

1. Name of the Faculty:	Roohi Sille	Course Code: CSEG 3003
2. Course :	Computer Graphics	L: 36
3. Program :	B. Tech CSE+CSF	T: NA
4. Target :	Level-1	P: NA C: 3

CHECKLIST

Check list Course Outcomes Attainment(COA)

SI.N o	Description	Date of Submission	Checke d	Remarks
1	Class Tests marks			
2	Quiz marks			
3	Assignment marks			
4	Mid Semester Marks			
5	End Semester Marks			
6	Check in COA format			
7	Whether respective CO of Class tests, Quiz's, Assignments, Mid and End semester maximum marks entered or not			
8	Ensure that all data got filled as per requirement			
9	Copy of quiz paper with the model answer and two/three answer sheets			
10	Copies of all test papers with two/three answer sheets			
11	Copies of all assignments with two or three model assignments			
12	Manual attendance sheet			
13	Copy of faculty time table			
14	Course Plan			
15	Class Tests, Quiz and assignment marks as per COs			
16	Copy of midterm examination paper and model solution			
17	Copy of end term examination paper and model solution			
18	List of minor/major project work given to the student			
19	Detailed internal assessment sheet			
20	Copy of final grade sheet (which was submitted to SRE) must be attached at the end of semester			
21	Copy of quiz /test conducted for lab			
22	Rubrics wise marks in Lab (Day to day evaluation sheet)			

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23	Copy of course attainment sheet (both pages)			
24	Indirect Attainment Sheet			

Signature of HOD/ Dean
Signature of Faculty
Date
Date:

UNIVERSITY OF PETROLEUM & ENERGY STUDIES

CSEG 324	COMPUTER GRAPHICS	L T P 3 0 0
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- **INTRODUCTION TO COMPUTER GRAPHICS AND OPENGL**
Overview of Computer Graphics, Computer Graphics Application and Software, Description of some graphics devices, Introduction to pixel, Why OpenGL, Features in OpenGL, OpenGL operations, Abstractions in OpenGL – GL, GLU & GLUT, 3D viewing pipeline, viewing matrix specifications, a few examples and demos of OpenGL programs.
- **SCAN CONVERSION – LINES, CIRCLES AND ELLIPSES; FILLING POLYGONS AND CLIPPING ALGORITHMS**
Scan Converting Lines, Mid-point criteria, Aliasing and Antialiasing, Problems of Aliasing, end-point ordering and clipping lines, Scan Converting Circles, Scan Converting Ellipses, Filling Polygons, Clipping Lines algorithms- Cyrus Beck, Cohen-Sutherland and Liang-Barsky, Clipping Polygons, problem with multiple components.
- **TWO-DIMENIONAL TRANSFORMATIONS**
Transformations and Matrices, Transformation Conventions, 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Translations and Homogeneous Coordinates, Rotation, Reflection, Scaling, Combined Transformation, Transformation of Points, Transformation of The Unit Square, Rotation About an Arbitrary Point, Reflection through an Arbitrary Line, A Geometric Interpretation of Homogeneous Coordinates, The Window-to-Viewport Transformations.
- **THREE-DIMENSIONAL TRANSFORMATIONS**
Introduction, Three-Dimensional Scaling, Three-Dimensional Shearing, Three-Dimensional Rotation, Three-Dimensional Reflection, Three-Dimensional Translation, Multiple Transformation, Rotation about an Arbitrary Axis in Space, Reflection through an Arbitrary Plane, Matrix Representation of 3D Transformations, Composition of 3D Transformations.
- **SCAN CONVERSION – LINES, CIRCLES AND ELLIPSES; FILLING POLYGONS AND CLIPPING ALGORITHMS**
Scan Converting Lines, Mid-point criteria, Aliasing and Antialiasing, Problems of Aliasing, end-point ordering and clipping lines, Scan Converting Circles, Scan Converting Ellipses, Filling Polygons, Clipping Lines algorithms- Cyrus Beck, Cohen-Sutherland and Liang-Barsky, Clipping Polygons, problem with multiple components.
- **VISIBLE-SURFACE DETERMINATION**

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COURSE PLAN

Target	50% (marks)s
Level-1	40% (population)
Level-2	50% (population)
Level-3	60% (population)

1. Method of Evaluation

UG	PG
Quizzes/Tests, Assignments (30%)	Quizzes/Tests, Assignments, seminar (50%)
Mid Examination (20%)	End semester (50%)
End examination (50%)	

2. Passing Criteria

Scale	PG	UG
Out of 10 point scale	SGPA – “6.00” in each semester CGPA – “6.00” Min. Individual Course Grade – “C” Course Grade Point – “4.0”	SGPA – “5.0” in each semester CGPA – “5.0” Min. Individual Course Grade – “C” Course Grade Point – “4.0”

*for PG, passing marks are 40/100 in a paper

*for UG, passing marks are 35/100 in a paper

3. Pedagogy

- Blackboard
- Presentation
- Class Test
- Quizzes
- Voiceover Presentation & Video lectures
- Assignments
- NPTEL videos
- YouTube videos
- Concept diary (needs to be maintained by students-short and concise notes that include course concepts that he/she has understood)

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4. References:

Text Books	Web resources	Journals	Reference books
1) Computer Graphics- C version, Second Edition, Pearson, Donald D. Hearn and M. Pauline Baker	https://youtube.com/results?search_query=Computer+Graphics+IIT+Madras		1) Mathematical Elements for Computer Graphics, Second Edition, McGraw Hill, David F. Rogers and J. Alan Adams
2) Computer Graphics with OpenGL, Fourth Edition, Pearson, Donald D. Hearn, M. Pauline Baker and Warren Carithers			2) Procedural Elements for Computer Graphics, Second Edition, McGraw Hill, David F. Rogers

GUIDELINES TO STUDY THE SUBJECT

Instructions to Students:

1. Go through the 'Syllabus' in the Black Board section of the website (<https://learn.upes.ac.in>) in order to find out the Reading List.
2. Get your schedule and try to pace your studies as close to the timeline as possible.
3. Get your on-line lecture notes (Content, videos) at Lecture Notes section. These are our lecture notes. Make sure you use them during this course.
4. Check your blackboard regularly
5. Go through study material
6. Check mails and announcements on blackboard
7. Keep updated with the posts, assignments and examinations which shall be conducted on the blackboard

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8. Be regular, so that you do not suffer in any way
9. **Cell Phones and other Electronic Communication Devices:** Cell phones and other electronic communication devices (such as Blackberries/Laptops) are not permitted in classes during Tests or the Mid/Final Examination. Such devices MUST be turned off in the class room.
10. **E-Mail and online learning tool:** Each student in the class should have an e-mail id and a pass word to access the LMS system regularly. Regularly, important information – Date of conducting class tests, guest lectures, via online learning tool. The best way to arrange meetings with us or ask specific questions is by email and prior appointment. All the assignments preferably should be uploaded on online learning tool. Various research papers/reference material will be mailed/uploaded on online learning platform time to time.
11. **Attendance:** Students are required to have minimum attendance of 75% in each subject. Students with less than said percentage shall NOT be allowed to appear in the end semester examination.
12. **Online Content:** Over 30% of your syllabus will be covered in fully online mode, Details of which is mentioned in the Syllabus details section.

This much should be enough to get you organized and on your way to having a great semester! If you need us for anything, send your feedback through e-mail [to your concerned faculty](#). Please use an appropriate subject line to indicate your message details.

There will no doubt be many more activities in the coming weeks. So, to keep up to date with all the latest developments, please keep visiting this website regularly.

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RELATED OUTCOMES

1. The expected outcomes of the Program are:

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	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 the public health and safety, and the cultural, societal, and environmental considerations.
PO4	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.
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	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.
PO7	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.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with 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.
PO11	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.
PO12	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.

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2. The expected outcomes of the Specific Program are: (upto3)

PSO1	Perform system and application programming using computer system concepts, concepts of Data Structures, algorithm development, problem solving and optimizing techniques,
PSO2	Apply software development and project management methodologies using concepts of front-end and back-end development and emerging technologies and platforms.
PSO3	Able to design, develop and deploy Mobile Applications (Apps) and protocols for Ubiquitous computing.

3. The expected outcomes of the Course are: (minimum 3 and maximum 6)

CO 1	Explore various graphics display devices and use graphical tool OpenGL.
CO 2	Apply scan converting algorithms to create various geometrical shapes.
CO 3	Carry out complex 2D and 3D geometric transformations.
CO 4	Design and develop curves and surfaces of higher order.

4. Co-Relationship Matrix

Indicate the relationships by 1- Slight (low) 2- Moderate (Medium) 3-Substantial (high)

Program Outcomes \ Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	1	2	2	2	-	-	-	-	-	-	-	-	-	-	-
CO 2	1	1	2	-	-	-	-	-	-	-	-	-	2	-	-
CO 3	1	2	2	-	-	-	-	-	-	-	-	-	1	-	-
CO 4	1	2	2	-	2	-	-	-	-	-	-	-	1	1	-

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Average	1	1.8	2	0.4	0.8								1.2	0.2	
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5. Course outcomes assessment plan:

Course Outcomes \ components	Assignment	Test/Quiz	Mid Semester	End Semester	Any other
CO 1	✓	✓	✓	✓	<input type="checkbox"/>
CO 2	✓	✓	✓	✓	<input type="checkbox"/>
CO 3	✓	✓	✓	✓	<input type="checkbox"/>
CO 4	✓	✓	✓	✓	<input type="checkbox"/>

BROAD PLAN OF COURSE COVERAGE

Course Activities:

S. No.	Description	Planned			Remarks
		From	To	No. of Sessions	
1.	UNIT -1 Introduction to computer graphics : Overview of computer graphics, Raster /Random scan display, Calligraphic refresh graphics , Display Input and output Device(CRT) Introduction to OpenGL GL,GLU,GLUT			4	ONLINE CONTENT (Voice over PPT and Lecture Notes) 1 Synchronous and 3 Asynchronous Assignment 1

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	3D Viewing Pipeline, Demo of OpenGL code.				
2.	UNIT 2: Scan conversion-Lines, Circles and Ellipses. Polygon Filling Algorithms and Clipping Algorithms Points & lines: Line drawing algorithms DDA algorithm Bresenham's line algorithm Problems of Aliasing ,end point and clipping lines Circle generation algorithms Ellipse generating algorithm Scan line polygon Flood fill algorithm Boundary fill algorithm Point clipping Line clipping Liang-Barsky line clipping algorithm Cohen Sutherland line clipping algorithm Polygon clipping Sutherland –Hodgman algorithm Weiler-Atherton Polygon clipping Text clipping	8	6 Synchronous and 2 Asynchronous Lecture (Online Lectures over Blackboard Collaborate and Offline Content via Voice Over PPT and Lecture Notes)		
3.	UNIT-3: 2D Transformations Homogenous coordinate system (HCS). Translation Rotation	5	4 Synchronous sessions for Lecture and		

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	Scaling Shearing Composite transformation Window to viewport transformations Rotation about point Reflection about a line				1 session for doubt clearance Mid Term
4.	UNIT-4: 3D Transformations Translation Rotation scaling Instance Rotation about an arbitrary axis in space reflection through an arbitrary plane polygon meshes		4		3 Lectures on Blackboard Collaborate and 1 OFFLINE Session via Voice over PPt and Lecture Notes
5.	UNIT-5: Curves Curve Representation, Non Parametric curves Cubic Splines Bezier Curves B-spline curves Rational B-spline curves Curved surfaces Quadric Surfaces Bezier Surfaces fractal – geometry		6		4 Synchronous and 2 Asynchronous Lecture (Online Lectures over Blackboard Collaborate and Offline Content via Voice Over PPT and Lecture Notes)
6.	UNIT-6: Hidden Surfaces Techniques for Efficient VSD,		5		Assignment 2 3 Synchronous and 2 Asynchronous Lecture

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	Depth comparison, Z-buffer algorithm, Back face detection, *BSP tree method, *The Painter's algorithm, Scan-line algorithm, Hidden line elimination, Area sub division methods				(Online Lectures over Blackboard Collaborate and Offline Content via Voice Over PPT and Lecture Notes) Quiz 2
7.	UNIT-7: Color & Shading Transparency, Shadows, Constant – Intensity shading, Gouraud Shading, Phong shading, Wireframe –visibility methods, Recursive ray, tracing algorithm , Radiosity model		4		3 Synchronous and 1 Asynchronous Lecture (Online Lectures over Blackboard Collaborate and Offline Content via Voice Over PPT and Lecture Notes) Test End Term

Synchronous Sessions: Lectures done through Blackboard Collaborate

Asynchronous Sessions: Lectures Content will be uploaded on Blackboard via Voice over PPT and

Handwritten Lecture Notes

Sessions: Total No. of Instructional periods available for the course

SESSION PLAN

UNIT-I

Lecture No.	Topics to be Covered	CO Mapped
1	Detailed Overview of the Course plan: Discussion on mode of delivery i.e. classroom /blackboard. Computer Graphics overview and its various applications	CO1
2	Pixels, Raster and Random scan display, Frame buffers.	CO1
3	CRT, Rasterization, Horizontal retrace and Vertical Retrace. Introduction to various 3D APIs and Introduction to OpenGL.	CO1, CO2
4	Discussion on various Libraries and its Programming syntax. OpenGL Rendering Pipeline and Demo of OpenGL code.	CO1
	Assignment 1	

SESSION PLAN

UNIT-II

Lecture No.	Topics to be Covered	CO Mapped
1	Overview of point and lines, their equations: Points & lines Line drawing algorithms DDA algorithm	CO2
2	Bresenham's line algorithm Problems of Aliasing ,end point and clipping lines	CO2
3	Circle generation algorithms Ellipse generating algorithm	CO2
4	Introduction to various polygon filling Techniques: Scan Line	CO2
5	Flood fill algorithm Boundary fill algorithm Introduction to Window and Viewport, Point clipping Line clipping.	CO2, CO3
6	Cohen Sutherland line clipping algorithm, with numerical	CO2
7	Liang-Barsky line clipping algorithm with numerical and other doubts related to clipping	CO2
8	Polygon clipping: Sutherland –Hodgman algorithm Weiler-Atherton Polygon clipping Text clipping Quiz 1	CO2

SESSION PLAN

UNIT-III

Lecture No.	Topics to be Covered	CO Mapped
1	Homogenous coordinate system (HCS). Translation Rotation Scaling	CO3
2	Shearing Composite transformation Window to viewport transformations	CO3 , CO4
3	Rotation about point. Reflection about a line.	CO3
4	Doubt clearing session on Composite transformations and Numerical.	CO3 , CO4
5	Doubt Clearance Session/Pending Topics.	CO3

SESSION PLAN

UNIT-IV

Lecture No.	Topics to be Covered	CO Mapped
1	3D transformations: Translation Rotation Scaling Instance MID SEM	CO3 , CO4
2	Rotation about an arbitrary axis in space, with numerical	CO3
3	Reflection through an arbitrary plane with numerical	CO3, CO4
4	Polygon Meshes	CO3

SESSION PLAN

UNIT-V

Lecture No.	Topics to be Covered	CO Mapped
1	Curve Representation(Introduction) : Non Parametric curves, Conic sections, Cubic Splines	CO4
2	Cubic Splines continued from Previous Lecture. Conic Sections(2D-Curves)	CO4 , CO3
3	B-Spline Curve	CO4, CO2
4	Bezier Curves and its Properties.	CO4
5	Bezier surfaces and Fractals	CO4
6	Pending topics and Numerical on the Curves.	CO4 , CO3
	Assignment 2	

SESSION PLAN

UNIT-VI

Lecture No.	Topics to be Covered	CO Mapped
1	Techniques for Efficient VSD, Depth comparison, Z-buffer algorithm	CO1
2	Back face detection, BSP tree method,	CO2
3	The Painter's algorithm, Scan-line algorithm,	CO3 , CO4
4	Hidden line elimination, Area sub division methods	CO4
5	Pending topics in VSD: Numerical on VSD	CO3
	Quiz 2	

SESSION PLAN

UNIT-VII

Lecture No.	Topics to be Covered	CO Mapped
1	Transparency, Shadows, Constant – Intensity shading,	CO3, CO4
2	Gouraud Shading, Phong shading,	CO2 , CO4
3	Wireframe –visibility methods Recursive ray tracing algorithm Radiosity model	CO4
4	Test END SEM	



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UNIVERSITY OF PETROLEUM & ENERGY STUDIES

College of Engineering Studies

Dehradun

COURSE PLAN

Programme : B.Tech (CSE+CSF)

Course : Computer Graphics Lab

Subject Code : CSEG 3103

No. of credits : 1

Semester : IV

Session : Jan 2022- July 2022

Batch : 2020-2024

Prepared by : Roohi Sille

Email : sanwarul@ddn.upes.ac.in

Approved By

HOD

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COURSE PLAN

A. PREREQUISITE:

- a. Basic Knowledge of Mathematics like Matrix and Geometry.
- b. Good knowledge of C and C++ for OpenGL.

