BITS PILANI – DUBAI
International Academic City, Dubai
Second Semester 2009 – 2010
Computer Graphics CS C471 (IV year)
Comprehensive Exam (Closed Book)

Duration: 3 Hours **Weightage : 40%**
Date: 25 May 2010 **MAX : 40 Marks**

Question 1 (Total: 12 Marks)

Part A (2 Marks)

Consider a triangle in Key Frame *k* and an octagon in Key Frame *k+1*.

1. Obtain V_{max}, V_{min}, N_{ls}, and N_p
2. State the procedures used to perform vertex equalization.

Part B (3 Marks)

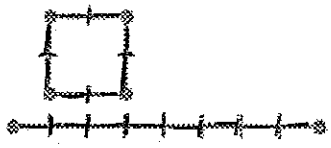
Consider the animation of a car between two traffic signals. Assume the following about this animation:

1. the car starts when it gets a green light in the first traffic signal and then stops at the red signal at the second traffic signal.
2. There is about 1000 meters between the signals and there are 100 in-betweens.

A. Obtain the times for the first five in-betweens after the first traffic signal and
B. Obtain the times for last five in-betweens before the second traffic signal.

Part C (1 Mark)

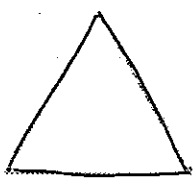
Determine the fractal similarity dimension, D, for the following fractal generator.



Part D (3 Marks)

For the initiator and generator given below, obtain the second iteration in the generation of the Koch curve i.e., apply the generator twice successively on the initiator.

Initiator

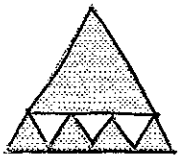


Generator

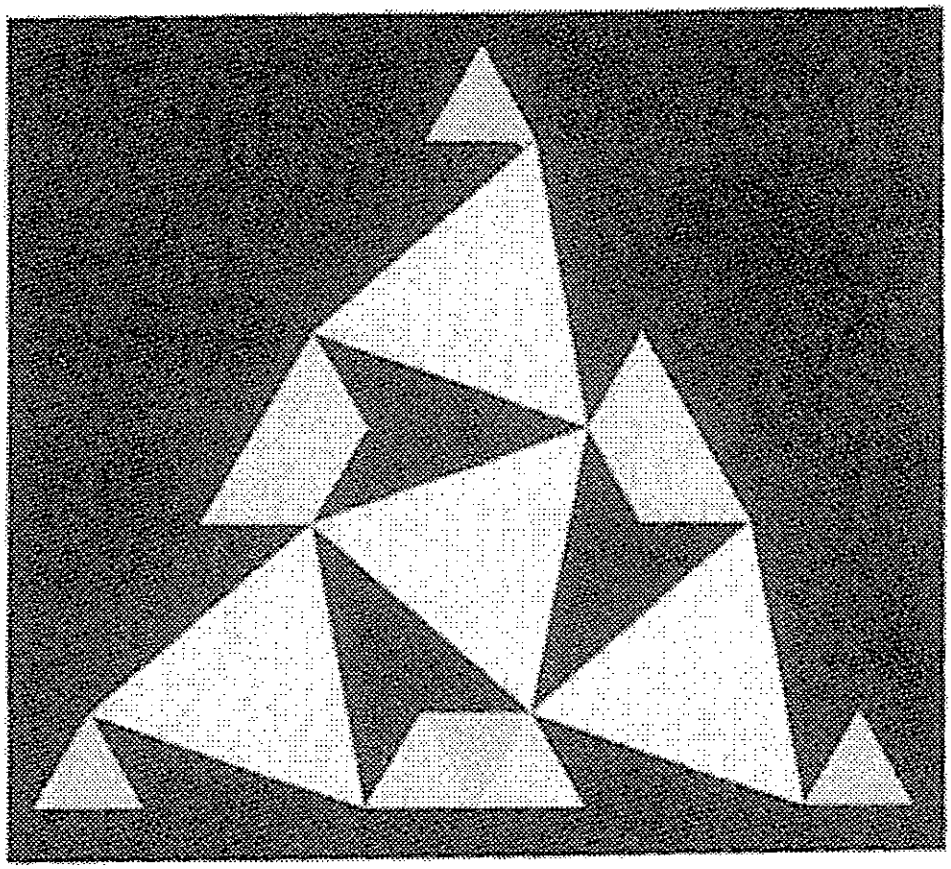
Part E (3 Marks)

Applying the given rule on the given shape obtain the new/transformed shape.

