= -224$	$(2,6)$	$2(2)(36)$ $4(36) = 144$	$2(6)(64)$ $12(64) = 768$
2 $(2,6)$	$P_2 = P_1 + 2\partial_y^2 x + \partial_y^2$ $= -224 + 144 + 36 = -44$	$(3,6)$	$6(36) = 216$	768
3. $(3,6)$	$P_3 = P_2 + 2\partial_y^2 x + \partial_y^2$ $= -44 + 216 + 36 = 208$	$(4,5)$ as $P_3 > 0$	$2(4)(36)$ $8(36) = 288$	640
4 $(4,5)$	$P_4 = 208 + 288 + 36 - 640 = -108$ as if $P > 0$ $P_{k+1} = P_k + 2\partial_y^2 x_{k+1} - 2\partial_x^2 y_{k+1} + \partial_y^2$	$(5,5)$	$2(5)(36)$ $= 360$	640
$(5,5)$	$P_5 = -108 + 360 + 36 = 288$	$(6,4)$	$2(6)(36)$ $= 432$	$8(64) = 512$ $(\text{old}dy - 2\partial_x^2)$
$(6,4)$	$P_6 = 288 + 432 + 36$ $- 512 = 244$	$(7,3)$	$2(7)(36)$ $= 504$	~~$dy - 2\partial_x^2$~~ ~~$512 - 2(64)$~~ $512 - 2(64)$ $= 384$

$dx > dy$

$$P_{2_0} = r_y^2\left(x+\tfrac{1}{2}\right)^2 + r_x^2(y_k-1)^2 - r_x^2 r_y^2$$

~~k=2~~ $x=7, y=3$ ↑

(x_k, y_k)	Decision parameter	(x_{k+1}, y_{k+1})		
3	$P_{2_0} = 36\left(7+\frac{1}{2}\right)^2 + 64(2)^2 - 36(64)$			
	$= -23$	$(8,2)$	$16(36)=576$	256
	negative value			
	so $x = x+1$			
	$y = y-1$			
$(8,2)$	$P_{2_1} = -23+576+64-256$			
1	$P_{2_0} < 0$ so			
	$= P_{2_0} + 2r_y^2 x_{k+1} + r_x^2 - 2y_{k+1} r_x^2$	$(8,1)$	576	$2(64)=128$
	$= 361$			
	so $x = x$			
	$y = y-1$			
	we will run until $y=0$			
	as $P_{21} > 0$ so $P_{22} = P_{2k} - 2r_x^2 y_{k+1} + r_x^2$			
2 $(8,1)$	$P_{2_2} = 361-128+64 = 297$	$(8,0)$	~~2(8)8~~	

= No need to calculate

as we need to move next iteration

=

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Unit-3

Two Dimensional Graphics

Transformation (translation, rotation, scaling, reflection, Shearing)

Homogeneous coordinates

Composite transformation

- Transformation means changing some graphics into something else by applying rules.
- When transformation takes place on a 2D plane, it is called 2D transformation.

Homogeneous coordinates

To perform a sequence of transformation such as translation followed by rotation and scaling, we need to follow a sequencial process -

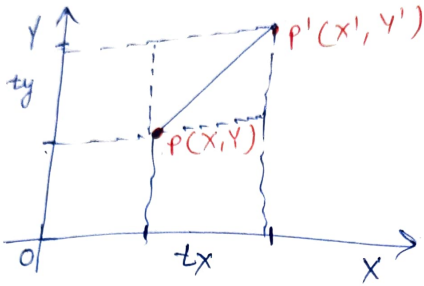
1) Translate the coordinates,
2) Rotate translated coordinates
3) Scale the rotated coordinate to complete composite transformation.

- To shorten this process, we have to use 3×3 transformation matrix. To convert 2×2 matrix to 3×3 matrix, we have to add an extra dummy coordinate (W).

this is called homogeneous coor
- any cartesian point P(X, Y) can be converted
homogeneous coordinates by P'(Xh, Yh, h).

Translation

translation can be done by adding translation coordi (tx, ty) to the o coordinate (X, Y) get new coordi (X', Y').



$x' = x + t_x$
$y' = y + t_y$

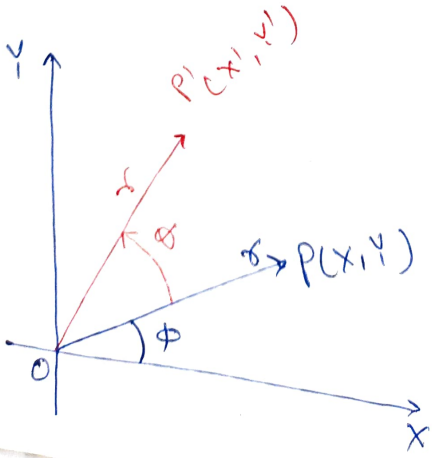
(t_x, t_y) — translation vector or shift vector

using column vectors →

$$P = \begin{vmatrix} x \\ y \end{vmatrix} \quad P' = \begin{vmatrix} x' \\ y' \end{vmatrix} \quad T = \begin{vmatrix} t_x \\ t_y \end{vmatrix}$$

$$\boxed{P' = P + T}$$

Rotation



In rotation, we rotate the object at particular angle θ from its origion.

→ in fig. point (x, y) is located at angle ϕ from the horizontal x coordinate with distance r from the origin.

↳ rotate it at angle θ and get new point $P'(x', y')$

using standard trigonometri -

$$x = r\cos\phi \quad \text{---(1)}$$

$$y = r\sin\phi \quad \text{---(2)}$$

$$x' = r\cos(\phi+\theta) = r\cos\phi\cos\theta - r\sin\phi\sin\theta \quad \text{---(3)}$$

~~$y' = r\sin(\phi+\theta) = r\cos\theta\sin\phi + r\sin\phi$~~

$$y' = r\sin(\phi+\theta) = r\cos\phi\sin\theta + r\sin\phi\cos\theta \quad \text{---(4)}$$

so

$$x' = x\cos\theta - y\sin\theta$$

$$y' = x\sin\theta + y\cos\theta$$

$$[x'\ y'] = [x\ y]\begin{bmatrix}\cos\theta & \sin\theta \\ -\sin\theta & \cos\theta\end{bmatrix} \quad \underline{\text{OR}}$$

$$P' = P \cdot R$$

$$R = \begin{bmatrix}\cos\theta & \sin\theta \\ -\sin\theta & \cos\theta\end{bmatrix}$$

$$R = \begin{bmatrix} \cos(-\theta) & \sin(-\theta) \\ -\sin(-\theta) & \cos(-\theta) \end{bmatrix}$$

$$R = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$$

Scaling

To change size of an object it is used.

Scaling can be achieved by multiplying the original coordinates of the object with scaling factor to get the desired result.

$P(x, y)$ – old cordinates $P'(x', y')$ – new

$S(S_x, S_y)$ – scaling factor

scales in x direction

scales in y "

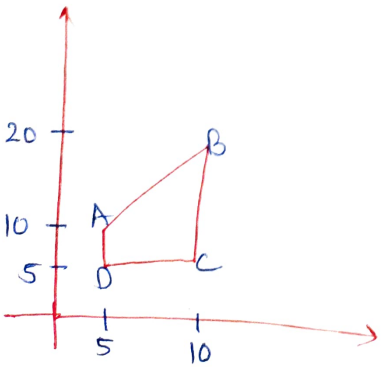
Q: Given a square object with coordinate point A(0,3), B(3,3), C(3,0), D(Apply the scaling para towards x axis and towards y axis.

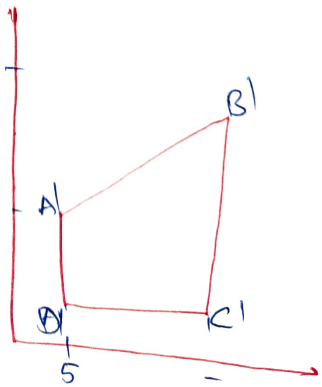
Mathematically we can write as.

$$x' = x \cdot S_x \text{ and } y' = y \cdot S_y$$

$$(x'y') = (xy) \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix}$$

$$P' = P \cdot S$$





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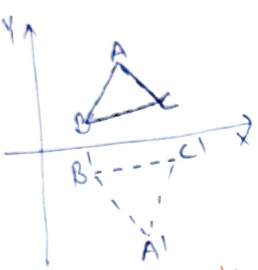
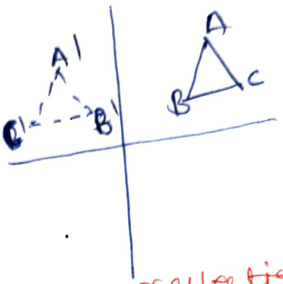
Reflection - Reflection is the mirror image of original object - or rotation with 180°

→ Size doesn't change.



reflection w.r.to X



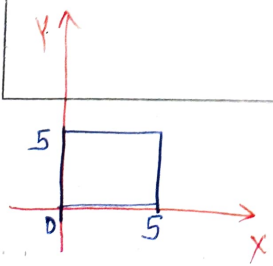
reflection w.r.to Y

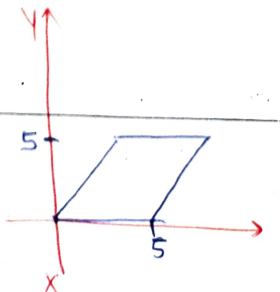
Shear (skewing) - This slants the shape of an object

→ Two Operation
- X - Shear — shift x coordinates value
- Y - Shear — shift Y coordinates value

→ In both cases only one coordinate changes its coordinates and other preserves it value.

X-Shear — preserve Y coordinate





This cause vertical lines to tilt right or left.

~~transformation matrix~~

$$X_{sh} = \begin{bmatrix} 1 & Sh_x \\ & \end{bmatrix} \qquad \begin{bmatrix} 1 & 0 & 0 \\ Sh_x & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Shearing equations

$$X_{new} = X_{old} + Sh_x \cdot Y_{old}$$

$$Y_{new} = Y_{old}.$$

$$\begin{bmatrix} X_{new} \\ Y_{new} \end{bmatrix} = \begin{bmatrix} 1 & Sh_x \\ 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \end{bmatrix}$$

↳ homogeneous coordinates. (3×3)

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ Sh_x & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ 1 \end{bmatrix}$$

Shearing Y axis -

Equation - $X_{new} = X_{old}$

$Y_{new} = Y_{old} + Sh_y \times X_{old}$

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

$$\begin{bmatrix} X_{new} \\ Y_{new} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ Sh_y & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \end{bmatrix}$$

homogeneous coordinates (3×3)

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & Sh_y & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ 1 \end{bmatrix}$$

Shearing in x-y direction

$$\begin{bmatrix} 1 & Sh_y & 0 \\ Sh_x & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

both x-y will be distorted.