**B. PROGRAM OUTCOMES (POs) and PROGRAM SPECIFIC OUTCOMES (PSOs)
for Computer Graphics :**

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. 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 the public health and safety, and the cultural, societal, and environmental considerations.

PO4. 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.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. 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.

PO7. 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.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with 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.

PO11. 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.

PO12. 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 (PSOs)

Computer Science Engineering with specialization in MAD/Devops Graduates will be able to:

PSO1. Perform system and application programming using computer system concepts, concepts of Data Structures, algorithm development, problem solving and optimizing techniques,

PSO2. Apply software development and project management methodologies using concepts of front-end and back-end development and emerging technologies and platforms.

PSO3. Ability to understand and apply graphical tools and modeling algorithms to design games and animations.

C. COURSE OUTCOMES FOR COMPUTER GRAPHICS: At the end of this course student should be able to

On completion of this course, the students will be able to

CO1. Acquaint with OpenGL library and understand the graphics code structure with it

CO2. Apply primitive operations to create 2D and 3D objects and perform various operations on them

CO3. Carry out complex 2D and 3D transformations on objects and create curves of 2nd and 3rd degree

CO4. Explore and implement various hidden surface removal techniques.

Table: Correlation of POs and PSOs v/s COs

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	2	2	2	-	-	-	-	-	-	-	-	-	-	3
CO2	1	1	2	-	-	-	-	-	-	-	-	-	2	-	2
CO3	1	2	2	-	-	-	-	-	-	-	-	-	1	-	1
CO4	1	2	2	-	2	-	-	-	-	-	-	-	1	-	1

1: Slight (Low)

2: Moderate (Medium)

3: Substantial (High)

D. OUTLINE OF PRACTICALS

Experiment 1: Introduction to OpenGL

Experiment 2: Drawing line using DDA, Bresenham's algorithm

Experiment 3: Drawing Circle and Ellipse using Mid-point algorithm

Experiment 4: Filling the objects using flood fill, boundary fill and scan line fill algorithm.

Experiment 5&6: Performing Clipping operation on line and polygon using Cohen Sutherland and Sutherland Hodgeman algorithms respectively.

Experiment 7&8: Performing 2D & 3D TRANSFORMATIONS on objects.

Experiment 9: Drawing Bezier curves.

Experiment 10: Animation & Event Handling using Mouse and Keyboard

Experiment 11&12: Creating 3D Shapes like Cube, Sphere and others.

E. PEDAGOGY

1. Students need to maintain a practical file which will contain all the executed experiments; file should contain all the output of all experiments, students will be evaluated on the basis of that file.
2. Student should carry mini lab copy which contains discussion of teachers note or algorithms of the experiments which will be executed.

F. COURSE COMPLETION PLAN

Total Lab sessions	12
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One Session =120 minutes

G. EVALUATION & GRADING

Continuous Evaluation- The performance of a student in a Practical subject will be evaluated as per process given below:

1. Components of evaluation
 - a. Viva voce / Quiz (50%) + Performance & Records (50%).
 - b. Lab performance and record evaluation shall be a continuous process throughout the semester.
 - c. Minimum three Viva voce/ Quiz based on practical sessions shall be conducted during the semester.
2. Distribution of marks for the lab sessions and the methodology should be conveyed to the students at the time of commencement of semester.
3. Final Grade Award Sheet needs to be submitted to SRE department before completion of End semester examination.

H. DETAILED LAB EXERCISE PLAN

Experiment 1: Introduction to OpenGL: [Virtual Lab Environment Setup]

- What is OpenGL?
- What is GLU/GLUT?
- What is OpenGL Architecture?
- Setting up the environment.
- First OpenGL Program: This initializes a window of Green color.

Discuss all the steps & functions in the program.

Experiment 2: Drawing a line [Usage of Open GL on Linux Environment for Virtual Environment]

- Draw a line using equation of line $Y=m*X+C$.
- Draw a line using DDA algorithm for slope $m < 1$ and $m > 1$.
- Draw a line using Bresenham algorithm for slope $m < 1$ and $m > 1$.

Take the input from user for all the three scenarios i.e. value of (x_1, y_1) and (x_2, y_2) .

Experiment 3: Drawing a Circle and an Ellipse [Done on OpenGL Environment]

- Draw the circle with the help of polar equations
- Draw the circle with the help of mid-point method.
- Draw the Ellipse with the mid-point method.

Take the value of radius, major axis and minor axis as input from the user.

Experiment 4: Filling –Area [Small Project will be given for demonstration]

- WAP to fill the polygon using scan lines.

- WAP to fill a region using boundary fill algorithm using 4 or 8 connected approaches.
- WAP to fill a region using flood fill algorithm using 4 or 8 connected approaches.

Take the value of seed point, intensity of new color as input from user.

Experiment 5 & 6: Viewing and Clipping [Geographical Animation for demonstration]

- Write an interactive program for line clipping using Cohen Sutherland line clipping algorithm.
- Write an interactive program for line clipping using Liang-Barsky line clipping algorithm.
- Write an interactive program for polygon clipping using Sutherland – Hodgeman polygon clipping algorithm.

Take the window coordinates as input from the user, also take polygon coordinates as input.

Experiment 7 & 8: Basic Two3 & Three Dimensional Transformations

- Write an interactive program for following basic transformation.
- Translation
- Rotation
- Scaling
- Reflection about axis.
- Reflection about a line $Y=mX+c$ and $aX+bY+c=0$.
- Shear about an edge and about a vertex.

Perform all the experiment for 3-D transformation.

Take the following values as input from user: Theta (angle of rotation), translation factor, scaling factor and other values. Make necessary assumptions.

Experiment 9: Drawing Bezier curves. [Virtual GLUT based demonstration]

- Write a program to draw a cubic spline.
- WAP to draw a Bezier curve.

Take necessary values as input from the user like degree of the Bezier curve.

Experiment 10: Animation & Event Handling using Mouse and Keyboard

- WAP to implement following scenarios
 - Mouse Handling
 - Mouse Motion Handling
 - Keyboard Handling
 - Animation Using Mouse

Take necessary values as input from the user like time, how long you want animation to run.

Experiment 11&12: Creating 3D Shapes like Cube, Sphere and others.

- WAP to create various 3D objects:
 - CUBE
 - SPHERE
 - CONE
 - TEAPOT.

Make necessary assumption for creating the 3-D objects, you can use inbuilt functions to simplify the coding, lightning and shading effect should also be there.

Suggestive reads:

1. OpenGL: Programming Guide, the Official Guide to Learning OpenGL.

Authors: Dave Shreiner, John Kessenich, Bill Licea-Kane, The Khronos OpenGL ARB Working Group.

2. OpenGL Programming Guide Paperback – 2008

Author by Mason Woo (Author), Dave Shreiner (Author)

GUIDELINES

Cell Phones and other Electronic Communication Devices: Cell phones and other electronic communication devices (such as Blackberries/Laptops) are not permitted in classes during Tests or the Mid/Final Examination. Such devices MUST be turned off in the class room.

E-Mail and online learning tool: Each student in the class should have an e-mail id and a pass word to access the LMS system regularly. Regularly, important information – Date of conducting class tests, guest lectures, via online learning tool. The best way to arrange meetings with us or ask specific questions is by email and prior appointment. All the assignments preferably should be uploaded on online learning tool. Various research papers/reference material will be mailed/uploaded on online learning platform time to time.

Attendance: Students are required to have **minimum attendance of 75%** in each subject. Students with less than said percentage shall **NOT** be allowed to appear in the end semester examination.

Course outcome assessment: To assess the fulfilment of course outcomes two different approaches have been decided. Degree of fulfillment of course outcomes will be assessed in different ways through direct assessment and indirect assessment. In Direct Assessment, it is measured through quizzes, tests, assignment, Mid-term and/or End-term examinations. It is suggested that each examination is designed in such a way that it can address one or two outcomes (depending upon the course completion). Indirect assessment is done through the student survey which needs to be designed by the faculty (sample format is given below) and it shall be conducted towards the end of course completion. The evaluation of the achievement of the Course Outcomes shall be done by analyzing the inputs received through Direct and Indirect Assessments and then corrective actions suggested for further improvement.

Passing criterion: Student has to secure minimum 30%/40% marks of the “highest marks in the class scored by a student in that

subject (in that class/group class)” individually in both the ‘End-Semester examination’ and ‘Total Marks’ in order to pass in that paper.

- Passing Criterion for B. Tech: minimum 30% of the highest marks in the class
- Passing Criterion for M. Tech: minimum 40% of the highest marks in the class

Sample format for Indirect Assessment of Course outcomes

NAME:
<i>ENROLLMENT NO:</i>
SAP ID:
COURSE:
PROGRAM:

Please rate the following aspects of course outcomes of computer graphics.

Use the scale 1-4*

Sl. No.		1	2	3	4
1	CO1 - Acquaint with OpenGL library and understand the graphics code structure with it				
2	CO2 - Apply primitive operations to create 2D and 3D objects and performing various operations on them				
3	CO3 - Carry out complex 2D and 3D transformations on objects and creating curves of 2nd and 3rd degree				
4	CO4 - Explore and implement various hidden surface removal techniques				

5	CO5 - Apply shading and colouring techniques on created 2D and 3D objects and also create 3D realistic imagery				
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*

1

Below Average

3

Good

2

Average

4

Very Good

00:00:00	Monday, 28. March 2022	Tuesday, 29. March 2022			Friday, 01. April 2022
08:00:00					
08:30:00					
09:00:00					
09:30:00					
10:00:00	Module : Operating Systems Room : 4002 / VR_B_468 Faculty : Roohi Sille Start Time : 10:00:00 End Time : 10:55:00 Batch : BT-CSE-II-B33 BT-CSE-II-B34		Module : Operating Systems Room : 4002 / VR_B_468 Faculty : Roohi Sille Start Time : 09:00:00 End Time : 09:55:00 Batch : BT-CSE-II-B33 BT-CSE-II-B34		Module : Operating Systems Lab Room : 6205 / VR_B_227 Faculty : Roohi Sille Start Time : 09:00:00 End Time : 09:55:00 Batch : BT-CSE-II-B33
10:30:00					
11:00:00	Module : Computer Graphics Room : 11213 / VR_B_2610 Faculty : Roohi Sille Start Time : 11:00:00 End Time : 11:55:00 Batch : BT-CSE-CSF-IV-B3 BT-CSE-CSF-IV-B4	Module : Operating Systems Lab Room : 6205 / VR_B_229 Faculty : Roohi Sille Start Time : 11:00:00 End Time : 12:55:00 Batch : BT-CSE-II-B34	Module : Computer Graphics Room : 11112 / Faculty : Roohi Sille Start Time : 11:00:00 End Time : 11:55:00 Batch : BT-CSE-CSF-IV-B3 BT-CSE-CSF-IV-B4		
11:30:00					
12:00:00					
12:30:00					
13:00:00	Module : Computer Graphics Lab Room : 90008 / VR_B_1282 Faculty : Roohi Sille Start Time : 13:00:00 End Time : 14:55:00 Batch : BT-CSE-CSF-IV-B3				
13:30:00					
14:00:00					
14:30:00					
15:00:00		Module : Computer Graphics Lab Room : 90008 / Faculty : Roohi Sille Start Time : 15:00:00 End Time : 16:55:00 Batch : BT-CSE-CSF-IV-B4			Module : Operating Systems Room : 4002 / VR_B_468 Faculty : Roohi Sille Start Time : 15:00:00 End Time : 15:55:00 Batch : BT-CSE-II-B33 BT-CSE-II-B34
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16:00:00					
16:30:00					
17:00:00					