Rule:

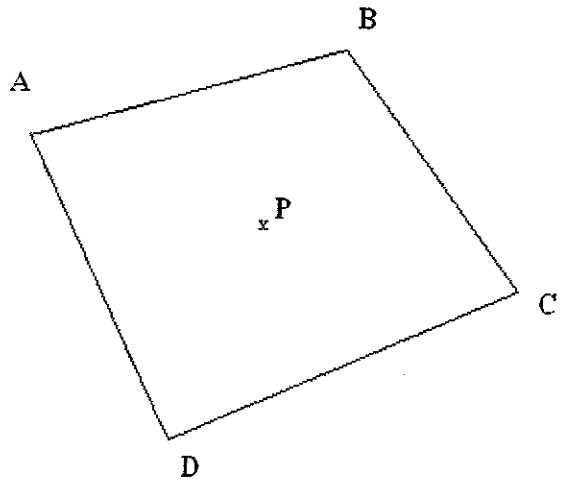


Initial/Given Shape:



Question 2 (3 Marks)

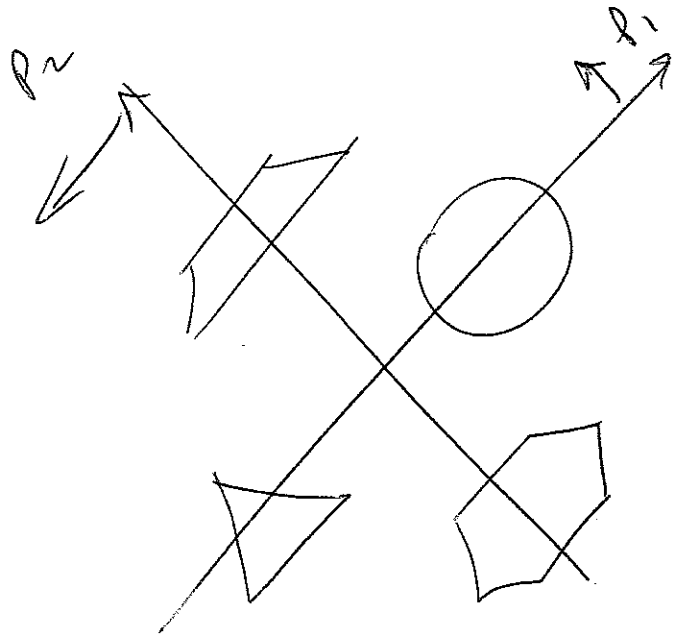
1. In the context of Gouraud polygon shading, show how you would obtain the intensity at the point P given the intensities at points A, B, C, and D in the diagram below.



2. If there is a single light source, and assuming an illumination model that includes ambient, diffuse, specular, and attenuation light
   a. What parameters would the intensity at A, B, C, and D depend on?
   b. What parameters would the intensity at P depend on?

Question 3 (2 Marks)