Q.

Given a triangle with points (1,1), (0,0) and (1,0). Apply shear parameter (2) on x-axis and (2) on y-axis and find out the new coordinates of the object

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Reflection on X-Axis

$x_{new} = x_{old}$

$y_{new} = -y_{old}$

$$\begin{bmatrix} x_{new} \\ y_{new} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \times \begin{bmatrix} x_{old} \\ y_{old} \end{bmatrix}$$

in homogeneous

$$\begin{bmatrix} x_{new} \\ y_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x_{old} \\ y_{old} \\ 1 \end{bmatrix}$$

Reflection on Y-axis

$x_{new} = -x_{old}$

$y_{new} = y_{old}$

$$\begin{bmatrix} x_{new} \\ y_{new} \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \times \begin{bmatrix} -x_{old} \\ y_{old} \end{bmatrix}$$

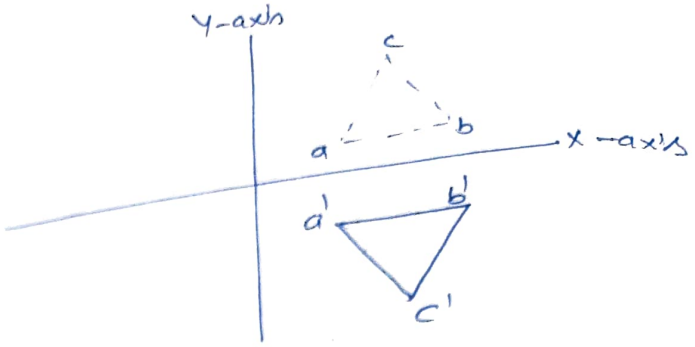
$$\therefore \begin{bmatrix} x_{new} \\ y_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x_{old} \\ y_{old} \\ 1 \end{bmatrix}$$

Q. A triangle with point A(3,4) B(6,4) C(5,6). Apply reflection on the x axis and obtain the new coordinate.

Reflection about x-axis

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

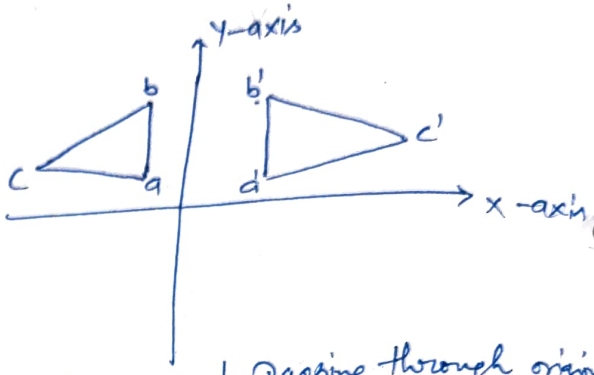
x-will remain same



Reflection about Y-axis

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

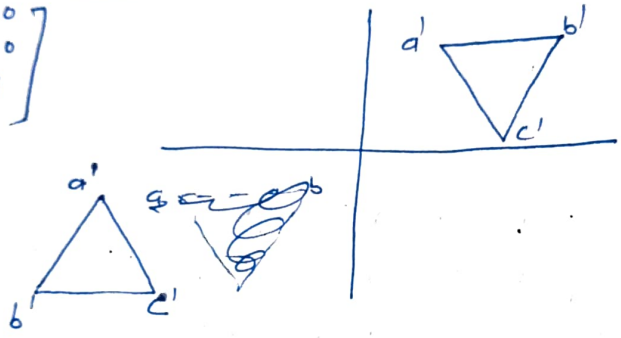
Y will remain same



Reflection about an axis perpendicular to x-y plane and passing through origin

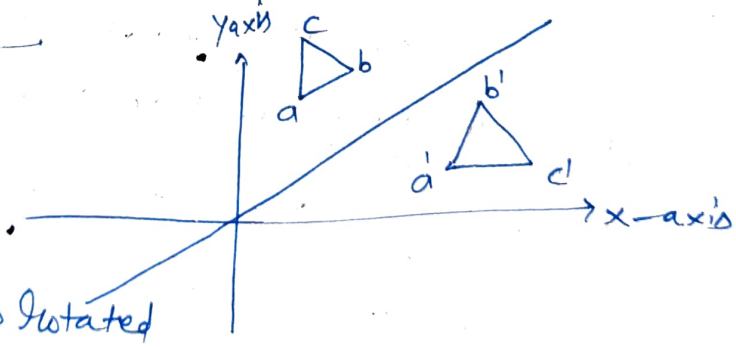
$$\begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

X, Y both will be reversed



Reflection about line y=x

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



first of all object is Rotated 45° clockwise. Reflection is done and again 45° counter clockwise

Ex. A triangle A (3,4)
B (6,4)
C (4,8

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Clipping

When we have to display a large portion of the picture, then not only scaling & translation is necessary, the visible part of the picture is also identified.

Certain parts of the image are inside, while other are partially inside.

For deciding the visible and invisible portion, a particular process called clipping is used.

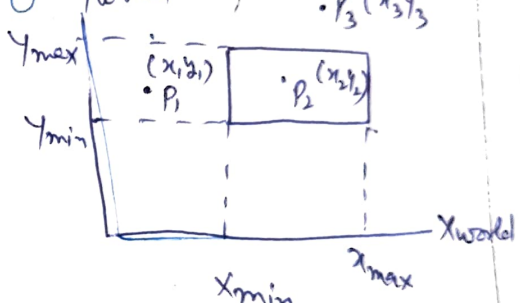
Types of line

Visible
Invisible
Clipped.

Types of Clipping

Point
Line
Polygon
curve
Text
exterior

Clipping Window → Region where to show image



world coordinates

~~Ch~~

~~To check~~ To check (x, y) either in or Not

$x_{min} \le x \le x_{max}$

$y_{min} \le y \le y_{max}$

Example

$x_{min} = 3$
$y_{min} = 3$
$x_{max} = 12$
$y_{max} = 15$

$P(7, 10)$

$3 \le 7 \le 12$ ✓
$3 \le 10 \le 15$ ✓

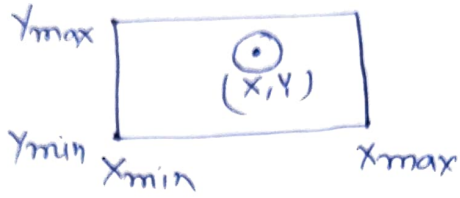
means point is inside

Point Clipping

Point clipping is used to determine, whether the point is in the windaw or not. Following conditions are checked.

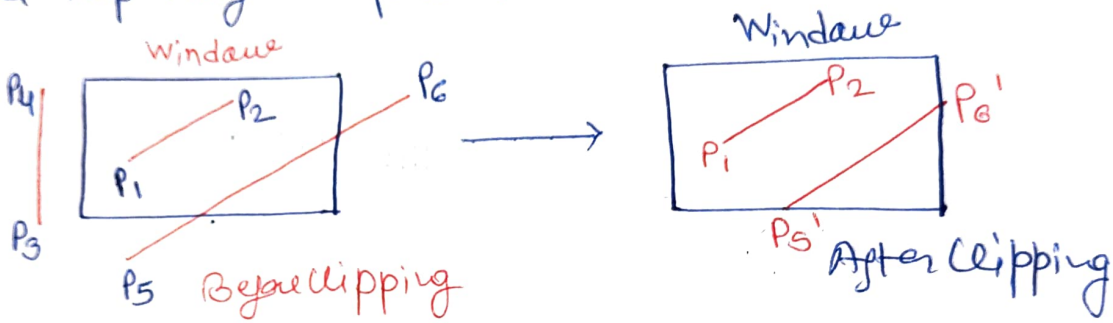
$x \leq x_{max}$ & $x \geq x_{min}$

$Y \leq Y_{max}$ & $Y \geq Y_{min}$



Line clipping

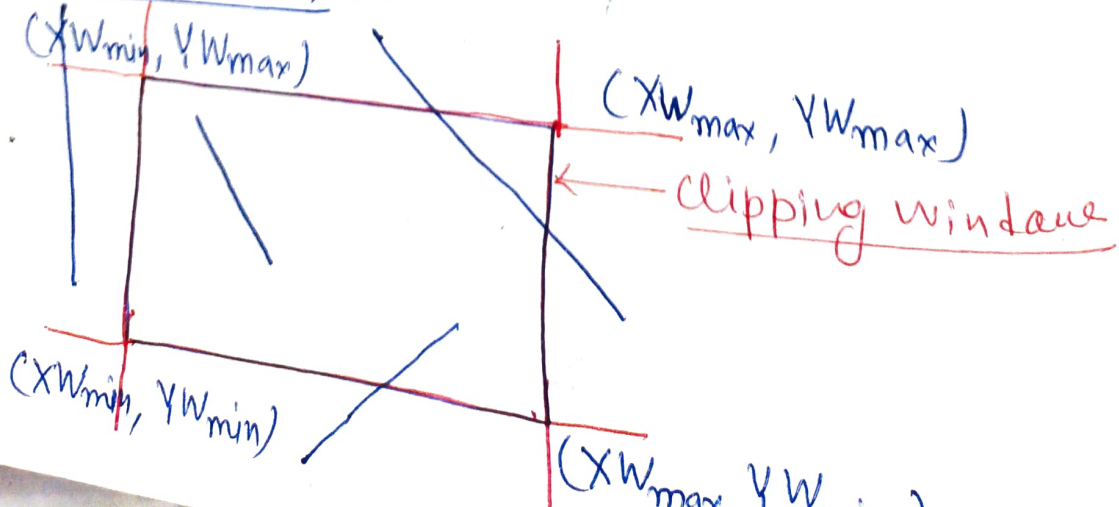
We cut the portion of line which is outside of windaw and keep only the portion that is inside the windaw.