Timetable View for Students and Faculty											
Monday, 04 April 2022			Tuesday, 05 April 2022			Wednesday, 06 April 2022			Thursday, 07 April 2022		
08:00:00											
08:30:00											
09:00:00											
09:30:00											
10:00:00	Module : VID_Aesthetics Principles in UI Design Room : VR_B_3057 / Faculty : JITENDRA RAJPUROHIT Start Time : 10:00:00 End Time : 10:30:00 Batch : BT-CSE-CSF-IV-B4		Module : VID_Aesthetics Principles in UI Design Room : VR_B_3057 / Faculty : JITENDRA RAJPUROHIT Start Time : 10:00:00 End Time : 10:30:00 Batch : BT-CSE-CSF-IV-B4		Module : Advanced Database Management Systems Room : 10102 / VR_B_2611 Faculty : SURENDAR VARADHARAJAN Start Time : 10:00:00 End Time : 10:30:00 Batch : BT-CSE-CSF-IV-B4				Module : Data Communi... Room : 10201 / VR_B_2611 Faculty : BITOPI DUTTA Start Time : 10:00:00 End Time : 10:30:00 Batch : BT-CSE-CSF-IV-B4		
10:30:00											
11:00:00	Module : Computer Graphics Room : 10201 / VR_B_2610 Faculty : GUNJAN CHHABRA Start Time : 11:00:00 End Time : 11:30:00 Batch : BT-CSE-CSF-IV-B4		Module : Advanced Database Management Systems Room : 10201 / VR_B_2611 Faculty : SURENDAR VARADHARAJAN Start Time : 11:00:00 End Time : 11:30:00 Batch : BT-CSE-CSF-IV-B4		Module : Computer Graphics Room : 10201 / VR_B_2610 Faculty : GUNJAN CHHABRA Start Time : 11:00:00 End Time : 11:30:00 Batch : BT-CSE-CSF-IV-B4			Module : Data Communication and Computer Networks Room : 10204 / Faculty : BITOPI DUTTA Start Time : 11:00:00 End Time : 11:30:00 Batch : BT-CSE-CSF-IV-B4			
11:30:00											
12:00:00											
13:00:00	Module : IT Application & Data Security Lab Room : 12121 / VR_B_2610 Faculty : JITENDRA RAJPUROHIT Start Time : 13:00:00 End Time : 14:00:00 Batch : BT-CSE-CSF-IV-B4		Module : Advanced Database Management Systems Lab Room : 10102 / VR_B_2611 Faculty : SURENDAR VARADHARAJAN Start Time : 13:00:00 End Time : 13:30:00 Batch : BT-CSE-CSF-IV-B4		Module : Environment & SDG Himalaya Fellowship Room : 10204 / Faculty : SURENDAR VARADHARAJAN Start Time : 13:00:00 End Time : 13:30:00 Batch : BT-CSE-CSF-IV-B4			Module : Critical Thinking and Writing Room : 10104 / Faculty : BITOPI DUTTA Start Time : 13:00:00 End Time : 14:00:00 Batch : BT-CSE-CSF-IV-B4			
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15:00:00	Module : Critical Thinking and Writing Room : 10204 / Faculty : BITOPI DUTTA Start Time : 15:00:00 End Time : 15:30:00 Batch : BT-CSE-CSF-IV-B4		Module : Computer Graphics Lab Room : 9009 / Faculty : GUNJAN CHHABRA Start Time : 15:00:00 End Time : 15:30:00 Batch : BT-CSE-CSF-IV-B4		Module : Advanced Database Management Systems Room : 10102 / VR_B_2611 Faculty : SURENDAR VARADHARAJAN Start Time : 15:00:00 End Time : 15:30:00 Batch : BT-CSE-CSF-IV-B4			Module : Advanced Database Management Systems Room : 10102 / VR_B_2611 Faculty : SURENDAR VARADHARAJAN Start Time : 15:00:00 End Time : 15:30:00 Batch : BT-CSE-CSF-IV-B4			
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MONTH / DATE	03rd Jan	2/05th Jan	2/12th Jan	2/13th Jan	2/17th Jan	2/19th Jan	2/20th Jan	2/22th Jan	2/23th Jan	2/31st Jan	2/02nd Feb	03rd Feb	07th Feb	08th Feb	09th Feb	2/21st Feb	2/23th Feb	2/28th Feb	2/02nd Mar	03rd Mar	07th Mar	10th Mar	13th Mar	28th Mar	30th Mar	04th Apr	05th Apr	06th Apr	07th Apr		
No.of Events	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
S.No.	Student's Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name	Student ID	Student Name
1	SE-OB #R12142201/ Shivam Goi	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
2	SE-OB #R12142201/Chirag Goi	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
3	SE-OB #R12142201/Simran Tal	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
4	SE-OB #R12142201/Rathika A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
5	SE-OB #R12142201/Ananya S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
6	SE-OB #R12142201/Ananya S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
7	SE-OB #R12142201/Sahil Raj	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
8	SE-OB #R12142201/Parikh Parik	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
9	SE-OB #R12142201/Manish Patel	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
10	SE-OB #R12142201/Aastha J	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
11	SE-OB #R12142201/Devrishi J	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
12	SE-OB #R12142201/Divyanshu	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
13	SE-OB #R12142201/Divyanshu	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
14	SE-OB #R12142201/Parvez Reh	A	A	A	P	P	A	A	P	P	A	P	A	A	P	A	A	A	P	P	A	A	P	P	A	A	A	A	A	A	
15	SE-OB #R12142201/Vishal Oh	A	P	A	P	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
16	SE-OB #R12142201/Kartikya	A	A	A	P	A	A	A	P	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
17	SE-OB #R12142201/Parvez Reh	A	A	A	P	A	A	P	A	P	A	P	A	P	A	P	A	P	P	P	A	A	P	P	A	A	A	A	A	A	
18	SE-OB #R12142201/Aayush San	A	A	A	A	P	P	A	A	P	A	A	A	A	A	A	A	A	A	A	A	P	P	A	A	A	A	A	A	A	
19	SE-OB #R12142201/Prajwal Ch	A	A	A	A	A	A	A	P	A	P	A	A	P	A	P	A	P	P	A	P	P	P	A	P	P	P	P	P	P	
20	SE-OB #R12142201/Bavneet J	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	P	P	P	A	P	P	P	P	P	P	P	
21	SE-OB #R12142201/Arnav	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P	P	P	P	P	P	P	P	
22	SE-OB #R12142201/Arnav Sh	A	A	A	P	P	A	A	A	A	A	A	A	A	A	P	A	A	P	P	P	P	P	P	P	P	P	P	P	P	
23	SE-OB #R12142201/ROHIT MESE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P	P	
24	SE-OB #R12142201/Arnav Sh	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
25	SE-OB #R12142201/Arnav Sh	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
26	SE-OB #R12142201/Himanchal	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
27	SE-OB #R12142201/Yash Mittu	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
28	SE-OB #R12142201/ABHAY Ti	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
29	SE-OB #R12142201/Abhishek	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
30	SE-OB #R12142201/Likhanshi	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
31	SE-OB #R12142201/Umarsh Bi	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
32	SE-OB #R12142201/Vijay Mall	P	A	A	A	A	A	A	P	A	A	A	A	A	A	A	A	A	P	P	P	P	P	P	P	P	P	P	P	P	
33	SE-OB #R12142201/Swami Seh	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
34	SE-OB #R12142201/Arnav Sh	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
35	SE-OB #R12142201/Laxmiya	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
36	SE-OB #R12142201/Vikram Ag	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
37	SE-OB #R12142201/Archit Patel	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
38	SE-OB #R12142201/Yash Ragh	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
39	SE-OB #R12142201/Yash Ragh	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
40	SE-OB #R12142201/Ananya D	A	A	A	P	P	A	P	P	A	P	A	P	A	P	A	P	A	P	P	P	P	P	P	P	P	P	P	P	P	
41	SE-OB #R12142201/Arnav Patel	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
42	SE-OB #R12142201/VASUJA	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
43	SE-OB #R12142201/Tanuj Jain	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
44	SE-OB #R12142201/VISHWA P	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
45	SE-OB #R12142201/Vigyan Urfi	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
46	SE-OB #R12142201/Arnav Patel	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
47	SE-OB #R12142201/Archit Patel	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
48	SE-OB #R12142201/Yash Tyagi	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
49	SE-OB #R12142201/Yash Tyagi	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
50	SE-OB #R12142201/Parvez Reh	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
51	SE-OB #R12142201/Rohit Raj	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
52	SE-OB #R12142201/Tanushri A	A	P	P	P	P	A	P	P	A	P	P	A	P	P	A	P	A	P	P	P	P	P	P	P	P	P	P	P	P	
53	SE-OB #R12142201/Arjan Subh	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
54	SE-OB #R12142201/Arnav Patel	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
55	SE-OB #R12142201/SAMYUKTA	A	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
56	SE-OB #R12142201/Alpana D	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
57	SE-OB #R12142201/Vikash Ku	A	P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
58	SE-OB #R12142201/Kartikay P	A	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	

Progressive Assessment and Course Summary

Report

Subject: Computer Graphics

Code: CSEG 20303

Credit: 3

Class: 2021 – 2025

Lecture taken (Hrs.)	5	8	5	3	6	3	
% of Syllabus covered	14	37	50	58	75	100	-
Signature of Faculty							
HoD							

Summary of Course

Summary	No. of Lectures	Tes t	Qui z	Assignme nt	Tutori al	% of syllabu s Covere d
Plan	36	01	1	02	-	100
Conduc t	36	01	1	02	-	100

Remarks:

Faculty Sign

HOD Sign

RECORD OF CLASS TEACHING

Subject: Computer Graphics

Course: B.Tech. CSE CSF

Code : CSEG 2030

Lecture No.	Topics Covered	Executed Date	Remarks
1	Computer Graphics overview and its various applications.	3.01.22	
2	Pixels, Raster and Random scan display, Frame buffers.	6.01.22	
3	CRT, Rasterization, Horizontal retrace and Vertical Retrace. Introduction to various 3D APIs and Introduction to OpenGL.	8.01.22	
4	Numerical Problems related to Pixels, Raster and Random scan display, Frame buffers, Horizontal retrace and Vertical Retrace.	11.01.22	
5	Introduction to OpenGL: Discussion on various Libraries and its Programming syntax. OpenGL Rendering Pipeline and Demo of OpenGL code.	14.01.22	
6	Points & lines: Line drawing algorithms DDA algorithm Problems of Aliasing, end point and clipping lines	18.01.22	
7	Bresenham's line drawing algorithm	20.01.22	
8	Circle generation algorithms	23.01.22	
9	CLASS TEST I + ASSIGNMENT 1	4.02.22	
10	Ellipse generating algorithm	08.02.22	
11	Scan line polygon	09.02.22	
12	Flood fill algorithm, Boundary fill algorithm	10.02.22	
13	Introduction to Window and Viewport, Point clipping, Line clipping	11.02.22	
14	Cohen Sutherland line clipping algorithm, with numerical	13.02.22	
15	Liang-Barsky line clipping algorithm with numerical and other doubts related to clipping	17.02.22	
16	Polygon clipping: Sutherland – Hodgman Algorithm, Weiler-Atherton Polygon clipping, Text clipping	18.02.22	

17	Tutorial and Doubt Clearing	20.02.22	
18	Translation, Rotation, Scaling, Shearing	24.02.22	
19	Homogenous coordinate system (HCS), Composite transformation	25.02.22	
20	Window to viewport transformations, Rotation about point, Reflection about a line	27.02.22	
21	Tutorial and Doubt Clearing	31.02.22	
After Mid-Term Examination			
22	3D transformations: Translation, Rotation, Scaling, Instance	4.3.22	
23	Rotation about an arbitrary axis in space, with numerical	6.3.22	
24	Reflection through an arbitrary plane with numerical, Polygon Meshes	7.3.22	
25	CLASS TEST- II + ASSIGNMENT 2	08.3.22	
26	Curve Representation(Introduction) : Non Parametric curves, Conic sections, Cubic Splines	012.3.22	
27	Continuation of Cubic Splines, Conic Sections (2D-Curves)	15.3.22	
28	Bezier Curves and its Properties.	17.3.22	
29	Numerical of Bezier Curves. B-Spline Curve.	20.3.22	
30	Techniques for Efficient VSD, Depth comparison, Z-buffer algorithm.	22.3.22	
31	Back face detection, BSP tree method.	24.3.22	
32	Scan-line algorithm, Area sub division methods.	28.3.22	
33	Numerical on VSD.	18.4.22	
34	Illumination Model, Transparency, Shadows.	20.4.22	
35	Constant – Intensity shading, Gouraud Shading, Phong Shading	28.4.22	

**UNIVERSITY OF PETROLEUM AND ENERGY
STUDIES**
Assignment-1

Program Name: B. Tech CSE+CSF

Semester: VI

Course Name : Computer Graphics

Max. Marks: 20

Course Code: CSEG2030

Note: Assignment should be hand written and upload the scanned copy on blackboard on or before the due date.

1. Digitize a line from (10, 15) to (20, 30) on a raster screen using Bresenham's straight line algorithm. Discuss its advantages over DDA also.
2. Use the Cohen Sutherland algorithm to clip line P1 (80, 30) and P2 (110, 20) shown in fig against a window lower left hand corner (50, 10) and upper right hand corner (80, 40). Explain one exceptional case also which violates the conditions of Cohen Sutherland algorithm.
3. Scan convert a circle represented through an equation $(y-5)^2+(x-10)^2 = 64$ for the first quadrant using midpoint algorithm. Indicate all coordinates in tabular form with corresponding calculations.
4. Explain text clipping in detail? Write down the condition when an ellipse become a circle and formulate it.

Test (30 marks)

1. Consider a quadratic B-spline curve with uniform knot spacing. Consider a segment with control points $(1, 0)$, $(1, 1)$ and $(0, 1)$ in that order. What are the end-points of the curve segment? What is the mid-point of the curve segment? (10 marks)
 - Now repeat the question for a cubic B-spline curve with control points $(-1, -1)$, $(-1, 1)$, $(1, 1)$, and $(1, -1)$. Using polar forms, and your answers to the evaluations above, derive the general function $f(t)$ for a cubic B-spline, given its 4 control points. Use this to derive the 4×4 matrix used for cubic B-spline curves.
2. We consider the problem of using a Bezier curve to approximate a circle. There exist efficient algorithms to draw Bezier curves, so it is often convenient to reduce other primitives to them. Because of symmetry in a circle, we will consider only the positive quadrant, i.e. with arc endpoints $(1, 0)$ and $(0, 1)$. What are the control points of a quadratic Bezier curve that best approximates the quarter circle? In particular, the end-points and tangents at those end points of the approximating Bezier curve must match those for the quarter circle. What is the maximum error in this approximation, i.e. the error at the mid-point of the Bezier curve? (10 marks)
3. Construct a bezier curve with control points $A(0,0)$, $B(1,2)$, $C(3,2)$ and $D(2,0)$. Generate five points of curve? (10 marks)

Quiz-1

Question 1

2 points ***

Which of the following is a Computer Graphics type?

Choose at least one correct answer

- A Raster and Vector Correct answer
- B Raster and Scalar
- C Scalar only
- D All of the above

Question 2

2 points ***

Which of the following plane is used for 2D transformations?

Choose at least one correct answer

- A Three-dimensional plane
- B Two-dimensional plane Correct answer
- C One-dimensional plane
- D Four-dimensional Plane

Question 3

2 points ***

Which of the following is the purpose for using clipping in computer graphics?

Choose at least one correct answer

- A copying
- B zooming
- C adding graphics

Question 4

2 points ***

Bitmap is a collection of _____ that describes an image.

Choose at least one correct answer

- A pixels Correct answer
- B algorithms
- C bits
- D colors

Question 5

2 points ***

Which of the following operations can be used to zoom in or out around any axis on a three-dimensional object from its original position?

Choose at least one correct answer

- A Rotation
- B Shearing
- C Scaling Correct answer
- D Translation

Question 6

2 points ***

Among the following process, which process is known as the elimination of parts of a scene outside a window or a viewport?

Choose at least one correct answer

- A editing
- B plucking
- C culling

Question 7
2 points ...

Viewing transformation is the process of mapping a world window in World Coordinates to the Viewport.

 True

Correct answer
 False

Question 8
2 points ...

Which of the following algorithm is a faster method for calculating pixel positions?

Choose at least one correct answer

 A) Parallel line algorithm

 B) Mid-point algorithm

 C) DDA line algorithm

Correct answer
 D) Bresenham's line algorithm

Question 9
2 points ...

If the boundary is specified in a single color, and if the algorithm proceeds pixel by pixel until the boundary color is encountered, it is known as _____

Choose at least one correct answer

 A) Parallel curve algorithm

 B) Flood-fill algorithm

 C) Scanline fill algorithm

Correct answer
Question 10
2 points ...