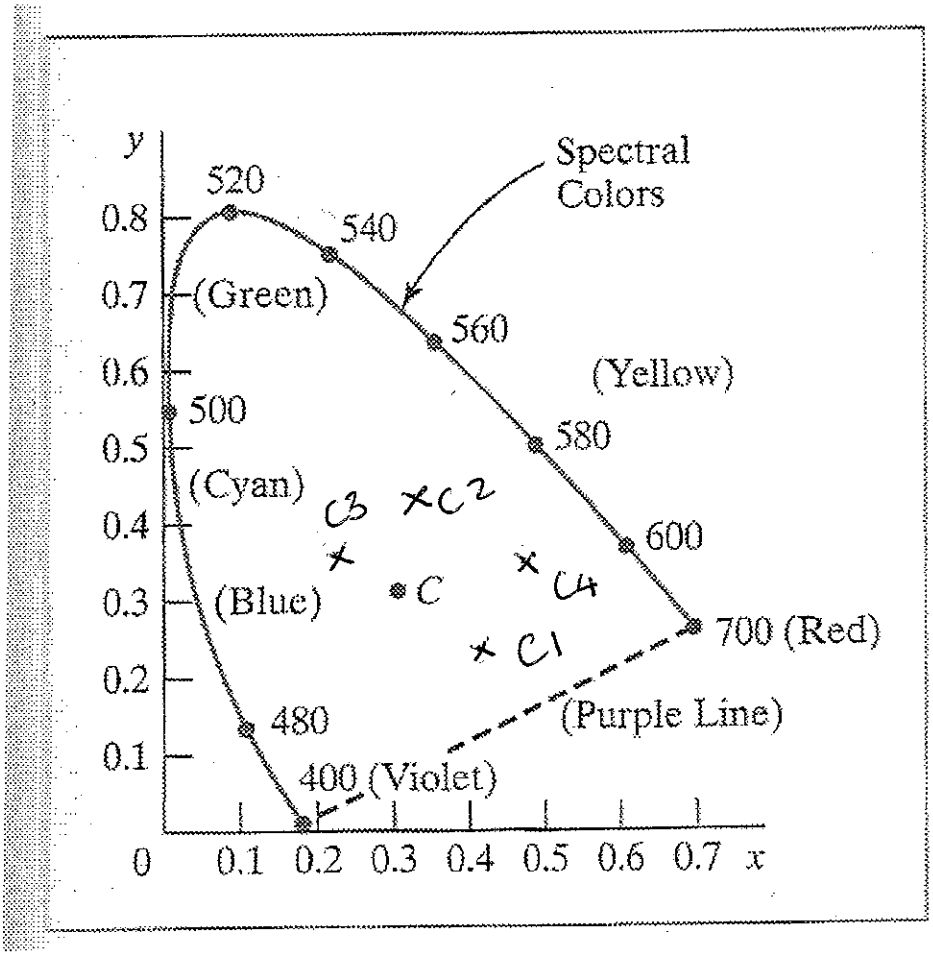
The figure below shows a region space partitioned with two planes. Can a BSP tree representation for this region and the objects in it be drawn? If not, modify the figure minimally and draw the corresponding BSP tree.



Question 4 (3 Marks)

In the CIE Chromaticity diagram given below, determine

1. the dominant wavelength and purity for C1 and C2.
2. the color combinations that are possible given C1, C2, C3, and C4.

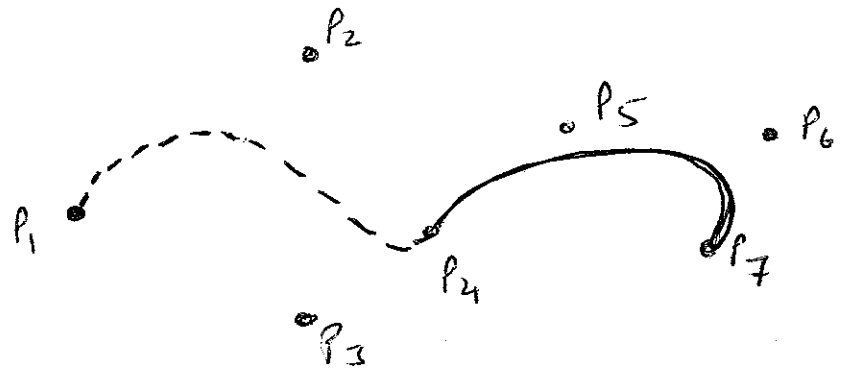


Question 5 (4 Marks)

1. Draw a pyramid on top of a cube.
2. State the Euler's formula for a simple polyhedra.
3. Determine the various parameters of the Euler's formula for the object in part (1).
4. Now draw a rectangular hole that passes through the object in part (1). Assume the hole is a vertical hole that passes through the center of the object.
    a. State the generalized Euler's formula that would apply for this type of objects.
    b. Determine various parameters of the generalized Euler's formula for this modified object.