Line clipping Algorithms:→

- Cohen Sutherland
- ~~P~~ Liang-Barsky
- NLN

Cohen Sutherland :→



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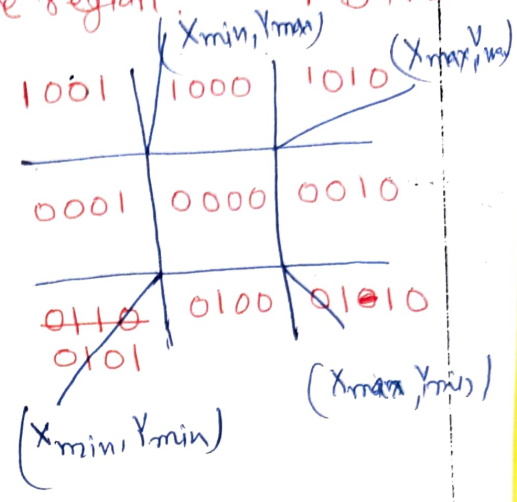
(3)

We use 4-bits to devide the entire region

region 1	region 2	region 3
region 4	region 5	region 6
region 7	region 8	region 9

TBRL



Three possibilities

1) line completely inside —— accept it
2) line " outside —— discard it
3) line partially inside —— find intersection point and draw only that portion of line that is inside.

Algo.

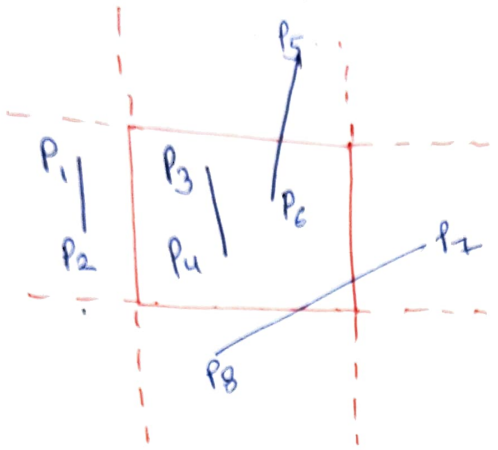
1) Assign region code for each endpoints.
2) If both endpoints have a region code 0000 then accept line (line is completely inside)
3) else perform Logical AND for both region code.
   3.1) If result is 0000 then
      3.1.1) choose an endpoint of the line that is outside the windows
      3.1.2) find intersection point at the windows boundary
      3.1.3) Replace endpoint with intersection point and update the region code.
   3.2) else

3.1.4) Repeat step 2 untill we find a clipped line either trivially accepted or trivially rejected.

3.2) else (if result not 0000) then reject line.

4) Repeat step 1 for other lines.

Ex



$P_1 = 0001$] Reject
$P_2 = 0001$
$P_3 = 0000$] accept
$P_4 = 0000$
$P_5 = 1000$ $P_5' = 0000$] accept
$P_6 = 0000$ $P_6 = 0000$
$P_7 = 0010$
$P_8 = 0100$

Case-1 for P_1 & P_2

0001
AND 0001
0001 Reject

Case-2 for P_3 & P_4

Both 0000 — accept

Case-3 for P_5 & P_6

1000
0000 AND
0000

→ Now choose endpoint of line which is outside the window.
→ $P_5 = 1000$
intersection point with window = $P_5' = 0000$
→ Repeat step 2 of algo — both endpoints are 0000 → accept

same of P_7 & P_8
one at a time means first P_7' then P_8'.

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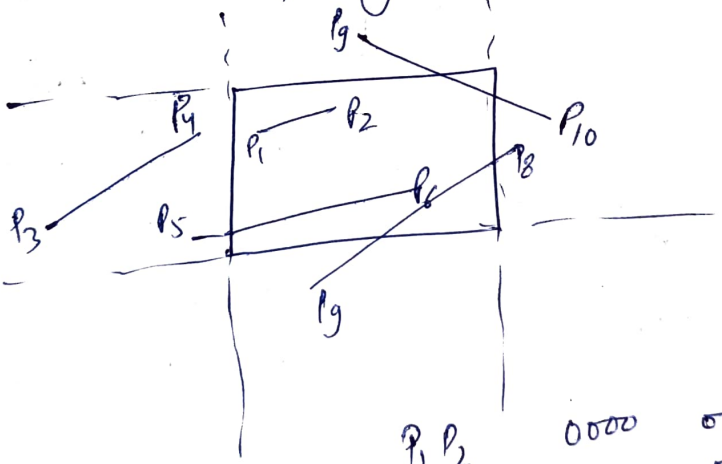
Summery Rules

(1) if both end points of a line have region code 0000 then line is completely inside

(2) if region code of a line's endpoint have some bit position then line is completely outside.

(3) If region code of both end points are not 0000 or mixed region code then perform logical AND op^n if AND is $\neq$ 0000 Reject otherwise partially accept.



P_1 P_2	0000	0000	
P_3 P_4	0000	0001	outside
P_5 P_6	0001	0000	0000 AND PC
P_7 P_8	0100	0010	0000 PC
P_9 P_{10}	1000	0010	0000 PC

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Clipping P_5 P_6

Intersection point P_5'

Slope Intercept method

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

P_7 P_8

P_5 P_6

P_9 P_{10}

P_5 P_6 → Cut left ∴ x_{wmin} Constant

ychange $\quad m = \frac{y - y_1}{x_{wmin} - x_1}$

left $y = m(x_{wmin} - x_1) + y_1$

P_7 P_8 → it cuts bottom & Right

Bottom → y Constant x to change

$$m = \frac{y_{wmin} - y_1}{(x - x_1)} \Rightarrow x = \frac{1}{m}(y_{wmin} - y_1) + x_1$$

Right $y = m(x_{wmax} - x_1) + y_1$

Top $x = x_1 + \frac{1}{m}(y_{wmax} - y_1)$

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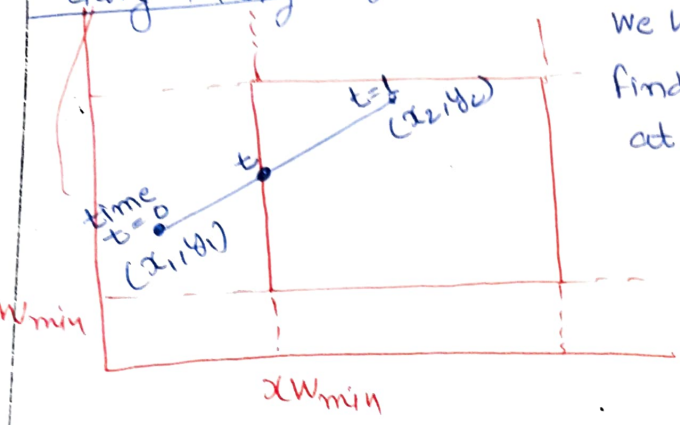
असतो मा सद्गमय

Liang Barsky Algorithm



We have take time t from 0 to 1
Find coordinate (x, y) of line at any time (t) - which is.

$$0 \le t \le 1$$

from parametric equation →

$$x = (1-t)x_1 + tx_2 \quad \text{—— (1)}$$

$$y = (1-t)y_1 + ty_2 \quad \text{—— (2)}$$

take eq. (1)

$$x = x_1 - x_1 t + tx_2$$

$$= x_1 + t(x_2 - x_1) \Rightarrow \boxed{x = x_1 + t\Delta x}$$

take eq (2)

$$y = y_1 - ty_1 + ty_2$$

$$= y_1 + t(y_2 - y_1) \Rightarrow \boxed{y = y_1 + t\Delta y}$$

As per point clipping algo

$$x_{wmin} \le x \le x_{wmax}$$

$$y_{wmin} \le y \le y_{wmax}$$

Now put value in these eq.

$$x_{wmin} \le x_1 + t\Delta x \le x_{wmax}$$

$$y_{wmin} \le y_1 + t\Delta y \le y_{wmax}$$

↳

$x_1 + t\Delta x \geq x_{wmin} \Rightarrow t\Delta x \geq x_{wmin} - x_1$

$x_1 + t\Delta x \leq x_{wmax} \Rightarrow t\Delta x \leq x_{wmax} - x_1$

$y_1 + t\Delta y \geq y_{wmin} \Rightarrow t\Delta y \geq y_{wmin} - y_1$

$y_1 + t\Delta y \leq y_{wmax} \Rightarrow t\Delta y \leq y_{max} - y_1$

We want all 4 in $\leq$ form, so multiply with $(-)$

$-t\Delta x \leq x_1 - x_{wmin}$ —— (3)

$t\Delta x \leq x_{wmax} - x_1$ —— (4)

$-t\Delta y \leq y_1 - y_{wmin}$ —— (5)

$t\Delta y \leq y_{max} - y_1$ —— (6)

→ Now represent in general equation form :-

$$tp_k \leq q_k \quad (k = 1 \cdots 4)$$

Compare with equation 3-4-5-6 with general equation and find value of p_k & q_k

- for (3) $k=1$ (5) $k=3$
- (4) $k=2$ (6) $k=4$

$$\frac{-t\Delta x \leq x_1 - x_{wmin}}{tp_1 \leq q_1} \Rightarrow \boxed{p_1 = -\Delta x \mid q_1 = x_1 - x_{wmin}}$$

$$\frac{t\Delta x \leq x_{wmax} - x_1}{tp_2 \leq q_2} \Rightarrow \boxed{p_2 = \Delta x \mid q_2 = x_{wmax} - x_1}$$

$$\frac{-t\Delta y \leq y_1 - y_{wmin}}{tp_3 \leq q_3} \Rightarrow \boxed{p_3 = -\Delta y \mid q_3 = y_1 - y_{wmin}}$$

$$\frac{t\Delta y \leq y_{max} - y_1}{tp_4 \leq q_4} \Rightarrow \boxed{p_4 = \Delta y \mid q_4 = y_{max} - y_1}$$

(1)

If $P_k = 0$ — line is parallel $\{$ for $k = 1 \dots 4$ $\}$
If $q_k < 0$ — line is outside

If P_k other than zero
if $P_k < 0$ then find t_1

$$t = \max\left(0, \frac{q_k}{P_k}\right)$$

else $P_k > 0$
then find t_2

$$t = \min\left(1, \frac{q_k}{P_k}\right)$$

— Now check $t_1 > t_2$ line — Completely outside

— $t_1 < t_2$ then use

$$x = x_1 + t\Delta x$$
$$y = y_1 + t\Delta y$$

Q Window A(20,20), B(90,20), C(90,70)
D(20,70), line P_1(10,30), P_2(80,90)

→ $xw_{min} = 20$ $x_1 = 10$ $\Delta x = 70$
$xw_{max} = 90$ $y_1 = 30$ $\Delta y = 60$
$yw_{min} = 20$ $x_2 = 80$
$yw_{max} = 70$ $y_2 = 90$

$P_1 = -70$ | $q_1 = -10$
$P_2 = 70$ | $q_2 = 80$
$P_3 = -60$ | $q_3 = 10$
$P_4 = 60$ | $q_4 = 40$

None of the P_k is zero but η_c is yes less than zero. — moving line is somewhat from outside.