Mid Semester Examination (Total Marks =20)

1. Write about windows and view port? (2 marks)
2. Explain Raster scan display? (2 marks)
3. Consider a raster system with resolution 640 by 480. What size is frame buffer (in bytes) for this system to store 12 bits per pixel? 450 kilobytes 500 kilobytes 350 kilobytes 400 kilobytes? (2 marks)
4. Calculate the points between the starting point (5, 6) and ending point (8, 12) based on DDA? (2 marks)
5. Given the center point coordinates (4, -4) and radius as 10, generate all the points to form a circle using midpoint circle drawing algorithm ? (5 marks)
6. Consider a triangle A(0,0), B(1, 1) and C(5, 2). The triangle has to be rotated by an angle of 45 degrees about the point P(-1, -1). What shall be the coordinates of new triangle? (2 marks)

$$A' = (1, \sqrt{2} - 1), B'(-1, 2\sqrt{2} - 1) \text{ and } C' \\ = (3\sqrt{2} - 1, 9/2\sqrt{2} - 1)$$

$$A' = (1, \sqrt{2} - 1), B'(2\sqrt{2} - 1, -1) \text{ and } C' \\ = (3\sqrt{2} - 1, 9/2\sqrt{2} - 1)$$

B-4.

Mid Semester Examination

1. Window Port:

- The coordinate area which is specially selected for display is the window port.
 - It is a region which is taken from real world as well as it can be controlled graphically and has visual areas with some program controls.
7. Clip the polygon having coordinates (-4, 3), (-8, 6), (2, 3), (2, -3), (5, -6) and (10, 10) using scan line fill algorithm? (5 marks)

View port:

- The view port can be defined as the window of display area in which window is perfectly mapped.
- It is region which is only a polygon viewing region.

2. Faster Scan Display ↴

- It is display which is used in television screen, computer screens, display monitors etc which is a point plotting device.
- The refresh buffer in it stores the drawing primitive in the form of points and pixels, and has a scanning process which is called refreshing.

\Rightarrow Given:

$$\text{resolution} = 640 \times 480$$

$$= 307200 \text{ pixels}$$

$$\text{no. of bits per pixel} = 12 \text{ bits/given}$$

frame buffer in bytes = resolution * No.
of bits per pixel.

$$= 640 * 480 * 12 \text{ bits}$$

$$= () / 8 \text{ Bytes}$$

$$= (610 * 480) / 8 * 1024 \text{ kilobytes}$$

$$= 3686400 / 8$$

$$= 450$$

$$\therefore \text{size of frame buffer} = 450 \text{ kb}$$

$$= 450000 \text{ bytes}$$

4 → starting point - (5, 6)
= ending point - (8, 12)

starting coordinates: $(x_0, y_0) = 5, 6$

ending coordinates: $(x_n, y_n) = 8, 12$

calculating - ΔX , ΔY and M

$$\rightarrow = -x_0 - 5 = 3$$

$$6V \quad y_n - y_0 = 12 * **$$

$$M = \Delta Y / \Delta X = 3 = 2$$

On calculation of no. of steps -

$| \Delta X | < | \Delta Y | = 3 < 6$

\therefore the number of steps
 $\Rightarrow \Delta Y = 6$

$\Delta M > 1$,

so case 3 is satisfied .

<u>x_p</u>	<u>y_p</u>	<u>x_{p+1}</u>	<u>y_{p+1}</u>	<u>round off - (x_{p+1}, y_{p+1})</u>
5	6	5.5	7	(6, 7)
		6	8	(6, 8)
		6.5	9	(7, 9)
		7	10	(7, 10)
		7.5	11	(8, 11)
		8	12	(8, 12)

Coordinates of circle $x_0, y_0 = (4, -)$
Radius of circle = 10

① firstly assuming coordinates of centre as (0, 0)

$$\rightarrow x_0 = 0$$

$$y_0 = R = 10$$

Case 1:

$$x_{k+1} = x_k + 1 = 0 + 1 = 1$$

$$y_{k+1} = y_k = 10$$

$$P_0 = 1 - 10$$

$$x_{plot} = x_c + x_0 = 4 + x_0$$

$$y_{plot} = y_c + y_0 = 4 + y_0$$

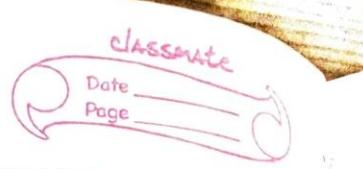
Similarly for other quadrants as well.

→ Quadrant 1:

(x_{k+1}, y_{k+1})	(x_{p+1}, y_{p+1})
(0, 10)	(4, 14)
(1, 10)	(5, 14)
(2, 10)	(6, 14)
(3, 10)	(7, 14)
(4, 9)	(8, 13)
(5, 9)	(9, 13)
(6, 8)	(10, 12)
(8, 6)	(12, 10)
(9, 5)	(13, 9)
(9, 4)	(13, 8)
(10, 3)	(14, 7)
(10, 2)	(14, 6)
(10, 1)	(14, 5)
(10, 0)	(14, 4)

All Points of circle

Q1 (x, y)	Q2	Q3	Q4
(4, 14)	(4, 14)	(4, -6)	(4, -6)
(5, 14)	(3, 14)	(3, -6)	(5, -6)
(6, 14)	(2, 14)	(2, -6)	(6, -6)
(7, 14)	(1, 14)	(1, -6)	(7, -6)
(8, 13)	(0, 13)	(0, -5)	(8, -5)
(9, 13)	(-1, 13)	(-1, -5)	(9, -5)
(10, 12)	(-2, 12)	(-2, -4)	(10, -4)
(12, 10)	(-4, 10)	(-4, -2)	(12, -2)
(13, 9)	(-5, 9)	(-5, -1)	(13, -1)
(13, 8)	(-5, 8)	(-5, 0)	(13, 0)
(14, 7)	(-6, 7)	(-6, 1)	(14, 1)
(14, 6)	(-6, 6)	(-6, 2)	(14, 2)
(14, 5)	(-6, 5)	(-6, 3)	(14, 3)
(14, 4)	(-6, 4)	(-6, 4)	(14, 4)


6→

$$R_{45^\circ P} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} \sqrt{2}/2 & \sqrt{2}/2 & 0 \\ -\sqrt{2}/2 & \sqrt{2}/2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -1 & -1 & 1 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} \sqrt{2}/2 & \sqrt{2}/2 & 0 \\ -\sqrt{2}/2 & \sqrt{2}/2 & 0 \\ -1 & (\sqrt{2}-1) & 1 \end{bmatrix}$$

$$\begin{bmatrix} A' \\ B' \\ C' \end{bmatrix} = \begin{bmatrix} A \\ B \\ C \end{bmatrix} \quad R_{45^\circ P} = \begin{bmatrix} 0 & 0 & 1 \\ 1 & 1 & 1 \\ 5 & 2 & 1 \end{bmatrix} \begin{bmatrix} \sqrt{2}/2 & \sqrt{2}/2 & 0 \\ -\sqrt{2}/2 & \sqrt{2}/2 & 0 \\ -1 & (\sqrt{2}-1) & 1 \end{bmatrix}$$

$$= \begin{bmatrix} -1 & \sqrt{2}-1 & 1 \\ -1 & 1 & 1 \\ \frac{3\sqrt{2}-1}{2} & \frac{9\sqrt{2}-1}{2} & 1 \end{bmatrix}$$

$$A' = (-1, \sqrt{2}-1), \quad B' = (-1, 2\sqrt{2}-1), \quad C' = \left(\frac{3\sqrt{2}-1}{2}, \frac{9\sqrt{2}-1}{2}\right)$$

→ Scan line algorithm →

① finding the y_{min} and y_{max}

② In this scan line intersects each edge of polygon from y_{min} to y_{max} .
so the points $\rightarrow P_0, P_1, P_2, P_3$

③ Sorting the intersection points in increasing order.

④ filling the pair of coordinates that are inside.

Question:

given coordinates $(-4, 3)$

$(-8, 6)$

$(2, 3)$

$(-2, -3)$

$(5, -6)$

$(10, 10)$

Calculation:

Ques 1: Explain the tiling resolution and how long would it take to load bit per pixel

in terms of the number of the vertical and.

- Total no. of bits $\rightarrow 640 \times 400 \times 2 \rightarrow 512000$
- OpenGL is independent of the windowing characteristics of each operating system but provide special "glue" routines for commands. These commands are free of concern

→ A number of transformations or sequence of transformation can be combined into a single one called composition.

must be rigid

$$\rightarrow \begin{bmatrix} 1 & & p_x \\ 0 & 1 & p_y \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta & & 0 \\ \sin\theta & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta & & 0 \\ \sin\theta & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & -p_x \\ 0 & 1 & 0 & -p_y \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

1. composite illumination at \rightarrow illuminates at every point

time

and time

* lighting equation at each vertex \rightarrow lighting equation $zzg Q(a')$ each pixel.

provide
shiny surfaces.

Define Concave polygon and convex polygon with diagram.

\rightarrow convex: all the interior angle of the polygon
prerequisites it should be closed surface
 \rightarrow all interior angles should be less than 180° .



\rightarrow concave: all the any one of the interior angles is greater than 180°

\rightarrow conditions:-

\rightarrow it should be closed surface

\rightarrow any one or more angle should be greater than 180°



Question 6 :-

- a) Define DDA Line Drawing Algorithm.
- b) Consider the line from (5,5) to (13,9). Use the Bresenham's algorithm to rasterize the line.

Solution :-

- (a) DDA stands for Digital Differential Analyzer. It is an incremental method of scan conversion of line, i.e. it works by incrementing the source coordinate points according to the values of the slope generated.

Algorithm :-

Starting coordinates = (X_0, Y_0)

Ending coordinates = (X_n, Y_n)

Step 1 :-

Calculate ΔX , ΔY and M from the given input.

These parameters are calculated as-

- $\Delta X = X_n - X_0$
- $\Delta Y = Y_n - Y_0$
- $M = \Delta Y / \Delta X$

Step 2 :-

Find the number of steps or points in between the starting and ending coordinates.

if (absolute (ΔX) > absolute (ΔY))

 Steps = absolute (ΔX);

else

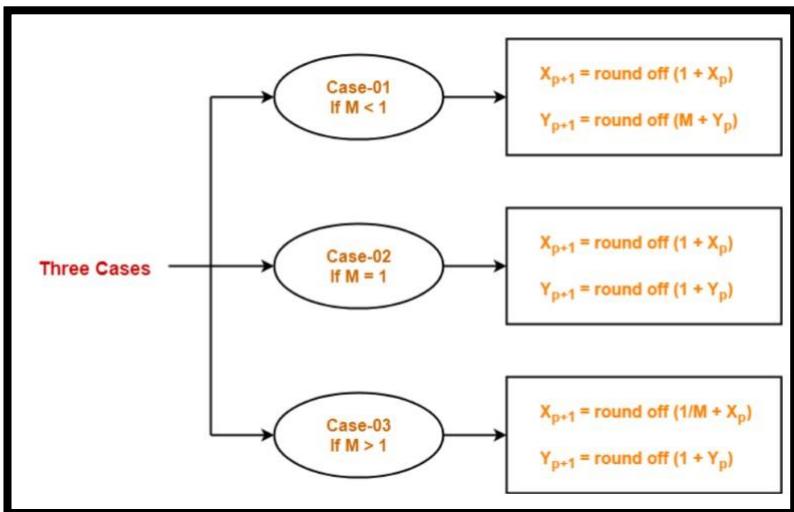
 Steps = absolute (ΔY);

Step 3 :-



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 the below three cases-



Step 4 :-

Keep repeating Step-03 until the end point is reached or the number of generated new points (including the starting and ending points) equals to the steps count.

Solution (B) & Starting Coordinate $(x_0, y_0) = (5, 5)$

For i=5

$$P_{k+1} = P_k + 2\Delta y - 2\Delta x$$

$$P_{k+1} = 0 + 8 - 16$$

$$P_{k+1} = -8$$

$$x_{k+1} = 10$$

$$y_{k+1} = 8$$

For i=7

$$P_{k+1} = P_k + 2\Delta y - 2\Delta x$$

$$P_{k+1} = 0 + 8 - 16$$

$$P_{k+1} = -8$$

$$x_{k+1} = 12$$

$$y_{k+1} = 9$$

For i=6

~~$P_{k+1} = P_k + 2\Delta y$~~

$$P_{k+1} = -8 + 8$$

$$P_{k+1} = 0$$

$$x_{k+1} = 11$$

$$y = 8$$

For i=8

$$P_{k+1} = P_k + 2\Delta y$$

$$P_{k+1} = -8 + 8$$

$$P_{k+1} = 0$$

$$x_{k+1} = 13$$

$$y = 9$$

i	P_k	P_{k+1}	x_{k+1}	y_{k+1}
1	0	-8	6	6
2	-8	0	7	6
3	0	-8	8	7
4	-8	0	9	7
5	0	-8	10	8
6	-8	0	11	8
7	0	-8	12	9
8	-8	0	13	9

AND-7) Z-Buffer Algorithm

It is also called a **Depth Buffer Algorithm**. Depth buffer algorithm is simplest image space algorithm. For each pixel on the display screen, we keep a record of the depth of an object within the pixel that lies closest to the observer. In addition to depth, we also record the intensity that should be displayed to show the object. Depth buffer is an extension of the frame buffer. Depth buffer algorithm requires 2 arrays, intensity and depth each of which is indexed by pixel coordinates (x, y).

Algorithm

For all pixels on the screen, set depth [x, y] to 1.0 and intensity [x, y] to a background value.

For each polygon in the scene, find all pixels (x, y) that lie within the boundaries of a polygon when projected onto the screen. For each of these pixels:

- (a) Calculate the depth z of the polygon at (x, y)
- (b) If $z < \text{depth}[x, y]$, this polygon is closer to the observer than others already recorded for this pixel. In this case, set depth [x, y] to z and intensity [x, y] to a value corresponding to polygon's shading. If instead $z > \text{depth}[x, y]$, the polygon already recorded at (x, y) lies closer to the observer than does this new polygon, and no action is taken.
3. After all, polygons have been processed; the intensity array will contain the solution.
4. The depth buffer algorithm illustrates several features common to all hidden surface algorithms
5. First, it requires a representation of all opaque surface in



scene polygon in this case.

6. These polygons may be faces of polyhedral recorded in the model of scene or may simply represent thin opaque 'sheets' in the scene.

7. The 11nd important feature of the algorithm is its use of a screen coordinate system. Before step 1, all polygons in the scene are transformed into a screen coordinate system using matrix multiplication.

Advantages of Z-buffer

- It is simple to use.
- Any kind of opaque surface can be handled/removed.
- It displays complex surface intersections easily.
- No depth storing of objects is needed and hence computational complexity is linear.

Disadvantages of Z-buffer

- Storage requirements are higher.
- Since depth storing is not done, a location in the z-buffer may have to be changed many times depending on the number of surfaces representing the scene.
- It is a time-consuming process as it needs to scan and convert every polygon.
- The space involved is very large. At least it requires $X*Y$ size of the buffers.

calculate the mean unit surface normal through a polygon describe by 4 position vectors \underline{ABCA} .