Question 6 (3 Marks)

For the Bezier curves shown below and that are joined at P^4, determine the requirements C^0 and C^1 continuity.



Question 7 (3 Marks)

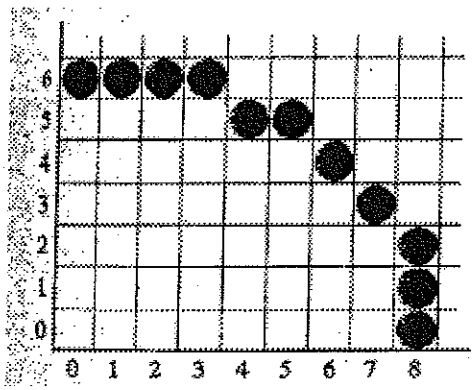
Complete the table below for Cyrus-Beck 3D clipping against canonical perspective projection view volume. Redraw the table in your answer sheet.

Clip Edge	Outward Normal, N_i	Point on Edge, P_{Ei}	$P_0 - P_{Ei}$	$N_i.D$	$t = N_i.(P_0 - P_{Ei})/(-N_i.D)$
Right: $x = -z$	(1, 0, 1)			$dx + dz$	
Left: $x = z$	(-1, 0, 1)			$dz - dx$	
Bottom: $y = z$	(0, -1, 1)			$dz - dy$	
Top: $y = -z$	(0, 1, 1)			$dz + dy$	
Front: $z = z_{min}$	(0, 0, 1)			dz	
Back: $z = -1$	(0, 0, -1)			$-dz$	

Question 8 (5 Marks)

The plot of pixel positions along the elliptical path centered at the origin and with $r_x = 8$, and $r_y = 6$ is given below. Also given is the midpoint ellipse algorithm is given below. The plot only covers the first quadrant. From the algorithm and the plot, determine the following

1. the points in region 1 and points in region 2
2. the number of adds/subtracts and the number of multiplies.



Midpoint Ellipse Algorithm

1. Input r_x, r_y, and ellipse center (x_c, y_c), and obtain the first point on an ellipse centered on the origin as

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

2. Calculate the initial value of the decision parameter in region 1 as

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

3. At each x_k position in region 1, starting at $k = 0$, perform the following test. If $p1_k < 0$, the next point along the ellipse centered on $(0, 0)$ is (x_{k+1}, y_k) and

$$p1_{k+1} = p1_k + 2r_y^2 x_{k+1} + r_y^2$$

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

$$p1_{k+1} = p1_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_y^2$$

with

$$2r_y^2 x_{k+1} = 2r_y^2 x_k + 2r_y^2, \qquad 2r_x^2 y_{k+1} = 2r_x^2 y_k - 2r_x^2$$

and continue until $2r_y^2 x \geq 2r_x^2 y$.

4. Calculate the initial value of the decision parameter in region 2 as

$$p2_0 = r_y^2 \left(x_0 + \frac{1}{2}\right)^2 + r_x^2 (y_0 - 1)^2 - r_x^2 r_y^2$$

where (x_0, y_0) is the last position calculated in region 1.

5. At each y_k position in region 2, starting at $k = 0$, perform the following test. If $p2_k > 0$, the next point along the ellipse centered on $(0, 0)$ is $(x_k, y_k - 1)$ and

$$p2_{k+1} = p2_k - 2r_x^2 y_{k+1} + r_x^2$$

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

$$p2_{k+1} = p2_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_x^2$$

using the same incremental calculations for x and y as in region 1. Continue until $y = 0$.

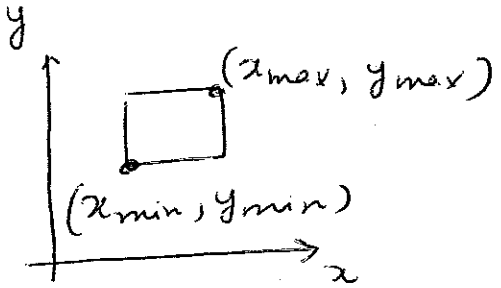
6. For both regions, determine symmetry points in the other three quadrants.