$P_k < 0$	$P_k > 0$
P_1, P_3	P_2, P_4
$t_1 = \max\left(0, \frac{-10}{-70}, \frac{10}{-60}\right)$	$t_2 = \min\left(1, \frac{80}{70}, \frac{40}{60}\right)$
$t_1 = 1/7$	$t_2 = \frac{2}{3}$

None get values of x & y

$x = 20$	$x = 56.67$
$y = 38.57$	$y = 70$

$$x = x_1 + t\Delta x$$

$$x = 10 + \frac{1}{7}(70)$$

$$= 10 + 10 = 20$$

$$y = y_1 + t\Delta y$$

$$= 30 + \frac{1}{7}(60)$$

$$= 30 + 8.57$$

$$= 38.57$$

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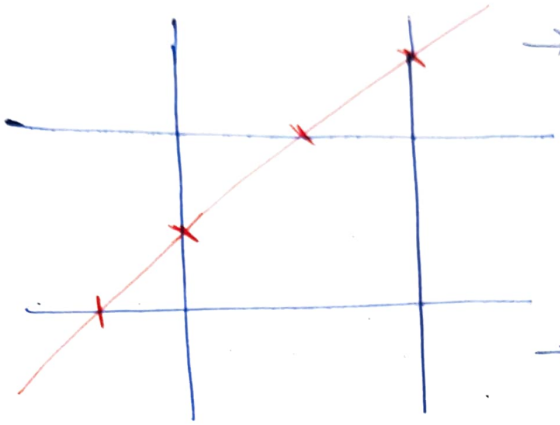
Nicholl - Lee - Nicholl Line Clipping

In Cohen-Sutherland line clipping sometimes multiple calculation of intersection point of a line is done before actual window boundary intersection.



→ These multiple intersection calculation is avoided in NLN line clipping procedure

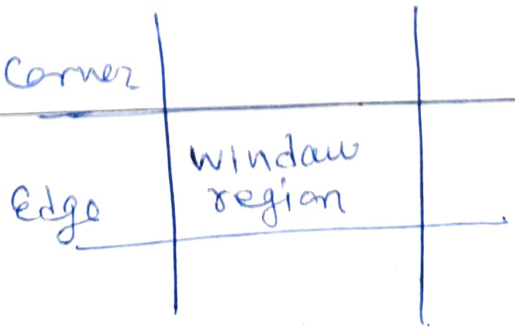
→ By creating more regions around the clip window the NLN algorithm avoid multiple clipping of an individual line segment.

→ NLN line clipping perform fewer comparisons and divisions so it is more efficient.

→ But NLN line clipping cannot be extended for three dimensions.

For given line we find first point falls in which region out of nine regions ~~about~~

- only three regions are considered -



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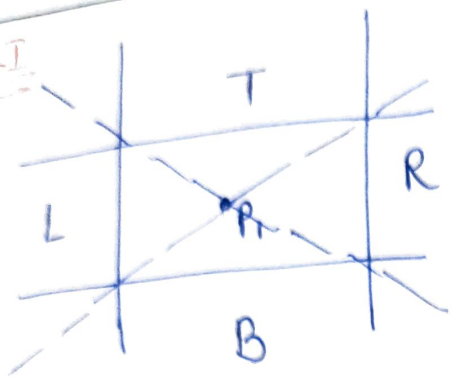
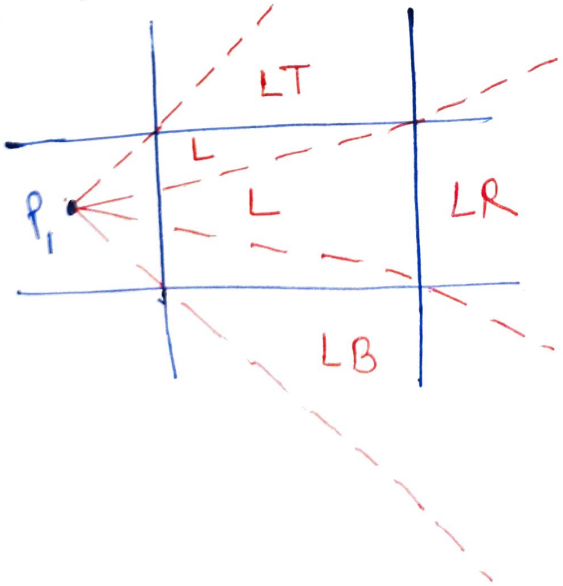
Case-I



Based on position of first point out of three regions highlighted we decide which space in new regions.

- Regions are name in such a way that name in which region P_2 falls is given the window edge which intersects the line.

Case-II P_1 is in edge region



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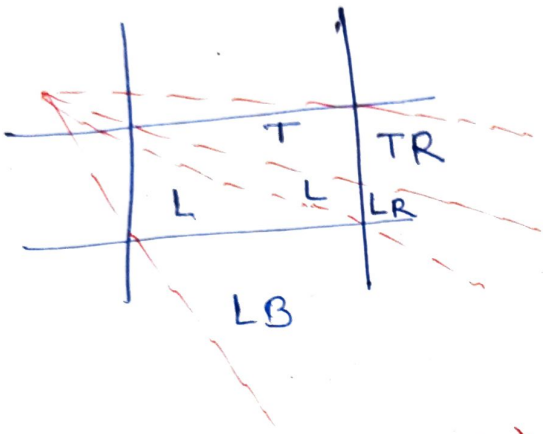
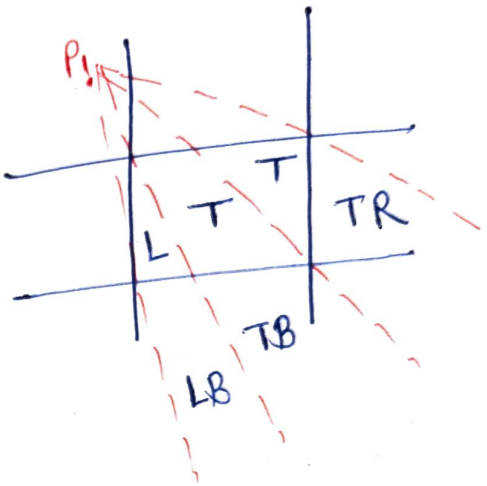
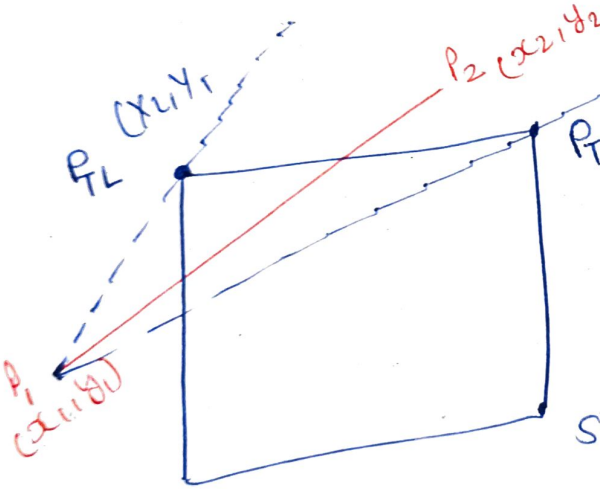
Case-II

P_1 is in corner region







Slop ~~P~~

~~$P_1P_{TL} < P_1P_2 < P_1P_{TR}$~~

$\text{Slop } P_1P_{TR} < \text{Slop } P_1P_2 < \text{Slop } P_1P_{TL}$

$$\frac{y_T - y_1}{x_R - x_1} < \frac{y_2 - y_1}{x_2 - x_1} < \frac{y_T - y_1}{x_L - x_1}$$

Parametric equation

$$x = x_1 + (x_2 - x_1)t$$

$$y = y_1 + (y_2 - y_1)t$$

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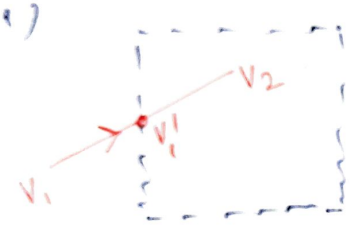
Sutherland Hodgman Polygon Clipping Algorithm.

* it clips the region of the polygon lying outside the window.
* Clip against each edge of window & obtain new set of vertices.
* 4 cases

(i)

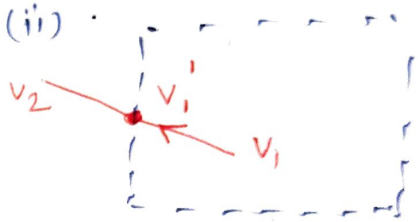


out → in

take :- intesect point + Destination point

ex — $V_1' V_2$

(ii)

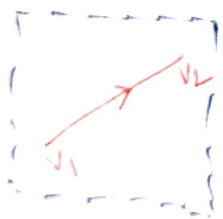


in → out

take :- intersection point only.

ex — V_1'

(iii)

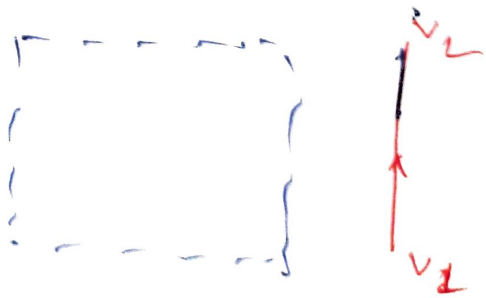


in → in

take :- destination Vertex V_2

ex — V_2

(iv)



out → out

take → nothing

LRBT

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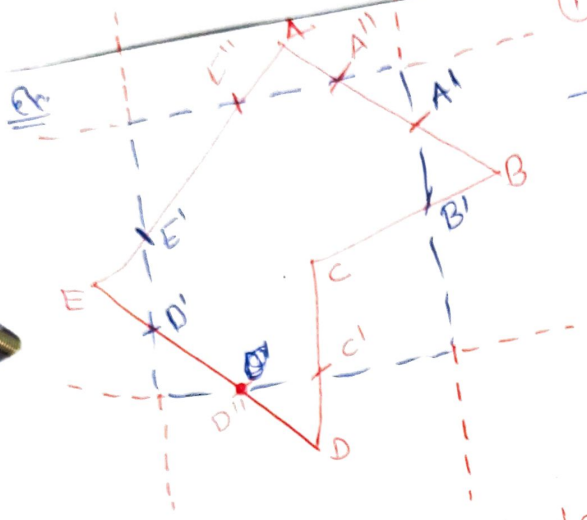
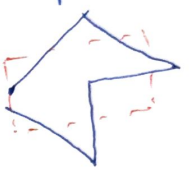
Ex.