A(2, 0, 0) B(0, 2, 0) C(0, 0, 2)
 $\Rightarrow (2-2, -2, 2)$ calculating the edge of the polygon \underline{ABCA} .

$$\begin{aligned} \underline{AB} &= (0-2)\hat{i} + (2-0)\hat{j} + (0-0)\hat{k} \\ &= -2\hat{i} + 2\hat{j} + 0\hat{k} \end{aligned} \quad (1)$$

$$\begin{aligned} \underline{BC} &= (0-0)\hat{i} + (0-2)\hat{j} + (2-0)\hat{k} \\ &= 0\hat{i} - 2\hat{j} + 2\hat{k} \end{aligned} \quad (2)$$

$$\begin{aligned} \underline{CD} &= (2-2-0)\hat{i} + (-2-0)\hat{j} + (2-2)\hat{k} \\ &= 2\cdot 2\hat{i} - 2\hat{j} + 0\hat{k} \end{aligned} \quad (3)$$

$$\begin{aligned} \underline{AD} &= (2-2-2)\hat{i} + (-2-0)\hat{j} + (2-0)\hat{k} \\ &= 0\cdot 2\hat{i} - 2\hat{j} + 2\hat{k} \end{aligned} \quad (4)$$

$$n_A = \underline{AB} \times \underline{AD}$$

$$\begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ -2 & 2 & 0 \\ 0\cdot 2 & -2 & 2 \end{bmatrix} = \hat{i}(4-0) - \hat{j}(-4-0) + \hat{k}$$

$$(4-2\cdot 0\cdot 2)$$

$$= 4\hat{i} + 4\hat{j} + (4-0\cdot 4)\hat{k}$$

$$= 4\hat{i} + 4\hat{j} + 3\cdot 6\hat{k}$$

$$n_B = \underline{BC} \times \underline{BA}$$

$$\begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & -2 & 2 \\ 2 & -2 & 0 \end{bmatrix} = \hat{i}(0-(-4)) - \hat{j}(0-4) + \hat{k}$$

$$(0-(-4))$$

$$4\hat{i} + 4\hat{j} + 4\hat{k}$$

$$n_C = \underline{CD} \times \underline{CB}$$

$$\begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2-2 & -2 & 0 \\ 0 & 2 & -2 \end{bmatrix} = \hat{i}(4-0) - \hat{j}(4\cdot 4-0) + \hat{k}(4\cdot 4)$$

$$= 4\hat{i} + 4\cdot 4\hat{j} + 4\cdot 4\hat{k}$$

$$N_0 = \vec{DA} \times \vec{DC}$$

$$\begin{bmatrix} \uparrow & \uparrow & \vec{R} \\ -0.2 & 2 & -2 \\ -2.2 & 2 & 0 \end{bmatrix} = \vec{i}(0 - (-4)) - \vec{j}(0 - 4 \cdot 4) + \vec{k}(-0 \cdot 4 - (-4 \cdot 4))$$

$$= 4\vec{i} + 4 \cdot 4 \vec{j} + 4\vec{k}$$

$$4\vec{i} + 4\vec{j} + 3.6\vec{k}$$

$$4\vec{i} + 4\vec{j} + 4\vec{k}$$

$$4\vec{i} + 4 \cdot 4 \vec{j} + 4 \cdot 4 \vec{k}$$

$$4\vec{i} + 4 \cdot 4 \vec{j} + 4\vec{k}$$

Mean surface

$$\left(\frac{4+4+4+4}{4} \right) \vec{i} + \left(\frac{4+4+4 \cdot 4+4 \cdot 4}{4} \right) \vec{j} + \left(\frac{3.6+4+4 \cdot 4}{4} \right) \vec{k}$$

$$= 4\vec{i} + 4 \cdot 2 \vec{j} + 4\vec{k}$$

unit surface normal.

$$= \frac{4\vec{i} + 4 \cdot 2 \vec{j} + 4\vec{k}}{|4\vec{i} + 4 \cdot 2 \vec{j} + 4\vec{k}|} = \frac{4\vec{i} + 4 \cdot 2 \vec{j} + 4\vec{k}}{\sqrt{(4)^2 + (4 \cdot 2)^2 + (4)^2}}$$

$$= \frac{4\vec{i} + 4 \cdot 2 \vec{j} + 4\vec{k}}{\sqrt{16 + 17.64 + 16}} = \frac{4\vec{i} + 4 \cdot 2 \vec{j} + 4\vec{k}}{\sqrt{49.64}}$$

$$= \frac{4\vec{i} + 4 \cdot 2 \vec{j} + 4\vec{k}}{7.04}$$

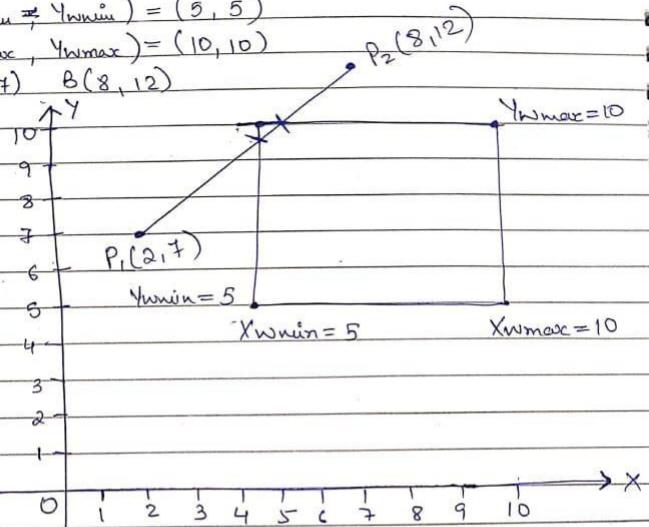
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Q8 (a) Given :-

$$(x_{w\min}, y_{w\min}) = (5, 5)$$

$$(x_{w\max}, y_{w\max}) = (10, 10)$$

$$A(2, 7) \quad B(8, 12)$$



We know,

$$P_1 = -\Delta x \Rightarrow -6$$

$$\Delta x = x_2 - x_1$$

$$P_2 = \Delta x \Rightarrow 6$$

$$= 8 - 2$$

$$P_3 = -\Delta y \Rightarrow -5$$

$$= 6$$

$$P_4 = \Delta y \Rightarrow 5$$

$$\Delta y = y_2 - y_1$$

$$= 12 - 7$$

$$= 5$$

Dae:

$$q_1 = x_1 - x_{\min} \Rightarrow 2 - 5 \Rightarrow -3$$

$$q_2 = x_{\max} - x_1 \Rightarrow 10 - 2 \Rightarrow 8$$

$$q_3 = y_1 - y_{\min} \Rightarrow 7 - 5 \Rightarrow 2$$

$$q_4 = y_{\max} - y_1 \Rightarrow 10 - 7 \Rightarrow 3$$

We can see

$$P_1 \text{ & } P_3 < 0$$

So,

we know,

$$t_1 = \max \left(0, \frac{q_k}{P_k} \right) \quad (\text{where } k = 1, 3)$$

$$= \max \left(0, \frac{q_1}{P_1}, \frac{q_3}{P_3} \right)$$

$$= \max \left(0, \frac{+8}{+8}, \frac{2}{-5} \right)$$

$$\boxed{t_1 = \frac{1}{2}}$$

We can also see,

$$P_2 \text{ & } P_4 > 0$$

So,

we know,

Date :

MON TUE WED THU FRI SAT SUN

$$t_2 = \min \left(1, \frac{q_k}{P_k} \right) \quad (\text{where } k=2 \text{ & } 4)$$

$$= \min \left(1, \frac{q_2}{P_2}, \frac{q_4}{P_4} \right)$$

$$= \min \left(1, \frac{8/4}{6/3}, \frac{3}{5} \right)$$

$$\boxed{t_2 = \frac{3}{5}}$$

We see,

$$t_1 < t_2$$

We have to take out intersection points,

for t_1 ,

$$\begin{aligned} x_0 &= x_1 + t_1 \Delta x \\ &= 2 + \frac{1}{2} \times 6 \end{aligned}$$

$$\boxed{x_0 = 5}$$

$$\begin{aligned} y_0 &= y_1 + t_1 \Delta y \\ &= 4 + \frac{1}{2} \times 5 \end{aligned}$$

$$\boxed{y_0 = 9.5}$$

Date :

MON TUE WED THU FRI SAT SUN

$$\begin{aligned} \text{for } t_2, \\ X' &= X_1 + t_2 \Delta x \\ &= 2 + \frac{3}{5} \times 6 \end{aligned}$$

$$X' = 5.6$$

$$\begin{aligned} Y' &= Y_1 + t_2 \Delta y \\ &= 4 + \frac{3}{5} \times 5 \end{aligned}$$

$$Y' = 10$$

The two points are :-

$$(X_0, Y_0) \rightarrow (5, 9.5)$$

$$(X', Y') \rightarrow (5.6, 10)$$

(b) Text Clipping :-

It is of three types :-

① All or None String Clipping

If all characters of the string are inside the window, then we will keep the string; if a string character is outside then whole string will be discarded.

STRIN_{b1}

STRING

Before clipping

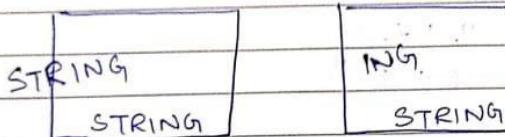
STRING

After Clipping

Date :
 MON TUE WED THU FRI SAT SUN

② All or None Character Clipping

It discards all those characters which are not completely inside the window. If a character overlaps a boundary of window that will also be discarded.

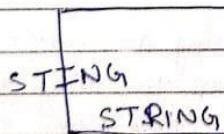


Before Clipping

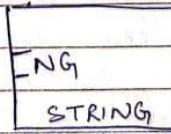
After Clipping

③ Component Character

Here, individual character is treated character that lies on boundary is discarded and same for the characters outside the window.



Before Clipping



After Clipping

ANS 9)

EXAMPLE 8.17

A mirror is placed vertically such that it passes through the points $(10, 0)$ and $(0, 10)$. Find the reflected view of triangle ABC with coordinates $A(5, 50)$, $B(20, 40)$, $C(10, 70)$.

Solution: We plot the mirror passing through $(0, 10)$ and $(10, 0)$

From figure we easily get $\tan \theta = \frac{10}{10} = 1$, which implies that $\theta = 45^\circ$

To make the line coincident with the x -axis we first translate it to make it pass through origin and then rotate it by $\theta = 45^\circ$ about origin.

Co-ordinates of triangle ABC in matrix form is

$$\begin{pmatrix} 5 & 50 & 1 \\ 20 & 40 & 1 \\ 10 & 70 & 1 \end{pmatrix}$$

We translate mirror, so that it passes through origin.

$$t_x = 0 \quad t_y = -10$$

$$T_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & -10 & 1 \end{bmatrix}$$

Immediately we write inverse transformation matrix for translation by $t_x = 0$ and $t_y = 10$ is

$$T_1^{-1} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 10 & 1 \end{bmatrix}$$

Now we rotate the mirror by 45° anticlockwise so that it matches with origin

$$R_1 = \begin{pmatrix} \cos \theta & \sin \theta & 0 \\ -\sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} \cos 45^\circ & \sin 45^\circ & 0 \\ -\sin 45^\circ & \cos 45^\circ & 0 \\ 0 & 0 & 1 \end{pmatrix} = \begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

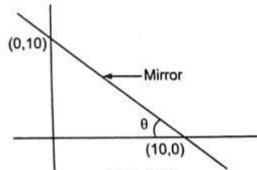


Fig. 8.18.

166

Immediately, we write inverse tr

$$R_1^{-1} = \begin{vmatrix} (-45^\circ) & \sin(-45^\circ) & 0 \\ -\sin(-45^\circ) & \cos(-45^\circ) & 0 \\ 0 & 0 & 1 \end{vmatrix} = \begin{vmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{vmatrix}$$

Transformation matrix for reflection about x -axis is

$$J_{\text{Ty}} = 0 \ -1 \ 0$$

0 0 1

The joys arr:

iii Trans lets the mirror and object so that it passes through origin i.e., T_1

(?) Rotate f irror rind object by 45° in anticlockwise i e. A,

i31 *or minor matches with z-axis then reflect triangle A8t
 14 } Rotate mirror and object by 46° clockwise i.e., fZ,
 about x-axis i.e., R_{ref}

- resultant transformation matrix is

$$R \rightarrow \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \end{pmatrix} \left| \begin{array}{ccc} \sqrt{2} & \sqrt{2} & 0 \\ -\frac{1}{\sqrt{2}} & \frac{j}{\sqrt{2}} & 0 \\ 0 & 0 & 0 \end{array} \right. \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \left| \begin{array}{ccc} \sqrt{2} & -\frac{j}{\sqrt{2}} & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{array} \right. \left| \begin{array}{ccc} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{array} \right.$$

$$-\frac{\sqrt{2}}{\sqrt{2}} \quad \frac{\sqrt{2}}{\sqrt{2}} \quad 0 \left| \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \right| \frac{1}{\sqrt{2}} \quad -\frac{1}{\sqrt{2}} \quad 0$$

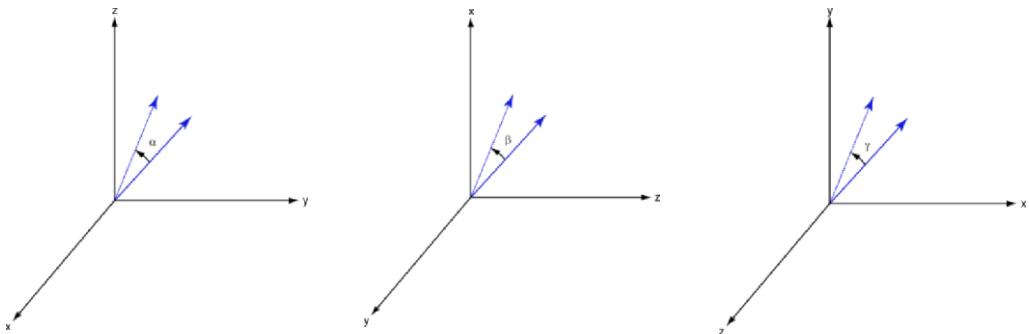
$$0 \quad 0 \quad 0 \left| \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 10 \end{pmatrix} \right. j$$

$$\left(\begin{array}{ccc|ccc} \sqrt{2} & -\sqrt{2} & 1 \\ \sqrt{2} & -\sqrt{2} & 0 \\ \cdot & \cdot & \cdot \end{array} \right) \xrightarrow{\begin{array}{l} R_1 \leftrightarrow R_2 \\ R_2 \leftarrow R_2 - R_1 \\ \cdot \leftarrow \cdot \end{array}} \left(\begin{array}{ccc|ccc} 1 & -\frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ \cdot & \cdot & \cdot \end{array} \right) \xrightarrow{\begin{array}{l} R_1 \leftarrow R_1 - R_2 \\ \cdot \leftarrow \cdot \end{array}} \left(\begin{array}{ccc|ccc} 1 & 0 & 0 \\ 0 & 1 & 0 \\ \cdot & \cdot & \cdot \end{array} \right)$$



$\rightarrow \mathbf{E} = \mathbf{0}$ at $\mathbf{g} = \mathbf{0}$

10 70 E 10 IO ! ••80 0 t



- Counterclockwise rotation around x-axis

$$f(x) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos \theta & -\sin \theta \\ 0 & \sin \theta & \cos \theta \end{pmatrix}$$

- Counterclockwise rotation around y-axis

$$f(y) = \begin{pmatrix} \cos \theta & 0 & \sin \theta \\ 0 & 1 & 0 \\ -\sin \theta & 0 & \cos \theta \end{pmatrix}$$

- Counterclockwise rotation around z-axis

$$f(z) = \begin{pmatrix} \cos \theta & -\sin \theta & 0 \\ \sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$



0 0 1

(Q9) c.) $t_x = -2, t_y = -4, t_z = -6$

$$M = [1 \ 6 \ 4 \ 1]$$

$$T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ t_x & t_y & t_z & 1 \end{bmatrix}$$

$$\Rightarrow T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -2 & -4 & -6 & 1 \end{bmatrix}$$

$$M' = M \cdot T$$

$$\Rightarrow M' = [1 \ 6 \ 4 \ 1] \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ -2 & -4 & -6 & 1 \end{bmatrix}$$

$$\Rightarrow M' = [1 \ 2 \ -2 \ 1]$$

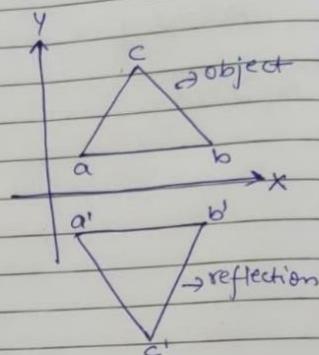
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Q10-

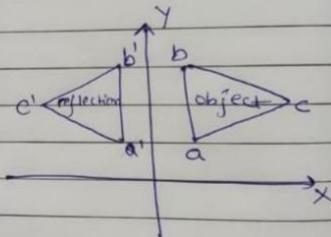
Reflection relative to -

X Axis.