7. Move each calculated pixel position (x, y) onto the elliptical path centered on (x_c, y_c) and plot the coordinate values:

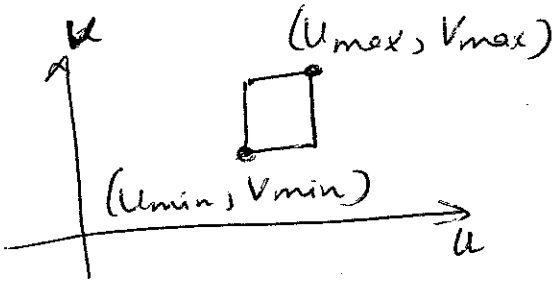
$$x = x + x_c, \qquad y = y + y_c$$

Question 9 (3 Marks)

The window in world coordinates and the window in viewport coordinates are given below. Write down the overall homogeneous coordinate matrix, M_{wv}, that is required to transform any object in world coordinates to the viewport.



Window in World Coordinates



Viewport Window

BITS PILANI – DUBAI
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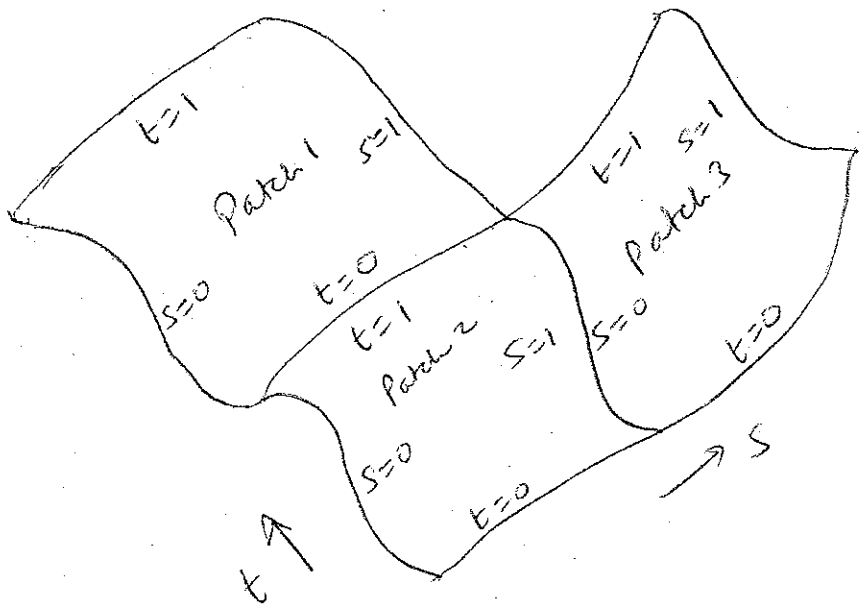
Computer Graphics CS C471 (IV year)
Test 2 (Open Book)

Duration : 50 minutes **Weightage : 20%**
Date: 2 May 2010 **MAX : 20 Marks**

Note: Only material indicated in Test 2 Notice should be used in this open book test.

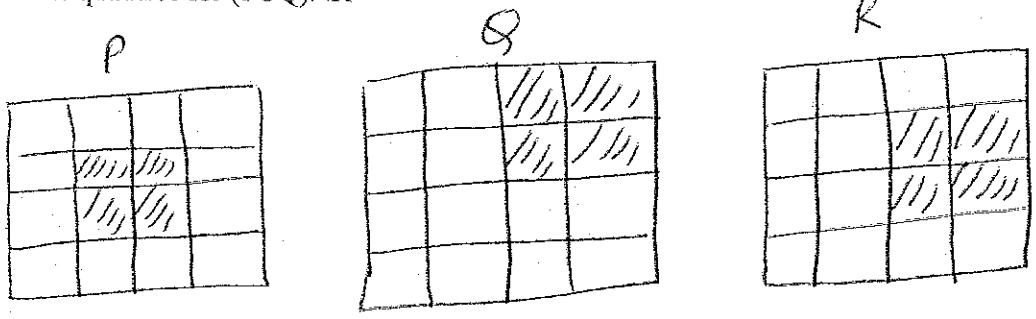
Question 1 (5 Marks)

For the joined patch surfaces shown below, what are the geometry matrix values (in terms of g_{ij}) for the three patches for C^1 continuity.