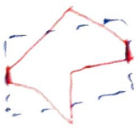
① Cliping against left edge :-

Vertex	Case	output
AB	in — in	B
BC	in — in	C
CD	in — in	D
DE	in — out	D'
EA	out — in	E' A



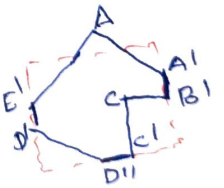
② Cliping Against Right edge

Vertex	case	output
AB	in — out	A'
BC	out — in	B' C
CD	in — in	D
DD'	in — in	D'
D'E'	in — in	E'
E'A	in — in	A



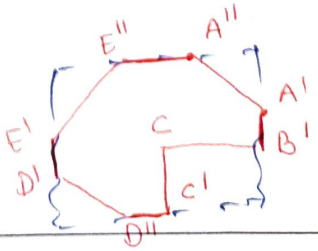
③ Clipping — Bottom

Vertex	Case	output
AA'	in — in	A'
A'B'	in — in	B'
B'C	in — in	C
CD	in — out	C'
DD'	out — in	D'' D'
D'E'	in — in	E'
E'A	in — in	A



④ TOP

Vertex	case	output
AA'	out — in	A'' A'
A'B'	in — in	B'
B'C	in — in	C
CC'	in — in	C'
C'D''	in — in	D''
D''D'	in — in	D'
D'E'	in — in	E'
E'A	in — out	E''



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Unit -5 Three Dimensional Graphics

3D display methods :— Projection

3D object Representation ① Polygon Surface — Polygon Tables
- Plane Equation
- Polygon Meshes

② Curves and Surface
- Quadric Surface
- Spline representation - interpolation Vs Approximation
- Cubic Spline interpolation method
- Bazier Curve & Surface
- B-Spline Curve & Surface

3D - Transformation. - translation, Rotation, Scaling
- Composite transformation

Viewing pipeline & Coordinates

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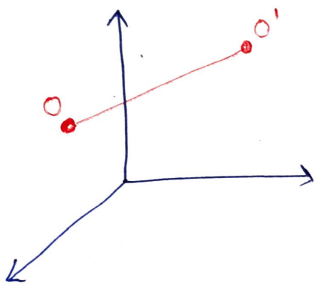
3D Translation in Computer Graphics

2D Translation

let - initial coordinates of the object O = $(X_{old}, Y_{old}, Z_{old})$

- New coordinates of the object O after translation = $(X_{new}, Y_{new}, Z_{old})$
- Translation Vector or shift vector = (T_x, T_y, T_z)



$$X_{new} = X_{old} + T_x$$

$$Y_{new} = Y_{old} + T_y$$

$$Z_{new} = Z_{old} + T_z$$

In matrix form

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

Q. Given a 3D object with coordinates A(1,1,1), B(3,3,2), C(3,0,0), D(0,0,0). Apply the translation with distance 1 towards X axis, 1 towards Y axis and 2 towards Z axis and obtain the new coordinates of the object.

A'(1,4,3) B'(4,4,4), C'(4,1,2) D'(1,1,2)

3D Rotation

initial coordinates of the object O = ($X_{old}, Y_{old}, Z_{old}$)

initial angle of _____ with respect to origin

Rotation angle = θ

New coordinates = ($X_{new}, Y_{new}, Z_{new}$)

X-Axis Rotation

$$X_{new} = X_{old}$$

$$Y_{new} = Y_{old} \times \cos\theta - Z_{old} \times \sin\theta$$

$$Z_{new} = Y_{old} \times \sin\theta + Z_{old} \times \cos\theta$$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

Y-Axis Rotation

$$X_{new} = Z_{old} \times \sin\theta + X_{old} \times \cos\theta$$

$Y_{new} = Y_{old}$

$Z_{new} = Z_{old} \times \cos\theta - X_{old} \times \sin\theta$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

For Z-Axis Rotation

$X_{new} = X_{old} \times \cos\theta - Y_{old} \times \sin\theta$

$Y_{new} = X_{old} \times \sin\theta + Y_{old} \times \cos\theta$

$Z_{new} = Z_{old}$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

Q. Given a homogeneous point (1,2,3). Apply rotation 90° degree towards X, Y, and Z axis and find out the new Coordinate points.

3D Scaling

Let,

initial coordinates of the object O = $(X_{old}, Y_{old}, Z_{old})$

Scaling factor for x-axis – S_x

" " " y-axis – S_y

" " " z-axis – S_z

New cordinates O = $(X_{new}, Y_{new}, Z_{new})$

$$X_{new} = X_{old} \times S_x$$
$$Y_{new} = Y_{old} \times S_y$$
$$Z_{new} = Z_{old} \times S_z$$

$$\begin{bmatrix} X_{new} \\ Y_{new} \\ Z_{new} \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} X_{old} \\ Y_{old} \\ Z_{old} \\ 1 \end{bmatrix}$$

Given a 3D object with coordinate point A(0,3,3), B(3,3,6), C(3,0,1), D(0,0,0). Apply the scaling parameter 2 towards x-axis, 3-towards y axis and 3-towards z axis and obtain the new coordinates of the object.

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B-Spline Curve

Limitation of Bezier Curve

The Bezier curve produced by Bernstein basis fn has limited flexibility.

(1) No. of control points decides the degree of the polynomial curve
↳ So if want to reduce the degree of the curve, then reduce no. of control points.

(2) The second limitation is that the value of the blending fn is non-zero for all parameter values over the entire curve.

- Due to this change in one vertex, change in the entire curve and this eliminates the ability to produce a local change with in a curve.

Properties of B-spline

1) B-Spline basis is non-global (local) effect.
— In this each control point affect the shape of the curve only over range of parameter values where its associated basis fn is non-zero.

$B_{0,3} = {}^3C_0 \cdot u^0 \cdot (1-u)^{3-0}$

$B_{0,3} = \frac{3!}{0!\,3!} \cdot u^0 \cdot (1-u)^3$

$B_{0,3} = 1 \cdot 1 \cdot (1-u)^3 \Rightarrow \boxed{B_{0,3} = (1-u)^3}$

$B_{1,3} = 3 \cdot u \cdot (1-u)^2$

$B_{2,3} = 3 \cdot u^2 (1-u)$

$B_{3,3} = u^3$

So $Q(u) = P_0 \cdot (1-u)^3 + P_1 \cdot 3 \cdot u \cdot (1-u)^2 + P_2 \cdot 3 \cdot u^2 \cdot (1-u) + P_3 \cdot u^3$

Write in fm of x

$x(u) = x_0 \cdot (1-u)^3 + x_1 \cdot 3u(1-u)^2 + x_2 \cdot 3u^2 \cdot (1-u) + x_3$

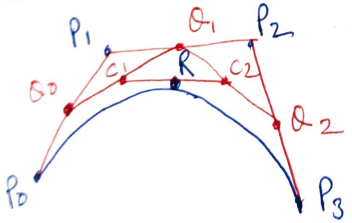
Same for

$y(u) =$

$z(u) =$

Q. How we derived it

Ex



Parametric eq. of line

$Q_0 = (1-u) P_0 + u \cdot P_1$

$Q_1 = (1-u) P_1 + u \cdot P_2$

$Q_2 = (1-u) P_2 + u \cdot P_3$

$C_1 = (1-u) Q_0 + u \cdot Q_1$

$C_2 = (1-u) Q_1 + u \cdot Q_2$

$R = (1-u) C_1 + u \cdot C_2$

$R = (1-u)[(1-u)Q_0 + u \cdot Q_1] + u \cdot [(1-u)Q_1 + u \cdot Q_2]$

$R = (1-u)[[(1-u)[(1-u)P_0 + u \cdot P_1] + u \cdot [(1-u)P_1 + u \cdot P_2)]] + u[[(1-u)[(1-u)P_1 + u \cdot P_2] + u \cdot [(1-u)P_2 + u \cdot P_3]]$

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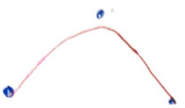
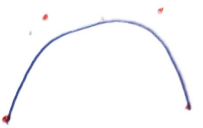
Bez. curve from two control point :-

three point :-



four point :-



Bez. curve always inside of curve bound.-

* eq. of bez. curve Q(u) :-

$$Q(u) = \sum_{i=0}^{n} P_i * B_{i,n}(u)$$

i = starting pt

$B_{i,n}(u)$ = Barnstien / Bez. f_i^n

P_i = Position Vector / control pt

↳ x cordinate form

$$X(u) = \sum_{i=0}^{n} x_i \cdot B_{i,n}(u)$$

where $Bez_{i,n}(u) = {}^{n}C_i \cdot u^i \cdot (1-u)^{n-i}$

$${}^{n}C_i = \frac{n!}{i!\,(n-i)!}$$ Binomial coefficient

Ex. 4 control points $i=0$ $n=3$

Eq. $Q(u) = P_0 \cdot B_{0,3}(u) + P_1 \cdot B_{1,3}(u) + P_2 \cdot B_{2,3}(u)$

$+ P_3 \cdot B_{3,3}(u)$

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Bezier Spline Curve

(1) Approximate spline curve
(2) ↳ First control point $P(0)$ & last control point $P_n(1)$
(3) follow bernstein polynomial g^n
(4) Polygon boundaries created by control points.
(5) Bez. curve always be inside convex hull of polygon boundaries.
(6) degree of polynomial eq. is always 1 less than control point.

Ex. — C.P = 4
degree = 3 hoga ✗ (3)

disadvantage

(1) degree depends on control points
like is 10 c.p than 9 degree ✗ (9) — complex to control
(2) it provide global control, means if we shift 1- control point, than whole shape of the curve is changed.