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

Y Axis.

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

Z Axis.

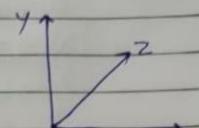
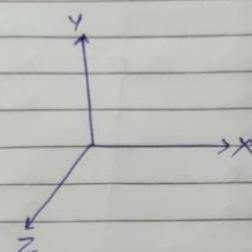
$$\left[\quad \right]$$

2D coordinate representation does not have a Z axis.

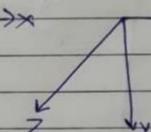
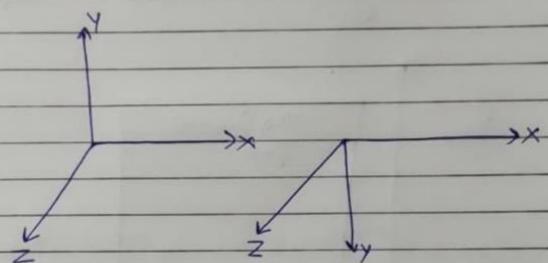
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 XY Plane

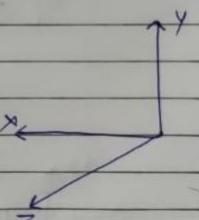
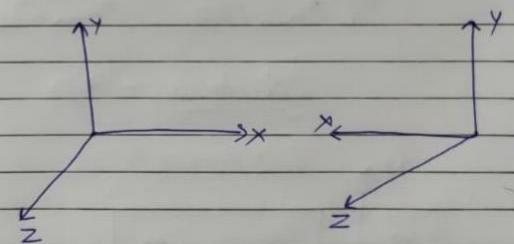
$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$


 XZ Plane

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


 YZ Plane

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



(b)

Window

$$x_{w\min} = 20$$

$$x_{w\max} = 80$$

$$y_{w\min} = 40$$

$$y_{w\max} = 80$$

$$(x_w, y_w) = (30, 80)$$

Viewport

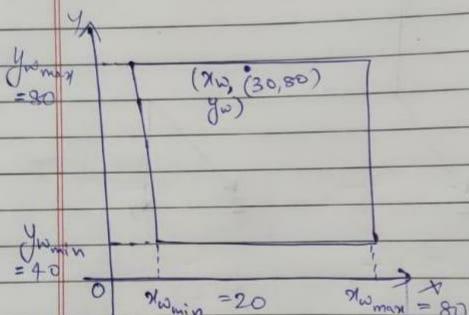
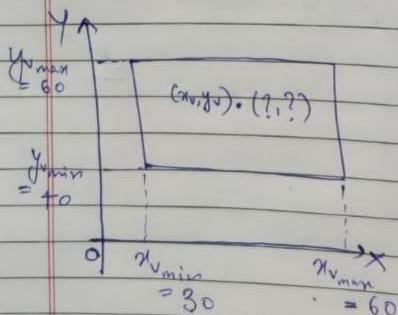
$$x_{v\min} = 30$$

$$x_{v\max} = 60$$

$$y_{v\min} = 40$$

$$y_{v\max} = 60$$

$$x_v, y_v = (? , ?)$$

WindowViewport

Date / /

$$\frac{x_w - x_{w\min}}{x_{w\max} - x_{w\min}} = \frac{x_v - x_{v\min}}{x_{v\max} - x_{v\min}}$$

$$\frac{y_w - y_{w\min}}{y_{w\max} - y_{w\min}} = \frac{y_v - y_{v\min}}{y_{v\max} - y_{v\min}}$$

$$\Rightarrow x_w - x_{w\min} = (x_{w\max} - x_{w\min}) \left(\frac{x_v - x_{v\min}}{x_{v\max} - x_{v\min}} \right)$$

$$x_w - x_{w\min} = (x_v - x_{v\min}) \underbrace{\left(\frac{x_{w\max} - x_{w\min}}{x_{v\max} - x_{v\min}} \right)}_{\text{Scaling factor } x (S_x)} - ①$$

Similarly,

$$y_w - y_{w\min} = (y_v - y_{v\min}) \underbrace{\left(\frac{y_{w\max} - y_{w\min}}{y_{v\max} - y_{v\min}} \right)}_{\text{Scaling factor } y (S_y)} - ②$$

ATQ.

$$S_x = \frac{x_{w\max} - x_{w\min}}{x_{v\max} - x_{v\min}} = \frac{80 - 20}{60 - 30} = \frac{60}{30} = 2$$

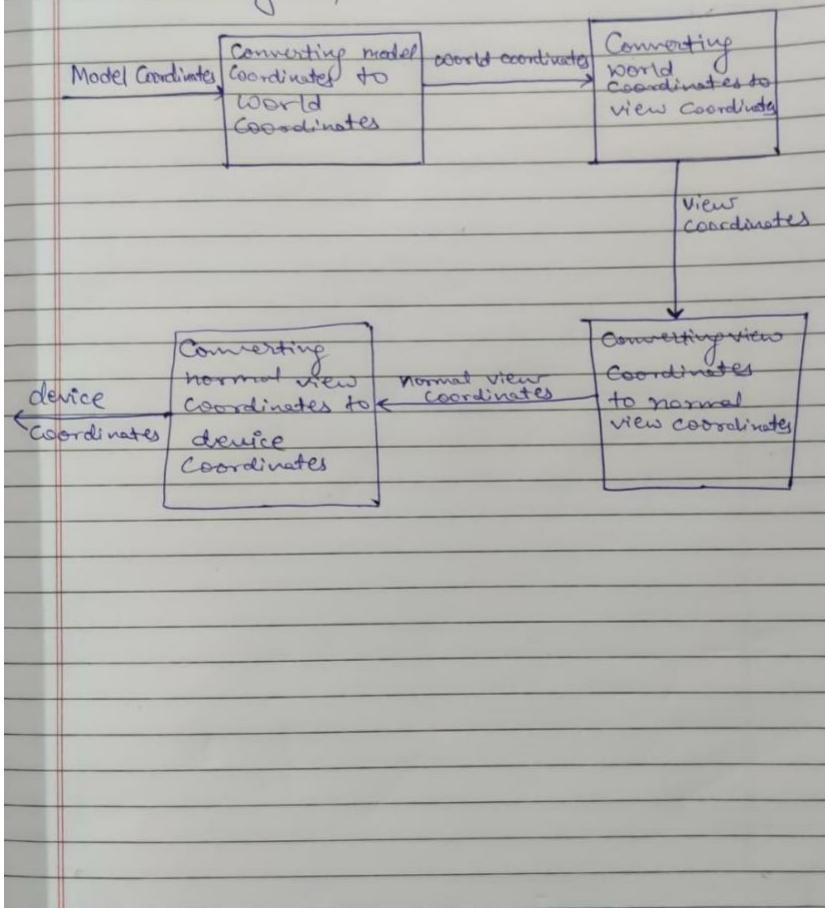
$$S_y = \frac{y_{w\max} - y_{w\min}}{y_{v\max} - y_{v\min}} = \frac{80 - 40}{60 - 40} = \frac{40}{20} = 2$$



(35,60)

Date / /

2D viewing Pipeline





$$B_{2,3}(u) = 3C_2(u)^2(1-u)$$

$$= 3u^2(1-u)$$

$$B_{3,3}(u) = \frac{3C_3(u)^3}{u^3}(1-u)$$

The eqn of bezier curve becomes:

$$P(u) = P_0(1-u)^3 + 3u(1-u)^2P_1 + 3u^2(1-u)P_2 + P_3 u^3 \quad - - (1)$$

Using eqn (1) we can find x & y

$$x(u) = 0(1-u)^3 + 4u(1-u)^2(3) + 3u^2(1-u)(2) - 2u^3$$

$$\Rightarrow x(u) = 21u(1+u^2-2u) + 6u^2(1-u) - 2u^3$$

$$\Rightarrow x(u) = 21u + 21u^3 - 42u^2 + 6u^2 - 6u^3 - 2u^3$$

$$\Rightarrow x(u) = 13u^3 - 36u^2 + 21u$$

$$y(u) = 0(1-u)^3 + 5(3u)(1-u)^2 + 0(3u^2)(1-u) + 1u^3$$

$$\Rightarrow y(u) = 15u(1+u^2-2u) + u^3$$

$$\Rightarrow y(u) = 15u + 15u^3 - 30u^2 + u^3$$

$$\Rightarrow y(u) = 16u^3 - 30u^2 + 15u$$

Final Equation : $P(u) = [x(u), y(u)]$

$$\Rightarrow P(u) = [(13u^3 - 36u^2 + 21u), (16u^3 - 30u^2 + 15u)]$$

b.) i.) RGB Color Model :

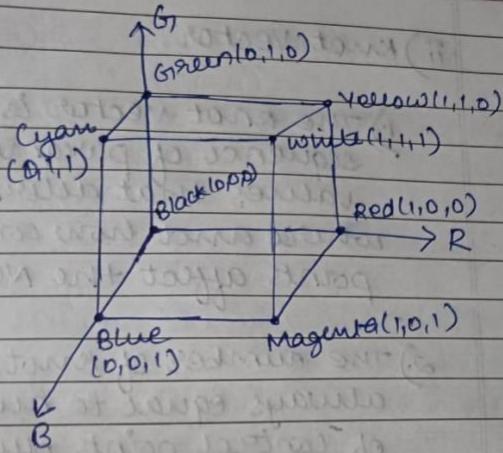
1) The RGB color model is one of the most widely used color representation method in computer graphics. It uses a color coordinate system with three primary colors:

R(Red), G(Green), B(Blue)

2) Each primary color can take an intensity value ranging from 0 to 1. Mixing these three primary colors at different intensity levels produces a variety of colors.

3) The corner of RGB color cube that is at the origin of coordinate system corresponds to black, whereas the Pt(1,1,1) represents white.

d.)



c.) In the RGB color model an arbitrary color within the cubic color space can be specified by its color coordinates (r, g, b) .

ii.) Knot Vector:

- 1) The knot vector is a sequence of parameter values that determines where and how control points affect the NURBS curve.
- 2) The number of knots is always equal to number of control points plus curve degree plus one.
- 3) The point between two segments of a curve that joins each other such points are known as knots in B-spline curve.
- 4) Knot vectors could be of 3 types:
 - a) Uniform: $t_{i+1} - t_i = \text{constant}$
 - b) Non-uniform: $t_i \leq t_{i+1}$
 - c) Open Uniform: $t_i = t_1, i \leq k$
 $t_{i+1} - t_i = \text{constant}, k \leq i \leq n+2$
 $t_i = t_{k(n+1)}, i \geq n+2$

iii) Bezier Curve Properties :-

1.) The degree of the polynomial defining the curve segment is one less than the number of defining polynomial points i.e,

Degree = Control points - 1

2.) A Bezier curve will always pass through the first & the last control points.

3.) They are always kept within a polygon boundary defined by the control points known as convex hull.

4.) Bezier curve exhibits global control means moving a control point alters the shape of the whole curve.

5.) The direction of tangent vector at the end points is same as that of the vector determined by first & last segments.

q.v.) Interpolation :

- 1) It is a method of reconstructing new data points within range of discrete set of known data points.
- 2) The number of data points obtained by sampling or experimentation represents values of function for limited number of values of independent variable.
- 3) The main task of interpolation is to find suitable mathematical expression for known curve. This technique is used when we have to draw curve by determining intermediate points b/w known sample points.
- 4) Types of Interpolation methods:
 - a) Inverse Distance Weighted:
Estimation is done by averaging values of sample data points.

- PAGE No. _____
DATE _____
- b) Kriging : It considers both distance & degree of variations between known data points.
- c) Natural Neighbours : It finds closest subset of input samples to query point.
- d) Spline : Estimation is done using mathematical function that minimizes overall surface curvature.
- e) Spline with barriers : This tool honors discontinuities encoded in both input barriers & input point data.