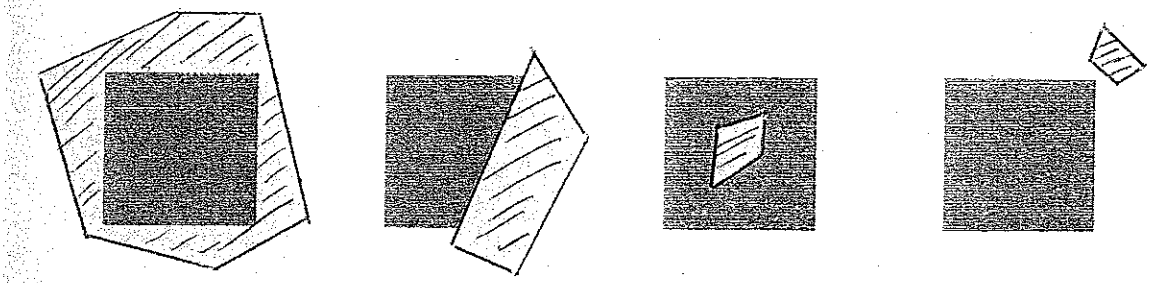
Question 2 (3 Marks)

For the objects shown below, draw
1. the quadtree for each object
2. the quadtree for (PUQ)∩R



Question 3 (6 Marks)

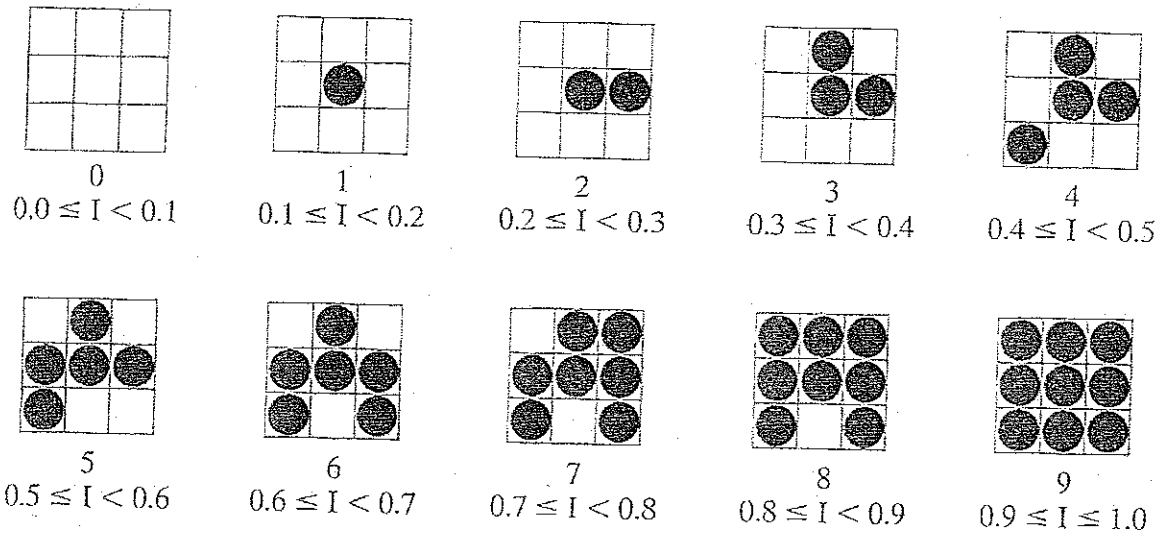
For the four types of possible relationships between polygon surfaces and a rectangular section of the viewing plane, write an algorithm, to be used in visible-surface detection, that will identify which of the four types does any given polygon surface correspond to.