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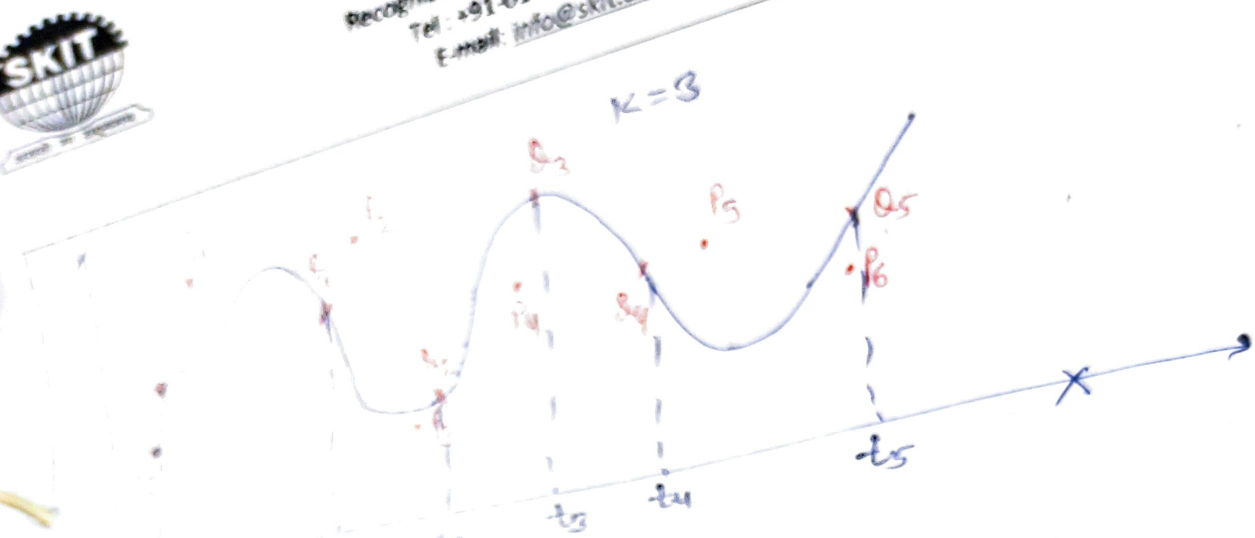

Parameter

$t_0=0$, $t_1=1$

$t_1=1$, $t_2=2$

$t_2=2$, $t_3=3$

$t_3=3$, $t_4=4$

$t_4=4$, $t_5=5$

- There will be a join point or knot between S_{i-1} & S_i for $i=3$ at the parameter value t_i known as KNOT VALUE [X]

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2) B-Spline curve made up of n+1 control P^4.

3) B-Spline curve let us specify the order of basis (k) fn and the degree of the resulting curve is independent of the no. of vertexes.

4) It is possible to change the degree of the curve without changing the no. of control points.

5) B-spline can be used for both open & closed curve.

6) If we have order k=4 then degree will be 3
$P(t) = x^3$

7) The curve line within the convex hull of its defining polygon.

In B-Spline we segment out the whole curve which is decided by the Order (k). By formula 'n-k+2'

Ex: Control point = 7
Order of curve (k) = 3
Then n=6 & Segment(Q) = 6-3+2 = 5

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Ex: $n = 5$; $k = 3$

then x_i $(0 \le i \le 8)$ knot values

* when $i = 0$, $k = 3$ so $i < k$ is true

$x_0 = 0$

$i = 1$, $k = 3$ $x_1 = 0$

$i = 2$, $k = 3$ $x_2 = 0$

$i = 3$, $k = 3$ $x_3 = i - k + 1 = 1$

$i = 4$, $k = 3$ $x_4 = 2$

$i = 8$, $k = 3$ $x_8 = 4$

$x_i = \{0, 0, 0, 1, 2, 3, 4, 4, 4\}$

$N_{0,3}(u) = (1-u)^2 \cdot N_{2,1}(u)$

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If $P(u)$ be the position vectors along the curve as a fn of the parameter (u), a - Bspline curve is given by -

$$P(u) = \sum_{i=0}^{n} P_i \cdot N_{i,k}(u) \qquad 0 \le u \le n-k+2$$

$N_{i,k}(u)$ is Bspline basis fn

$$N_{i,k}(u) = \frac{(u-x_i)\, N_{i,k-1}(u)}{x_{i+k-1} - x_i} + \frac{(x_{i+k} - u)\, N_{i+1,k-1}(u)}{x_{i+k} - x_{i+1}}$$

- The values of x_i are the elements of a knot vector satisfying the relation $x_i \le x_{i+1}$
- The parameter u varies from 0 to $n-k+2$ along the $P(u)$

$x_i \ (0 \le i \le n+k)$ → Knot values

$x_i = 0$ if $i < k$

$x_i = i - k + 1$ if $k \le i \le n$

$x_i = n-k+2$ if $i > n$

B-Spline Curves →

↳ Most widely used class of approximating splines

↳ Came to resolve the disadvantage having by bezier curve.

In There are two characteristics of bezier method which limits the flexibility of resulting curve.

↳ (i) Number of Polygon vertices ~~fixed~~ fixes the order of resulting polynomial which defines the curve

for eg. Cubic curve is defined by 4 vertices. To reduce the degree, we have to reduce no of vertices.

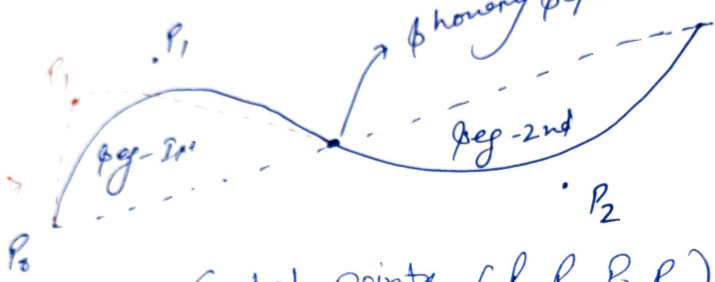
↳ (ii) Bezier curve is a result of blending the values of all defining vertices.

that means changes in one vertex is felt in entire curve.

The global nature of bezier curve eliminates the ability to produce local change within the curve.

If Pi as a group

In the Beizer B-Spline curve, the control points local control over the curve shape rather than the glo control like Beizer-Curve.



Control points (P_0, P_1, P_2, P_3)

- Bspline curve after changing the position of Control

B-Spline curve is non global. Each vertex B_i is asso with a unique basis function.

A B-spline curve is given by

$$Q(t) = \sum_{i=0}^{n} P_i * N_{i,k}(t)$$

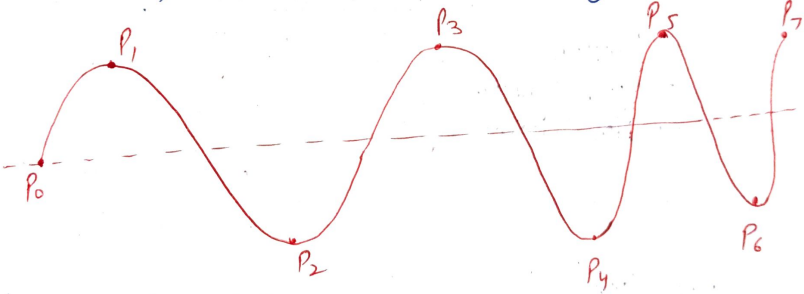
where P_i, K, t are control points, degree, parameter of curv

$$N_{i,k}(t) = \frac{(t - x_i) * N_{i,k-1}(t)}{x_{i+k-1} - x_i} + \frac{(x_{i+k} - t) * N_{i+1,k-1}(t)}{x_{i+k} - x_{i+1}}$$

and following are some conditions for x_i as follows:-

$$x_i = 0 \quad \text{if} \quad 1 \le i \le k$$
$$x_i = i - k + 1 \quad \text{if} \quad k \le i \le n$$
$$x_i = 0 \quad \text{if} \quad i \le n$$

B-Spline curves are independent of number of control points. Each segment shape is decided by some specific control points that come in that region of segment.



[We have $n+1$ control points so $n+1 = 8 = \text{so } n = 7$

Let's assume order of this curve is k so the curve that we get will be of a polynomial of degree of $k-1$.

$2 \le k \le n+1$ so if $k=4$ curve degree $= k-1 = 3$.

Total number of segments $= n - k + 2 = 7 - 4 + 2 = 5$

Knot → point b/n two segments of a curve that
each other such points
In cubic polynomial degree curve, knots are
$n+4$.
in othe cases $n+k+1$ knots

So knot vectors will be

Total knots = $n+k+1 = 7+4+1 = 12$

Knot vectors are of three types

- Uniform → $k=2$ [0 0 1 2 3 4 4]
- Open-Uniform → $k=3$ [0 0 0 1 2 3 3 3]
  $k=4$ [0 0 0 0 1 2 2 2 2]
- Non Uniform → $k=4$ [0 0 0 0 1 1 1 1] k zeros followed by

Properties

- Each basis function has 0 or +ve value for all parameter
- Each basis function has one maximum value except for k=1
- Degree of B-spline curve polynomial does not depend on number of control points
- provides local control
- Sum of basis function for a give parameter is one

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3-D Concepts

To model and display a three dimensional scene, ~~there~~ many considerations are needed to take into account but not only the coordinate values for the third dimension. We need to consider object boundaries, internal components or cross-sectional views of solid objects.

for example. To rotate an object about an axis in 3-D space but in 2-D we rotate around an axis that is perpendicular to the xy plane.

Viewing transformations are much complicated because we need to consider many parameters to select when specifying how a 3-D scene is to be mapped to a display device.

3-D display methods

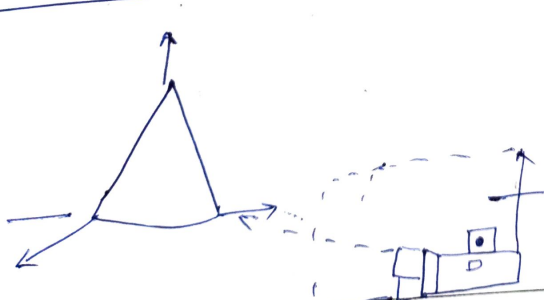

fig:- Coordinate reference for obtaining a particular view of a 3-D scene

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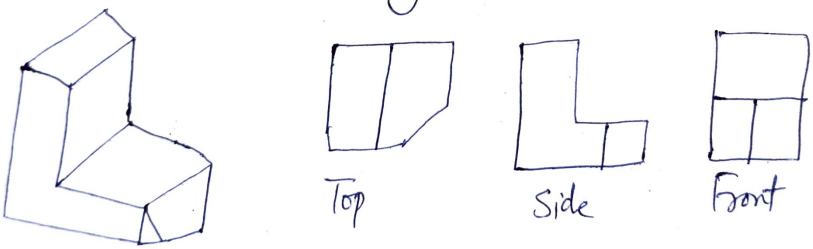
To obtain a display of 3-D scene, modeled in world coordinates we must first setup a coordinate reference for the camera. Object descriptions are then transferred to the camera reference coordinates and projected onto the selected display plane.