Ans 11) SCAN LINE

Dougon = {2, 7}, {4, 12}, {8, 15}, {16, 9}, {11, 5}, {8, 7}, {5, 5}

Previous Vertex	Current Vertex	Next Vertex	$y_P > y_C > y_N$	Current Vertex Type	Action
G(5, 5)	A(2, 7)	B(4, 12)	$y_P < y_C < y_N$	Not local extremum	Split A
A(2, 7)	B(4, 12)	C(8, 15)	$y_P < y_C < y_N$	Not local extremum	Split B
B(4, 12)	C(8, 15)	D(16, 9)	$y_P < y_C > y_N$	Local Maximum	None
C(8, 15)	D(16, 9)	E(11, 5)	$y_P > y_C > y_N$	Not local extremum	Split D
D(16, 9)	E(11, 5)	F(8, 7)	$y_P > y_C < y_N$	Local Minimum	None
E(11, 5)	F(8, 7)	G(5, 5)	$y_P < y_C > y_N$	Local Maximum	None
F(8, 7)	G(5, 5)	A(2, 7)	$y_P > y_C < y_N$	Local Minimum	None

- **Vertex A** should be split into two vertices **A'** ($x_{A'}, 6$) and **A(2, 7)**

$$m = (5 - 7)/(5 - 2) = -2/3$$

$$x'_{A'} = 5 + (-3/2)(7 - 1 - 5) = 7/2 = 3.5 \approx 4$$

The vertex **A** is split to **A'** (4, 6) and **A(2, 7)**

- **Vertex B** should be split into two vertices **B'** ($x_{B'}, 11$) and **B(4, 12)**

$$m = (7 - 12)/(2 - 4) = 5/2$$

$$x'_{B'} = 2 + (2/5)(12 - 1 - 7) = 18/5 = 3.6 \approx 4$$

The vertex **B** is split to **B'** (4, 11) and **B(4, 12)**

- **Vertex D** should be split into two vertices **D(16, 9)** and **D'** ($x_{D'}, 8$)

$$m = (5 - 9)/(11 - 16) = 4/5$$

$$x'_{D'} = 11 + (5/4)(9 - 1 - 5) = 59/4 = 14.75 \approx 15$$

The vertex **D** is split to **D(16, 9)** and **D'** (15, 8)

Modified Edge Table							
#	Edge		1/m	ymin		Qmax	
0	A (2, 7)	B'	4, 11)	2/5	7	2	11
1	B (4, 12)	C	8, 15)	4/3	12	4	15
2	C (8, 15)	D	16, 9)	- 8/6	9	16	15
3	D' (15, 8)	E	11, 5)	5/4	5	11	8
4	E (11, 5)	F	8, 7)	- 3/2	5	11	7
5	F (8, 7)	G	{5, 5)	3/2	5	5	7
6	G (5, 5)	A'	(4, 6)	- 3/2	5	5	6

Activation Table												
y	5	6	7	8	9	10	11	12	13	14	15	
Activated Edge #s	3, 4, 5, 6		0	2			1					

Edge number 0

#	Edge	1/m	y _{min}	x	y _{max}
0	A (2, 7) B'(4, 11)	$2/5 = 0.4$	7	2	11

Scan line	x-intersection
$y = 8$	$2 + 0.4 = 2.4 \quad 2$
$y = 9$	$2.4 + 0.4 = 2.8 - 3$
$y = 10$	$2.8 + 0.4 = 3.2 - 3$
$y = 11$	4

Edge number 1

6	Edge	1/m	y _{min}	^	y _{max}
1	B (4, 12) C (8, 15)	$4/3 = 1.3$	12	4	15

Scan line	x-intersection
$y = 12$	4
$y = 13$	$4 + 1.3 = 4.3 \quad 4$
$y = 14$	$4.3 + 1.3 = 5.6 \quad 6$
$y = 15$	8

Edge number 4

#	Edge		1/m	ymin		Qmax
4	E (11, 5)	F (8, 7)	$-3/2 = -1.5$	5	11	7

Scan line	x-intersection
$y = 5$	11
$y =$	$11 - 1.5 = 0.5 \quad 1U$

Edge number 5

#	Edge		1/m	ymin		Qmax
5	F (8, 7)	G (5, 5)	$3/2 = 1.5$	5	5	7

Scan line	x-intersection
$y = 5$	5
$y = 6$	$5 + 1.5 = 6.5 - 7$
$y = 7$	8

Edge number 6

#	Edge		1/m	ymin		Qmax
6	G (5, 5)	A' (4, 6)	$-3/2 = -1.5$	5	5	6

Scan line	x-intersection
$y = 5$	5

5	Edge		1/ITI	ymin		Qmax
2	C (8,15)	D (16, 9)	$-8/6 = -1.3$	9	16	15

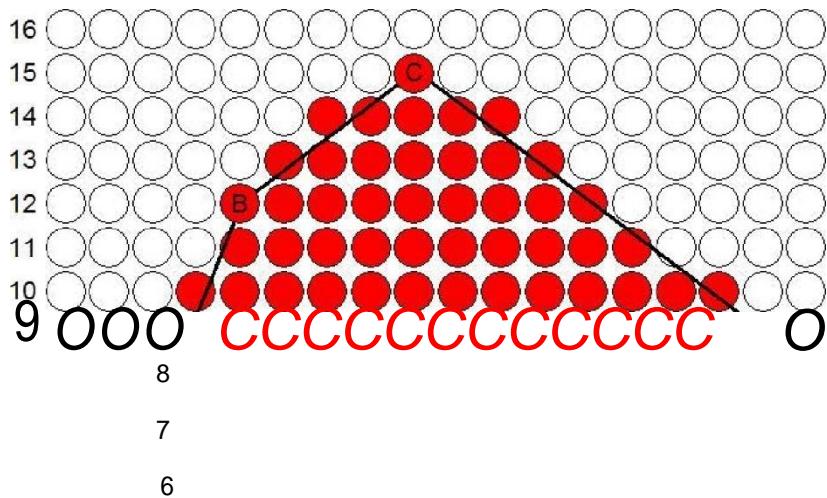
Scan line	x-intersection
$y = g$	1b
$y = 10$	$16 - 1.3 = 1d.7 \quad 15$
$y = 11$	$14.7 - 1.3 = 13.4 \quad 13$
$y = 12$	$12.4 - 1.3 = 12.1 - 12$
$y = 13$	$12.1 - 1.3 = 10.8 - 11$
$y = 14$	$10.8 - 1.3 = 9.5 \quad 10$
$v = 1?$	8

Edge number 3

#	Edge		1/ITI	ymin		Qmax
3	D' 15, 8 E 11, 5)		$5/4 = 1.25$	5	11	8

Scan line	x-intersection
$y = 5$	1
$y =$	$11 + 1.25 = 12.25 - 12$
$y = 7$	$12.25 + 1.25 = 13.5 - 14$

Scan line	x-intersections							x-intersections pair Ascending order	
	Edge#								
	0	1	2	3	4	5	6		
5				11	11	5	5	(5, 5), (11, 11)	
6				12	10	7	4	(4, 7), (10, 12)	
7	2			14	8	8		(2, 8), (8, 14)	
8	2			15				(2, 15)	
9	3		16					(3, 16)	
10	3		15					(3, 15)	
11	4		13					(4, 13)	
12		4	12					(4, 12)	
13		4	11					(4, 11)	
14		6	10					(6, 10)	
15		8	8					(8, 8)	



5	000000	000000	000000
4	000000000000000000000000		
3	000000000000000000000000		
2	000000000000000000000000		
1	000000000000000000000000		
	000000000000000000000000		

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Last Name	First Name	Username	Student ID	Last Acces	Availability	Assignment	MidSem2	Quiz-1 [Tc]	Test -1 [Tc]	Assignment
.	ABHAY TY	500082827	R21422002 ######	Yes		0	0	0	18	0
.	Ashutosh	500086297	R21422018 ######	Yes		0	0	26	0	0
.	Bavisetti	500087858	R21422015 ######	Yes		15	18	28	22	15
.	Bhavesh J	500087897	R21422019 ######	Yes		0	0	28	24	0
.	BOMMISE	500087940	R21422015 ######	Yes		15	18	28	24	15
.	POOJA JO	500084950	R21422014 ######	Yes		0	14	28	0	0
.	PRIYAL AR	500085124	R21422014 ######	Yes		0	0	0	0	0
.	SAHIL RAJ	500085033	R21422013 ######	Yes		18	18	26	24	18
.	TUSHAR L	500086668	R21422017 ######	Yes		0	14	26	0	0
AERON	PRANAV	5E+08	R21422015 ######	Yes		18	18	26	22	18
Agarwal	Vikram	5E+08	R21422012 ######	Yes		0	18	26	18	0
AGGARWA/	LAKSHYA	5E+08	R21422065 ######	Yes		18	18	28	24	18
ALI	ASHHAR	5E+08	R21422014 ######	Yes		18	18	26	24	18
ARORA	VEDANT	5E+08	R21422015 ######	Yes		18	18	30	24	18
BANSAL	VANSH	5E+08	R21422015 ######	Yes		0	18	28	24	0
Chaturvec	Pranjal	5E+08	R21422017 ######	Yes		18	18	28	24	18
Chaudhar	Kartikkeya	5E+08	R21422017 ######	Yes		0	18	26	0	0
Dass	Alpana	5E+08	R21422018 ######	Yes		18	18	28	24	18
ETTAM	VINEEL	5E+08	R21422013 ######	Yes		18	18	24	24	18
GARG	JANHVEE	500085838	R21422014 ######	Yes		18	18	28	24	18
GUPTA	HIMANSH	5E+08	R21422013 ######	Yes		18	18	28	18	18
KAPOOR	AKSHITA	5E+08	R21422015 ######	Yes		18	18	28	24	18
KAPOOR	ARYAN	5E+08	R21422015 ######	Yes		0	15	26	22	0
Kapoor	Tanishka	5E+08	R21422018 ######	Yes		18	18	28	24	18
KATIYAR	VIKAS	5E+08	R21422012 ######	Yes		18	18	28	22	18
KAUR	TANUSHPI	5E+08	R21422016 ######	Yes		18	18	28	24	18
KUMAR	SHUBHAM	5E+08	R21422016 ######	Yes		0	18	20	0	0
Kumar	Vikash	5E+08	R21422015 ######	Yes		18	18	28	24	18
KUMAR D/	ANOOP	5E+08	R21422018 ######	Yes		18	18	28	24	18
KUMARI	ARPITA	5E+08	R21422015 ######	Yes		12	16	28	24	12
MALIK	VIJAY	5E+08	R21422012 ######	Yes		0	18	28	24	0
MITTAL	YASH	5E+08	R21422013 ######	Yes		18	18	28	24	18
NANDA	ISHITA	5E+08	R21422015 ######	Yes		18	18	28	24	18
Nangla	Archit	5E+08	R21422015 ######	Yes		18	18	28	24	18
NEGI	PRATYUSH	5E+08	R21422015 ######	Yes		18	18	28	24	18
NEGI	SHUBHAM	5E+08	R21422016 ######	Yes		15	18	28	0	15
OHDAR	VISHAL	5E+08	R21422016 ######	Yes		18	18	28	24	18
PANDEY	AADARSH	5E+08	R21422006 ######	Yes		17	18	28	24	17
PATHAK	KARTIKEY	5E+08	R2142206C ######	Yes		18	18	30	24	18
PRATAP	VISHWA	5E+08	R21422013 ######	Yes		18	18	28	24	18
RAKHRA	DHRUV	5E+08	R21422015 ######	Yes		18	18	26	24	18
REHMAN	PARVEJ	5E+08	R21422016 ######	Yes		13	18	30	20	13
ROY	SUBHRON	5E+08	R21422014 ######	Yes		0	18	0	18	0
Sahoo	Samyukta	5E+08	R21422018 ######	Yes		18	18	28	24	18
Sareen	Ayush	5E+08	R21422017 ######	Yes		15	18	28	24	15
Sharma	Arnav	500087903	R21422015 ######	Yes		15	18	28	24	15
Singh	Anoop	5E+08	R21422017 ######	Yes		18	18	30	22	18
SINGH	HASHMEE	5E+08	R21422014 ######	Yes		15	18	28	24	15
SINGH	PURUJEET	5E+08	R21422014 ######	Yes		18	18	28	24	18
SINGH CH/	VIVEK	5E+08	R21422015 ######	Yes		15	15	26	20	15
Sonwane	Mayank	5E+08	R21422015 ######	Yes		13	18	28	20	13
SUBRAMA/	ARJUN	5E+08	R21422017 ######	Yes	In Progress	15	12	0	In Progress	
TIWARI	RAGHAV	5E+08	R21422015 ######	Yes		18	18	28	20	18
TOMAR	VAIBHAV	5E+08	R21422014 ######	Yes		18	18	28	22	18
TRIPATHI	ADARSH	5E+08	R21422015 ######	Yes		18	18	28	24	18
TYAGI	DEVVRATI	500086352	R21422016 ######	Yes		0	18	26	12	0
TYAGI	YASH	5E+08	R21422013 ######	Yes		14	18	30	0	14
VARDHAN	ARIHANT	5E+08	R21422015 ######	Yes		18	18	28	24	18
VARDHAN	YASH	5E+08	R21422013 ######	Yes		0	18	0	0	0
VERMA	VANYA	5E+08	R21422012 ######	Yes		18	18	28	24	18