Surrounding Surface | Overlapping Surface | Inside Surface | Outside Surface

Question 4 (3 Marks)

Write down the mask matrix that will generate the following 3 x 3 grid patterns to obtain 10 intensity levels using dithering.



0 $0.0 \leq I < 0.1$ | 1 $0.1 \leq I < 0.2$ | 2 $0.2 \leq I < 0.3$ | 3 $0.3 \leq I < 0.4$ | 4 $0.4 \leq I < 0.5$

5 $0.5 \leq I < 0.6$ | 6 $0.6 \leq I < 0.7$ | 7 $0.7 \leq I < 0.8$ | 8 $0.8 \leq I < 0.9$ | 9 $0.9 \leq I \leq 1.0$

Question 5 (3 Marks)

Explain why the Phong shading is computationally more expensive than Gouraud shading.

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Test 1 (Closed Book)

No. of Questions : 4
No. of Pages : 2

Duration : 50 minutes **Weightage : 25%**
21 March 2010 **MAX : 25 Marks**

Note: Show all working to get full credit.

Question 1: Given a circle with radius r = 5, use the midpoint circle algorithm to determine the coordinates of the first 4 pixels that will be drawn.

1. What is the average number of multiplications and additions are required to compute (x_{k+1}, y_{k+1}) given p_k?
2. For the second pixel coordinates calculated (x_1, y_1), how many other pixel coordinates can be computed with minimal effort? What are the values for these pixel coordinates?
3. The following formulae may be useful:
   a. $p_0 = 1 - r$ *OR* $p_0 = 5/4 - r$
   b. $p_{k+1} = p_k + 2x_{k+1} + 1$ OR $p_{k+1} = p_k + 2x_{k+1} + 1 - 2y_{k+1}$

(4 + 1 + 2 Marks)

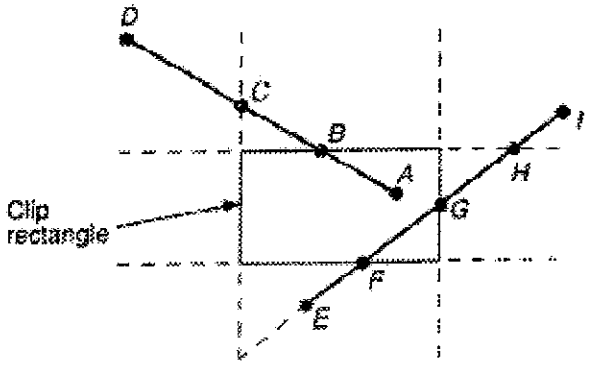
Question 2: What are the 3D homogeneous matrices required to perform the following transformations?

1. (1, 2, 3) → (-2, -4, 6)
2. Rotate the line defined between (1, 1, 3) and (2, 4, 3) to obtain the line defined between (-1, 1, 3) and (-4, 2, 3).

(2 + 4 Marks)

Question 3: Apply the Cohen-Sutherland line clipping algorithm to the lines in the diagram below.

1. State, explicitly, the Cohen-Sutherland algorithm before determining the number of comparisons required below.
2. To reduce the line AD to AB that is within the viewport, how many comparisons are required?
3. To reduce the line EI to FG that is within the viewport, how many comparisons are required?



(3 + 2 + 2 Marks)

Question 4: Determine if the following data sets represent perspective or parallel projection types. Justify your answer.