Parallel Projection :-

- method for generating a view of a solid object is to project points on the object surface along parallel lines onto the display plane.
- Parallel lines in world coordinate scene project into parallel lines on 2-D display plane.



- discards z-coordinate and parallel lines from each other
- Specify a direction of projection instead of center of projection
- Project points on the object surface along parallel lines onto the display plane
- Parallel lines are still parallel after projection

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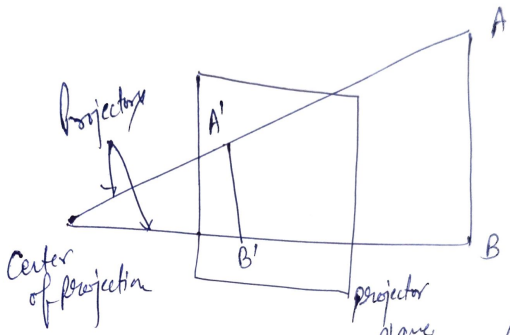
Perspective projection :

- Method for generating views of 3-D scene into project points to the display plane along converging paths. → (next page)



- Distance b/n object and projection center is finite
- It is difficult to define the actual size and shape of object
- ~~Relati~~ Realistic but tough to implement
-

... KUB Color model

... model — (8) 2021

... Illumination model (3) 2017

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This cause objects farther from the viewing position. to be displayed smaller than objects of the same size that are nearer to the viewing position.

- In a perspective Pro., parallel lines in a scene that are not parallel to the display plane are projected into converging line.

Depth Cueing :-

→ depth i/f is important so that we can easily identify, for a particular viewing direction, which is the front and which is the back of display objects.

→ A simple method for indicating depth with wireframe display is to vary the intensity of object according to their distance from the viewing position..

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Unit-6

Illumination and color models

Light sources – Basic illumination model
- hafton pattern
- dithering technique
- ~~Properties of light~~

Properties of Light → Standard primaries and Chromaticity diagram

Intuitive Color Concept – RGB Color model
YIQ Color model
CMY Color model
HSV Color model
HLS Color model

Color Selection -

RTU Questions

2016
2021
2022
2018 (8)

1. Describe phong shading in detail
2. Explain in brief RGB, CMY and HSV color model
   ↳ (8) 2022, 2019, 2017, 2016, 2018
3. Explain Diffuse reflection and specular reflection
   ↳ (15) 2022, 2021 [2-2], 2017 [3-3], 2018 (8)
4. Explain Halfton pattern and Dithering technique in detail — (15) 2021
5. Write a routine to convert RGB Color model to HSV Color model — (8) 2021
6. Explain Illumination model. (3) 2017

(7) explain Phong Shading. Compare with Gouraud
↳ (7) 2017
(8) Describe Gouraud Shading. - 2016 (4)
(9) What is HSV color model - 2016 (4)
(10) Discuss about half toning. - 2018 (3)
(11) What is ray tracing ? How can you render polygon surface using Gouraud shading. (8) 2018

According to RTU Question ~~Bank~~, Syllabus

1) Illumination model, diffuse illumination, diffuse reflection, coefficient of reflection, Lamberts law.
2) Gouraud shading
3) Phong Shading

→ Object illuminated on the basis of the following properties:-

(1) Intensity of Ambient light
(2) Types of object surface
(3) surface color

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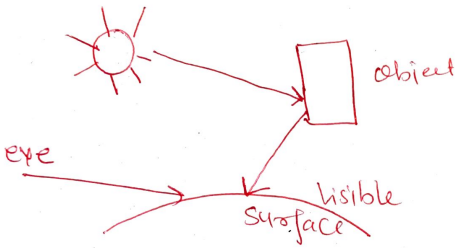
Types of illumination models are :-

1) Ambient light
2) Diffuse Reflection
3) Specular Reflection and Phong model

Ambient light — A surface that is not exposed directly to light source still will be visible if nearby objects are illuminated.



The combination of light reflection from various surfaces to produce a uniform illumination is called Ambient light.

Ambient light has no spatial or directional characteristics and amount on each object is a constant for all surfaces and all directions.

illumination equation $I = K_a I_a$

I — resulting intensity
K_a — object intrinsic intensity
I_a — intensity of ambient light

because Ia equall on all surface from all direction.

$I = K_a$

The light K_a (ambient - reflection coefficient) $0 \leftrightarrow 1$

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Illumination Model

Shading
dark light

illumination
रोशनी
Brightness

intensity.
तीव्रता
Quantity of illumination

Shading model
Illumination model } - Same
light model

Illumination model or a light model — is the model for calculating light intensity at a single surface point.

Components of illumination model

Light source - type, color and direction of the light source.

Surface properties - reflectance, opaque/transparent, shiny/dull.

Light source Object that radiates energy are called light sources, like — sun, bulb, lamb

→ Sometimes light source are referred as light emitting object and light reflectors.

I_a - Ambient intensity parameter, is idependent on
- Surface orientation
and - Viewer location

But the different surface may reflect diffent amount of ambient light

$I_{amb} = k_a \cdot I_a$
↳ percentage of light reflected by surface.

Diffuse Reflection (surface position is dependent)
- The light that is reflected in all direction is known as D.R.
- The Reflected light is dependent of viewing position & equally bright from all direction &
- But the light position w.r.t surface orientation is important.

The diffuse surface are rough or grainy like clay, soil, fabric
Surface appears equally bright from all viewing direction.
The brightness at each pt is proportional to cosθ

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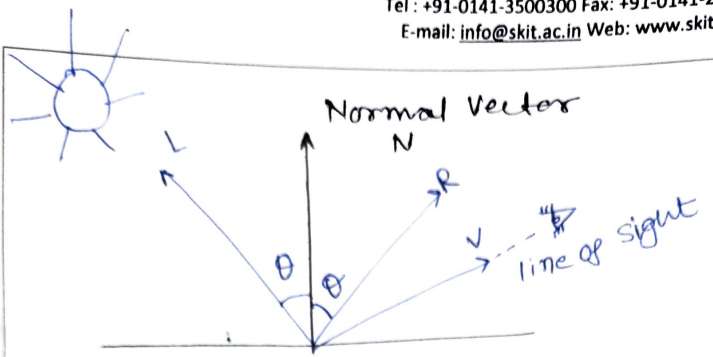

L = light of source direction
N = Normal Vector
θ = angle of incidence
V = line of sight
R = direction of reflection
α = angle b/w R & V

- Color of an object is determined by the color of the diffuse reflection of the incident light (R)
  - if any object surface is red then there is a diffuse reflection for red component of light and all other components are absorbed by the surface.

- If surface is exposed only to a ambient light, we can express the intensity of the diffuse reflection at any point on the surface as:

$$I_{amb,diff} = k_d \cdot I_a$$

k_d — diffuse-reflection coefficient (0 — 1)

k_d — defines the fractional amount of the incident light that is diffusely reflected.

$k_d = 0$ —

$k_d = 1$ — for highly reflective surface

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- $\cos\theta = N \cdot L$ (Lambertian cosine law)

- diffuse reflection equation is:- (for single point source)

$I_{L,diff} = K_d \cdot I_L \cos\theta$

$$I_{diff} = K_d \cdot I_L (N \cdot L)$$

When $\cos\theta$
+ve — surface is illuminated
-ve — light source is behind the surface.

$$I_{diff} = K_d \cdot I_a + K_d \cdot I_L (N \cdot L)$$

↳ Total diffuse

Specular reflection ~~and phong model~~

When we look at an illuminated shiny surface, such as polished metal, a person's forehead, we see a highlight or bright spot at certain viewing direction. Such phenomenon is called specular reflection.

~~Gouraud~~ Shading

Polygon Rendering method
OR
surface shading method

→ Illumination model is applied to fill the interior of polygons.

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Two ways of polygon surface rendering:-

1) Single intensity for all points in a polygon
2) Interpolation of intensities for each point in a polygon

Methods

1. Constant intensity shading
2. Gouraud shading
3. Phong shading.

→ Fast and simple method for rendering an object with polygon surface

- Each polygon shaded with single intensity calculated for the polygon.

Procedure

1. Take a point on the object surface and calculate the intensity.
2. Render the surface with same intensity throughout the surface.
3. Repeat above procedure for each polygon surface.

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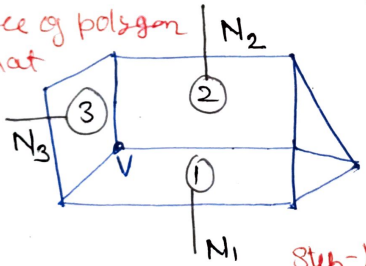
Gouraud Shading

- Intensity interpolation method
- Renders a polygon surface by linearly interpolating intensity values across the surface

Procedure -

1. Determine the average unit normal vector at each polygon vertex.
2. Calculate each of the vertex intensities by applying an illumination model.
3. Linearly interpolate the vertex intensities over the polygon surface.



no. of surface of polygon sharing that vertex.