First Name User Name Student ID		Screen Sh Screen Sh Screen Sh Screen Sh Screen Sh Screen Sh File 1 24/O Lab File 2 Lab 3 Tot Experiment Screen Sh Experiment Experiment & Clipping Total Pts: 5 Score 601151 Viva 1 To Viva 2 To Viva 3 Total Pts: 30 Score															
POOJA JO 50008495 R2142201445	10	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0												0 0 0			
PRIVAL RAJ 50008512 R2142201464	0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0												0 0 0			
SAHIL RAJ 50008523 R2142201391	90.33333	5 4 5 5 5 4 5 5 5 5 5 5 5 5 5 5 5 5	96.66667	48.33333										30 22 22 10 42			
PRANAV 5E+08 R2142201561	55.5	4 3 3 3 3 4 2 2 2 4 2 5 65 32.5												20 0 18 10 24			
Vikram 5E+08 R2142201298	5	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0												0 0 0 10 5			
ASHAAR 5E+08 R2142201436	80.5	0 0 5 5 5 5 5 5 5 5 5 5 4 4 4 3 85 42.5												24 18 24 10 38			
VEDANT 5E+08 R2142201585	72.33333	5 5 5 5 5 5 5 5 5 5 5 5 4 5 4 96.66667 48.33333												20 18 0 10 24			
VANSH 5E+08 R2142201578	8.333333	0 0 0 0 0 0 0 0 2 2 2 2 0 0 0 2 16.66667 8.333333												0 0 0 0 0			
VINEEL 5E+08 R2142201306	65	5 3 3 3 3 4 5 2 5 2 5 5 5 5 5 5 80 40												20 0 20 10 25			
JANHVEE 50008583 R2142201493	59.16667	0 5 5 5 5 5 5 5 5 5 5 4 4 4 5 88.33333 44.16667												20 0 0 10 15			
HIMANSH 5E+08 R2142201376	10	0 0 0 0 0 0 0 0 0 0 0 2 0 0 5 5 20 10												0 0 0 0 0			
ARYAN 5E+08 R2142201586	10	0 0 0 0 0 0 2 2 2 2 2 0 2 2 2 2 20 10												0 0 0 0 0			
VIKAS 5E+08 R2142201296	51.66667	5 5 4 2 2 2 2 2 5 5 5 5 5 5 5 5 78.33333 39.16667												15 0 0 10 12.5			
ARPITA 5E+08 R2142201596	39	0 0 0 0 0 0 0 5 2 2 2 0 2 2 2 2 25 12.5												18 15 10 10 26.5			
YASH 5E+08 R2142201337	53.16667	5 2 3 0 0 0 5 5 5 5 0 5 0 5 5 58.33333 29.16667												20 18 0 10 24			
ISHITA 5E+08 R2142201599	89.66667	5 5 5 5 5 5 5 5 5 5 5 4 5 5 5 47.33333 49.16667												25 24 22 10 40.5			
PRATYUHS 5E+08 R2142201590	61.66667	5 5 0 0 0 0 5 5 5 5 2 5 4 5 5 3 73.33333 36.66667												15 15 10 10 25			
SHUBHAM 5E+08 R2142201621	47.33333	0 0 0 0 0 0 5 4 0 4 4 4 5 0 36.66667 18.33333												15 15 18 10 29			
VISHWAA 5E+08 R2142201326	88.16667	5 5 5 5 5 5 5 5 5 5 5 5 4 5 4 98.33333 49.16667												26 22 20 10 39			
DHRUV 5E+08 R2142201555	48.33333	0 3 3 3 5 5 5 5 2 2 5 2 5 2 5 66.66667 33.33333												20 0 0 10 15			
SUBHRONI 5E+08 R2142201401	28.33333	0 0 0 0 0 0 2 2 2 2 2 0 0 2 16.66667 8.333333												15 0 0 15 20			
HASHMEE 5E+08 R2142201437	37.5	0 0 5 5 5 5 5 5 5 5 0 2 2 2 25 32.5												0 0 0 10 5			
PURUJEET 5E+08 R2142201446	40.83333	0 5 5 5 5 5 5 5 4 5 5 5 0 2 71.66667 35.83333												0 0 0 10 5			
VIVEK 5E+08 R2142201503	29	0 0 0 0 0 0 0 0 0 0 2 0 0 0 15 7.5												15 18 0 10 21.5			
RAGHAV 5E+08 R2142201502	73.33333	5 5 4 3 5 5 5 5 5 5 2 4 4 5 5 86.66667 43.33333												20 20 10 10 30			
VAIBHAV 5E+08 R2142201439	59.16667	0 3 3 3 5 5 5 5 5 5 3 5 4 4 5 58.33333 39.16667												0 20 10 10 20			
ADARS 5E+08 R2142201527	72.66667	0 5 5 5 5 5 5 5 5 5 4 4 4 5 5 88.33333 44.16667												15 18 14 10 28.5			
YASH 5E+08 R2142201347	35.83333	0 0 0 0 0 0 4 5 4 4 2 0 2 2 2 21.66667 15.83333												15 15 0 10 20			
ARIHANT 5E+08 R2142201523	87	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 100 50												22 22 20 10 37			
YASH 5E+08 R2142201348	0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0												0 0 0 0 0			
VANYA 5E+08 R2142201279	63.33333	5 2 5 5 5 5 5 5 5 5 3 5 5 5 5 51.66667 45.83333												25 0 0 10 17.5			
Last Name First Name User Name Student ID Last Access Availability Viva 3 Total Pts: 30 Score		Screen Sh Screen Sh Screen Sh Screen Sh Screen Sh Screen Sh File 1 24 Lab File 2 Lab 3 Tot Experiment Screen Sh Experiment Experiment & Clipping Total Pts: 5 Score 601152 Viva 1 To Viva 2 To Viva 3 Total Pts: 30 Score															
ABHAY TY 50008282 R214220028	Yes	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0												0 0 0 0 0			
Ashutosh 50008629 R21422021	Yes	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0												0 0 0 0 0			
Bavisetti 50008785 R21422021	Yes	18 42.46154	0 0 0 0 0 0 0 0 3 3 0 2 0 3 0 16.92308 8.461538											22 18 18 10 34			
Bhavesh J 50008789 R21422021	Yes	13.84615	0 0 0 0 2 0 0 0 2 2 0 4 2 4 2 27.69231 13.84615											0 0 0 0 0			
BOMMISE 50008794 R21422021	Yes	10 57.46154	2 2 2 3 2 2 3 2 3 3 2 4 4 4 4 56.92308 28.46154											20 18 10 10 29			
TUSHAR L 50008668 R21422021	Yes	10.76923	0 0 0 2 0 0 0 2 2 2 0 2 2 2 2 21.53846 10.76923											0 0 0 0 0			
AGGARWAL LAKSHYA 5E+08 R21422026	Yes	20 73.46154	3 5 4 5 5 0 3 2 5 5 4 5 4 5 4 76.92308 38.46154											22 18 20 10 35			
Chaturvedi Pranjal 5E+08 R21422027	Yes	27.84615	0 0 0 5 0 0 0 0 0 0 0 0 0 0 0 7.692308 3.846154											20 18 10 24			
Chaudhan Kartikeya 5E+08 R21422021	Yes	8.461538	0 0 0 3 0 0 0 0 0 0 0 2 2 2 2 16.92308 8.461538											0 0 0 0 0			
Dass Alpana 5E+08 R21422021	Yes	71.15385	5 5 5 5 5 5 5 5 5 0 5 5 5 5 5 52.30769 46.15385											18 22 20 10 25			
KAPOOR AKSHITA 5E+08 R21422021	Yes	24 89.5	5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 100 50											25 20 24 10 39.5			
Kapoor Tanishka 5E+08 R21422021	Yes	22.30769	0 0 0 5 0 0 0 3 3 0 4 5 4 5 4 44.61538 22.30769											0 0 0 0 0			
KAUR TANUSHPI 5E+08 R21422021	Yes	20 85.23077	5 5 4 5 5 5 5 5 5 5 5 5 5 5 5 5 98.46154 49.23077											20 24 20 10 37			
KUMAR SHUBHAM 5E+08 R21422021	Yes	0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0											0 0 0 0 0			
Kumar Vikash 5E+08 R21422021	Yes	18 87.23077	5 5 5 5 5 5 5 5 5 4 5 5 5 5 5 5 98.46154 49.23077											28 20 18 10 38			
KUMAR DIANOOP 5E+08 R21422021	Yes	5 75.96154	5 5 5 5 5 5 5 5 3 5 5 5 5 5 5 5 96.92308 48.46154											22 18 5 10 27.5			
MALIK VIJAY 5E+08 R21422021	Yes	1 36.26923	0 0 0 2 0 0 0 2 2 0 2 2 2 2 2 21.53846 10.76923											22 18 1 10 25.5			
Nangla Archit 5E+08 R21422021	Yes	15 79.65385	5 5 5 5 5 5 5 5 5 0 5 5 5 5 5 5 92.30769 46.15385											24 18 15 10 33.5			
OHDAR VISHAL 5E+08 R21422021	Yes	24 90.23077	5 5 4 5 5 5 5 5 5 5 5 5 5 5 5 5 98.46154 49.23077											30 18 24 10 41			
PANDEY AADARSH 5E+08 R21422020X	Yes	20 78.07692	5 5 5 5 5 5 5 3 3 0 5 5 5 5 5 5 86.15385 43.07692											22 18 20 10 35			
PATHAK KARTIKEY 5E+08 R21422026X	Yes	15 69.46154	0 5 0 5 5 5 3 5 5 3 5 5 5 5 5 5 76.92308 38.46154											20 17 15 10 31			
REHMAN PARVEJ 5E+08 R21422021	Yes	1 14.34615	0 0 0 2 0 0 0 2 2 0 2 4 2 4 2 27.69231 13.84615											0 0 1 0.5			
Sahoo Samyukta 5E+08 R21422021	Yes	20 87.23077	5 5 5 5 5 5 5 5 5 4 5 5 5 5 5 5 98.46154 49.23077											24 22 20 10 38			
Sareen Ayush 5E+08 R21422021	Yes	10 42	0 0 0 0 5 0 0 0 5 5 0 2 2 2 5 2 40 20											24 0 10 10 22			
Sharma Arnav 50008793 R21422021	Yes	15 57.26923	0 0 0 3 0 0 0 3 3 0 4 5 4 5 4 41.53846 20.76923											28 20 15 10 36.5			
Singh Anoop 5E+08 R21422021	Yes	15 80.23077	5 5 5 5 5 5 5 5 5 4 5 5 5 5 5 5 98.46154 49.23077											20 17 15 10 31			
Sonwane Mayank 5E+08 R21422021	Yes	10 59.23077	5 5 5 5 5 5 5 5 5 4 5 5 5 5 5 5 98.46154 49.23077											0 0 10 10 10			
SUBRAMAARUNI 5E+08 R21422021	Yes	0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0											0 0 0 0 0			
TYAGI DEVVRATI 500086552 R21422021	Yes	13.07692	0 0 0 3 0 0 0 3 3 0 4 0 4 0 4 0 26.15385 13.07692											0 0 0 0 0			

ID	Student Name	Roll No.	SAP ID	(CO1)	(CO2)	(CO3)	(CO4)	(CO5)
1	VANYA VERMA	R2142201097	500082727	Strong	Strong	Strong	Strong	Strong
2	VIKAS KUMAR KATIYAR	R2142201098	500084152	Moderate	Moderate	Moderate	Moderate	Moderate
3	VIKRAM AGARWAL	R2142201107	500083325	Strong	Strong	Strong	Moderate	Moderate
4	VINEEL ETTAM	R2142201480	500083931	Moderate	Strong	Moderate	Moderate	Moderate
5	VISHWA PRATAP	R2142201481	500084020	Strong	Strong	Strong	Strong	Strong
6	YASH MITTAL	R2142201485	500082857	Strong	Moderate	Strong	Strong	Strong
7	YASH TYAGI	R2142201486	500084418	Strong	Strong	Strong	Strong	Strong
8	YASH VARDHAN RAGH	R2142201487	500083751	Strong	Strong	Strong	Strong	Strong
9	HIMANSHU GUPTA	R2142201534	500084889	Moderate	Moderate	Strong	Moderate	Moderate
10	SAHIL RAJ	R2142201535	500085033	Moderate	Strong	Moderate	Strong	Strong
11	SUBHRONEEL ROY	R2142201538	500084985	Moderate	Strong	Moderate	Strong	Strong
12	ASHHAR ALI	R2142201539	500085026	Strong	Strong	Strong	Strong	Strong
13	HASHMEET SINGH SAL	R2142201540	500084890	Strong	Strong	Strong	Strong	Strong
14	VAIBHAV TOMAR	R2142201541	500084879	Strong	Strong	Strong	Strong	Strong
15	POOJA JOSHI	R2142201542	500084950	Strong	Strong	Moderate	Strong	Strong
16	PURUJEET SINGH	R2142201811	500084940	Strong	Strong	Strong	Strong	Strong
17	PRIYAL ARORA	R2142201812	500085124	Moderate	Moderate	Moderate	Moderate	Moderate
18	JANHVEE GARG	R2142201813	500085838	Moderate	Strong	Weak	Moderate	Moderate
19	RAGHAV TIWARI	R2142201814	500085061	Strong	Strong	Moderate	Moderate	Moderate
20	VIVEK SINGH CHANDE	R2142201815	500084998	Strong	Strong	Strong	Strong	Strong
21	ARIHANT VARDHAN	R2142201816	500086019	Strong	Strong	Weak	Moderate	Moderate
22	ADARSH TRIPATHI	R2142201817	500086025	Moderate	Moderate	Moderate	Moderate	Moderate
23	DHRUV RAKHRA	R2142201818	500086220	Strong	Strong	Strong	Strong	Strong
24	PRANAV AERON	R2142201819	500086202	Strong	Strong	Strong	Strong	Strong
25	VANSH BANSAL	R214220232	500086172	Moderate	Strong	Strong	Strong	Strong
26	VEDANT ARORA	R214220492	500084901	Moderate	Moderate	Moderate	Moderate	Moderate
27	ARYAN KAPOOR	R214220511	500083065	Strong	Strong	Moderate	Strong	Strong
28	PRATYUSH NEGI	R214220673	500083242	Moderate	Strong	Weak	Moderate	Moderate
29	ARPITA KUMARI	R214220728	500086232	Strong	Moderate	Moderate	Strong	Strong
30	ISHITA NANDA	R214220973	500086361	Moderate	Moderate	Moderate	Moderate	Moderate
31	SHUBHAM NEGI	R214220023	500086306	Strong	Moderate	Moderate	Weak	Weak
32	AADARSH PANDEY	R2142201137	500083154	Strong	Strong	Strong	Moderate	Moderate
33	ABHAY TYAGI	R2142201141	500082819	Strong	Strong	Strong	Strong	Strong
34	VIJAY MALIK	R2142201146	500083210	Moderate	Moderate	Moderate	Moderate	Moderate
35	DEVVRATH TYAGI	R2142201214	500082939	Moderate	Moderate	Moderate	Moderate	Moderate
36	SHUBHAM KUMAR	R2142201247	500084088	Strong	Strong	Strong	Strong	Strong
37	TANUSHPREET KAUR	R2142201315	500084112	Weak	Moderate	Weak	Strong	Strong
38	VISHAL OHNDAR	R214220133	500082677	Moderate	Weak	Moderate	Weak	Weak
39	PARVEI REHMAN	R2142201488	500085700	Strong	Strong	Weak	Moderate	Moderate
40	PRASHANSA SHRIVAST	R2142201489	500084959	Moderate	Moderate	Moderate	Moderate	Moderate
41	TUSHAR LOHIAH	R2142201491	500085567	Strong	Strong	Strong	Strong	Strong
42	ARJUN SUBRAMANIAN	R2142201493	500085838	Strong	Strong	Strong	Strong	Strong
43	Kartikeya Chaudhary	R2142201494	500084966	Moderate	Strong	Strong	Strong	Strong
44	Anoop Singh	R2142201495	500084922	Moderate	Moderate	Moderate	Moderate	Moderate
45	Ayush Sareen	R2142201496	500085833	Strong	Strong	Moderate	Strong	Strong
46	Pranjal Chaturvedi	R2142201497	500085556	Moderate	Strong	Weak	Moderate	Moderate
47	ANOOP KUMAR DAS	R2142201498	500085043	Strong	Moderate	Moderate	Strong	Strong
48	Tanishka Kapoor	R2142201821	500087232	Moderate	Moderate	Moderate	Moderate	Moderate
49	Samyukta Sahoo	R2142201823	500086209	Strong	Moderate	Moderate	Weak	Weak
50	Alpana Dass	R2142201824	500086826	Strong	Strong	Strong	Moderate	Moderate
51	Ashutosh Singh	R2142201825	500087272	Strong	Strong	Strong	Strong	Strong
52	Raj Laxmi	R214220198	500082307	Moderate	Moderate	Moderate	Moderate	Moderate
53	Vikash Kumar	R214220247	500082671	Moderate	Moderate	Moderate	Moderate	Moderate
54	Bavisetti Dharmesh	R214220336	500083515	Strong	Strong	Strong	Strong	Strong
55	Bhavesh Jakhar	R214220377	500082306	Weak	Moderate	Weak	Strong	Strong
56	Arnav Sharma	R214220407	500084615	Moderate	Moderate	Moderate	Moderate	Moderate
57	BOMMISETTI GAUTAM	R214220480	500083485	Strong	Strong	Strong	Strong	Strong
58	Mayank Sonwane	R2142201497	500085556	Weak	Moderate	Weak	Strong	Strong
59	Archit Nangla	R2142201498	500085043	Strong	Strong	Strong	Strong	Strong
60	AKSHITA KAPOOR	R2142201821	500087232	Weak	Moderate	Weak	Strong	Strong
61	KARTIKEY PATHAK	R2142201823	500086209	Moderate	Moderate	Moderate	Moderate	Moderate
62	LAKSHYA AGGARWAL	R2142201824	500086826	Strong	Strong	Strong	Strong	Strong