Data element	Data Set 1	Data Set 2
VRP (WC)	(16, 0, 54)	(16, 0, 54)
VPN (WC)	(0, 1, 0)	(0, 0, 1)
VUP (WC)	(-1, 0, 0)	(0, 1, 0)
PRP (VRC)	(12, 8, 30)	(20, 25, 20)
Window (VRC)	(-1, 25, -5, 21)	(-20, 20, -5, 35)

(5 Marks)

BITS PILANI – DUBAI
International Academic City, Dubai
Second Semester 2009 – 2010
Computer Graphics CS C471 (IV year)
Quiz 1 (Closed Book)

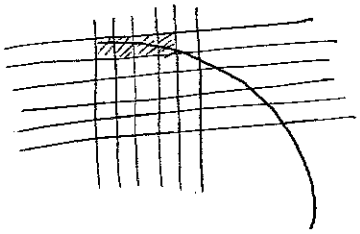
No. of Questions : 7
No. of Pages : 2

Duration : 20 minutes **Weightage : 8%**
3 March 2010 **MAX : 8 Marks**

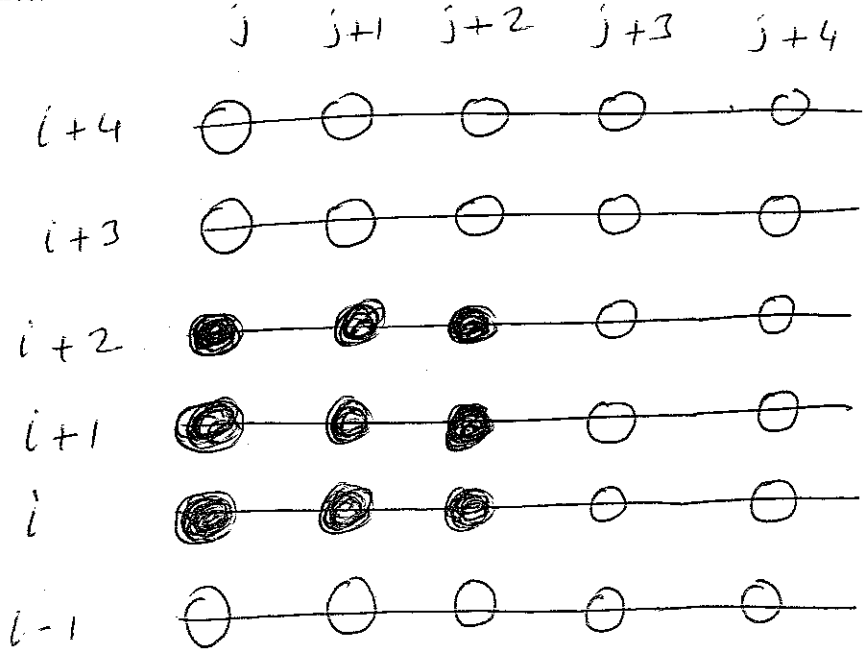
Question 1: Name the main reason why Bresenham's line algorithm is better than the DDA algorithm. **(1 Mark)**

Question 2: Assuming that I want to plot an ellipse with 32 points using the midpoint *ellipse* algorithm. How many points have to be computed that require a lot of computation and how many can be computed with minimal effort? **(1 Mark)**

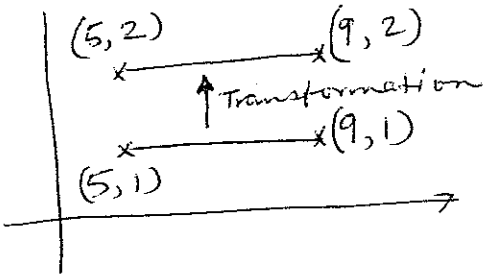
Question 3: In the following picture, the pixels that will be illuminated are shown in the diagram. The actual circle to be displayed is also shown. Which will be next pixel that will be illuminated? **(1 Mark)**



Question 4: In the diagrams below for a straight line identify by a tick mark the next set of pixels that will be illuminated by the *Rectangular Pen technique* for drawing thick lines: **(1 Mark)**



Question 5: What are two ways in which you can accomplish the following transformation? **(2 Marks)**



Question 6: Write the matrix for a 3D Rotation of 60 degrees about the y-axis in homogenous coordinates (no need for calculation of values). **(1 Mark)**

Question 7: Assume that an object is rotated with matrix R(θ), then translated with matrix T(tx, ty), and then scaled with matrix S(sx, sy). Write the matrix for the composition of the three transformations. **(1 Mark)**

M = _____ . _____ . _____