Vertex V is shared by Surface ① ② ③

→ Calculate N_v (Normal Unit Vector at Vertex V)

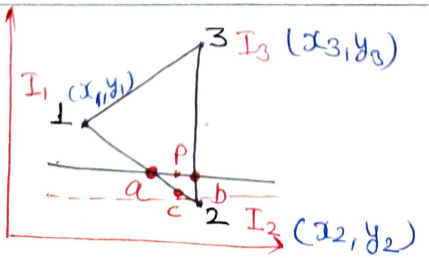
$$N_v = \frac{N_1 + N_2 + N_3}{|N_1 + N_2 + N_3|}$$

Step-1

$$N_v = \frac{\sum_{i=1}^{n} N_i}{\left|\sum_{i=1}^{n} N_i\right|}$$

(A.U.V)

Apply illumination model



Intensity of a $I_a = \frac{y_a - y_2}{y_1 - y_2} I_1$

$$I_a = \frac{y_a - y_2}{y_1 - y_2} \cdot I_1 + \frac{y_1 - y_a}{y_1 - y_2} \cdot I_2$$

intensity of b $= \frac{y_b - y_2}{y_2 - y_3} \cdot I_3 + \frac{y_3 - y_b}{y_2 - y_3} \cdot I_2$

Intensity of $P_{I_b} = \frac{x_p - x_a}{x_b - x_a} \cdot I_b + \frac{x_b - x_p}{x_b - x_a} \cdot I_a$

Now to calculate intensity on other points - we can use previously calculated intensities to reduce calculation -

at any point c →

$$I_c = I_a + \boxed{\frac{I_2 - I_1}{y_1 y_2}}$$ always constant for edge (1-2)

Phong Shading
or
Normal vector interpolation Shading

---

1. Determine the average Unit Normal vector at each polygon Vertex
2. Linearly interpolate the vertex normal over the surface of polygon.
3. Apply the illumination model along each scan to determine projected pixel intensities of surface points

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Curve & Representation

When set of points infinite or finite are joined continuous then what we get is called curve.

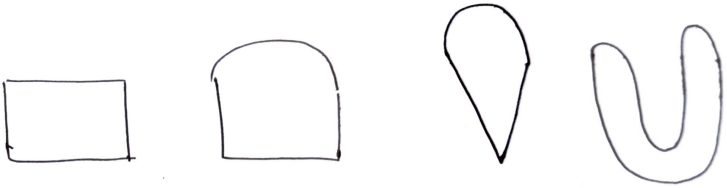
or

when we start from a point for drawing a geometrical figure and end at some other point without any gap, so what we get is called curve.

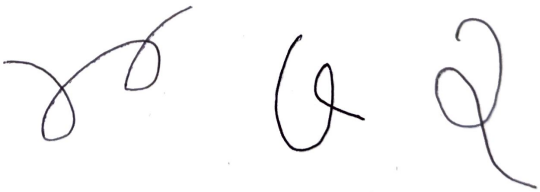
Types of curve

Open

Close



Crossing curve



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Representing Curves

Explicit Implicit Parametric

Explicit Rep. of Curve

→ In this the dependent variable has been given "explicitly" in terms of the independent variable.

donated as

$y = f(x)$ Ex. $y = ax^n + bx \cdots$

$y = 5x^3 + 2x + 1$

→ explicit representation is single valued for each value of x only a single value of y is computed.

Implicit Rep. of curve

In this dependent variable is not expressed in terms of some independent variable.

$f(x, y) = 0$ $x^2 + y^2 - 1 = 0$

$y^4 + x^3 + 18 = 0$

→ It can represent multivalued curve (multiple y values for an x value)

$x^2 + y^2 - R^2 = 0$

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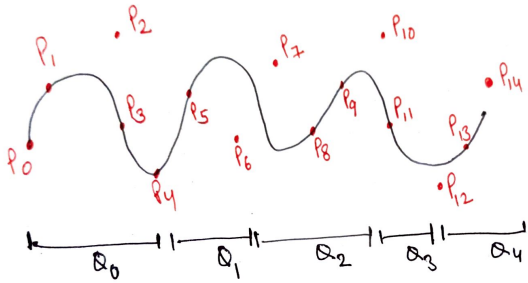
Parametric curve

The parametric representation for curve is -

$$x = x(t)$$
$$y = y(t)$$
$$z = z(t)$$

A curve is approximated by a piecewise polynomial curve instead of piecewise linear curve.



Each segment Q of the overall curve is given by three 3 functions (x, y, z) which are cubic polynomial in the parameter of t or v.

The cubic polinomial that defines a curve segment

$$Q(t) \begin{bmatrix} x(t) & y(t) & z(t) \end{bmatrix}$$

where $T = [t^3 \; t^2 \; t \; 1]$

$$x(t) = a_x t^3 + b_x t^2 + c_x t + d_x$$
$$y(t) = a_y t^3 + b_y t^2 + c_y t + d_y$$
$$z(t) = a_z t^3 + b_z t^2 + c_z t + d_z \quad (1)$$

$$0 \le t \le 1$$

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- We can convert an implicit f^n into explicit f^n

Ex Convert imp. f^n $x^2+y^2-1=0$ into explicit.

$$y = \pm\sqrt{1-x^2}$$

↳ it is simple process.

Parametric Curve

- There are many curve which we cannot write dow as a single equation in terms of only x and y.
- Instead of defining y in terms of x ($y=f(x)$) or x " " " y ($x=f(y)$)

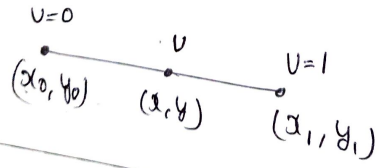
we define both x and y in terms of a third variable called a parameter.

$$x = f_x(v)$$
$$y = f_y(v)$$

v is parameter

like line parametric equation is

$$x = (1-v)x_0 + vx_1$$
$$y = (1-v)y_0 + vy_1$$



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The coefficient matrix is defined as

$$C = \begin{bmatrix} a_x & a_y & a_z \\ b_x & b_y & b_z \\ c_x & c_y & c_z \\ d_x & d_y & d_z \end{bmatrix}$$

& $A(t) = \begin{bmatrix} x(t) & y(t) & z(t) \end{bmatrix} = T.C$

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Spline Representation

Spline is flexible strip used to produce a smooth curve through a designated set of points.

Interpolation and approximation splines

- We specify curve by giving a set of coordinate positions called control points.

- Interpolation Spline - When curve section passes through each control point, the curve is said to interpolate the set of control points and that spline is known as interpolation spline.

Approximation Spline :- When curve section follows general control point path without necessarily passing through any control point, the resulting curve is said to approximate the set of control points and that curve is known as approximation Spline.

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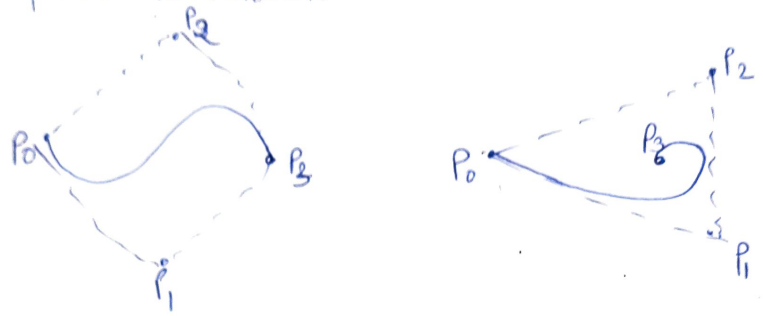
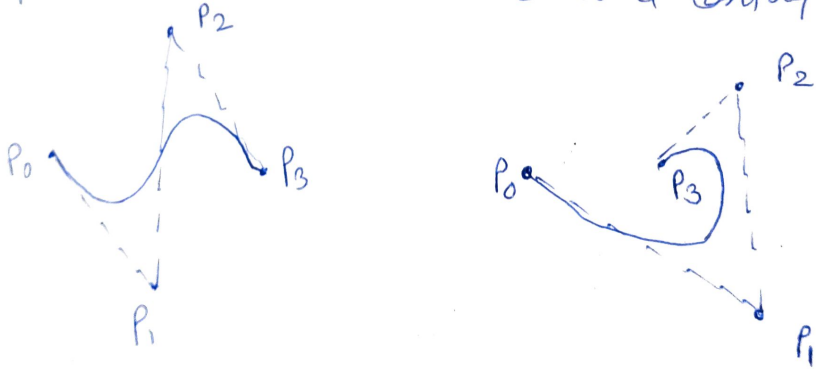
Convex Hulls

- The boundary formed by the set of control points for a spline is known as a convex hull.



Control Graph – A polyline connecting the control points in order is known as a control graph



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Color Model -

A color model is an abstract mathematical model describing the way colors can be represented as tuples of numbers.

OR

Any method for explaining the properties or behavior of color within some particular context is called color model.

Primary color — set of color that can be combined to make a useful range of colors.

Color Gamut — set of all colors that we can produce from the primary colors.

Complementary colors — pairs of colors, when combined in the right proportions, produce white.

Ex. in RGB model — Red & cyan, green & magenta, blue & yellow.

Shades, Tints & Tones

- A shade is produced by "dimming" a hue (adding Black)
  Dark blue = pure blue + black
- A tint ——— "lightening" a hue (adding white)

- Tone refers to the effect of reducing the "colorfulness" of a hue. [adding gray] or [adding black & white]

Into

Two models

Additive color :- (RGB)

1) Use light to display color
2) Mixing begins with black and ends with
3) Used for computer display.

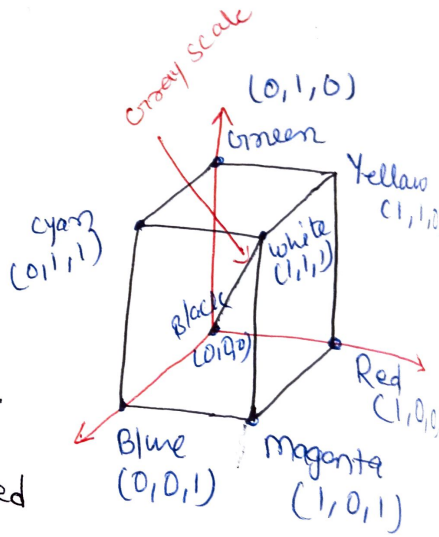
Subtractive color :- (CMYK)

1) Use ink to display color
2) Mixing begins with white & ends with Bl
3) Used in printed material

RGB - color model

→ Vertices of the cube on the axes represent primary colors and the remaining vertices are complementary color points for each of the primary colors.

- Shades of gray are represented along the main diagonal.



YIQ

Luminance — brightness
Chrominance — color

- Used for US TV broadcast
- Designed to separate luminance (Y) from Chrominance (I & Q)

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Convert RGB to YIQ

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} .299 & 0.587 & 0.114 \\ .5957 & -.274453 & -.321263 \\ .211456 & -.522591 & .311135 \end{bmatrix} \cdot \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Convert from YIQ to RGB

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} \begin{bmatrix} 1 & 0.9563 & 0.6210 \\ 1 & -0.2721 & -0.6474 \\ 1 & -1.1070 & 1.7046 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix}$$