American University of Beirut
Faculty of Arts & Sciences — *Department of Mathematics*

Math 285-Computer Graphics
Final - Fall 1996
Time: 2 hours
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Student Id Number	Student Name (Surname, First)	Grade / 100

NB: All graphics commands should be given in OpenGL format

A. General (9 points)

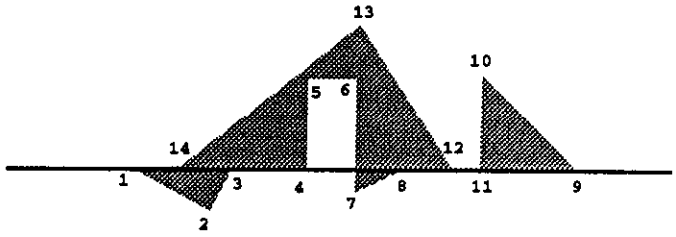
Answer by True or by False each of the following questions:

1. A rubber band state is active when only when a button is not held down.
2. Panning consists of mapping a variable size window to a variable size viewport.
3. In OpenGL Graphics segments (display lists) cannot be nested.
4. In the replicating methods for producing thick primitives, each computed pixel is duplicated in rows for lines with slope > 1
5. In direct manipulation technique, objects, attributes, or relations are represented visually.
6. A potentiometer is a locator device that can be used to enter bounded value.

B. Output Primitives (30 points)

1. Define each of the following:
   (a) Flyback time (c) Depth cueing (e) An interaction task
   (b) An icon (d) Surface rendering (f) A dialogue box
2. Explain the role of a video-controller in a raster scan system and sketch a diagram showing its main components.
3. How many pixels will be produced for the line from (x, y) to (r, s) by Bresenham's algorithm? Count the first and last pixel.
4. Consider an RGB system that has a 512×512 frame buffer with 20 bits per pixel and a color lookup table with 24 bits per pixel. How many distincts gray levels can be displayed with this system? How may colors can be displayed simultaneously?
5. Sketch out the piece of text *I ENJOY GRAPHICS* using a left path and an upvector of (-1, 0).

6. In the process of scan-line algorithm for area filling, what are the contents of the active edge list when processing the scan line indicated in the following picture. Describe the spans on that line.



C. Dithering (5 points)

1. A picture has been calculated for display on a workstation and then moved to a bi-level device and drawn using the following 4×4 **ordered dithering** matrix:

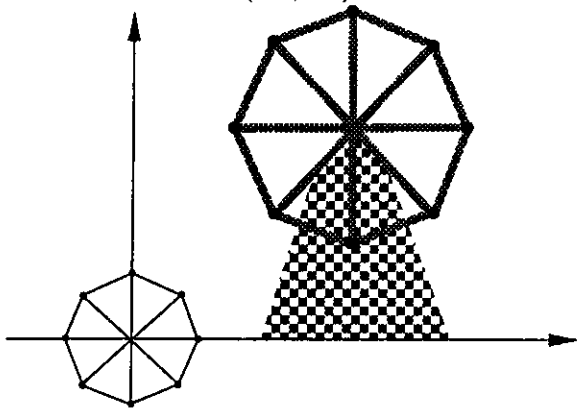
$$\begin{pmatrix} 15 & 7 & 13 & 5 \\ 3 & 11 & 1 & 9 \\ 12 & 4 & 14 & 6 \\ 0 & 8 & 2 & 10 \end{pmatrix}$$

Will the pixel $(103, 103)$ with intensity 12 be turned on? Explain why.

D. OpenGL (10 points)

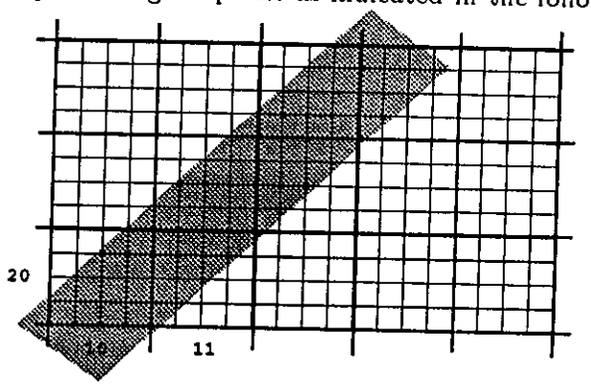
1. Write an OpenGL segment that computes n points on a circle centered at the origin and of radius $r = 1$ and display a fan as shown below.

2. The fan above is to be used in a windmill shown below after enlarging it two times. Using the fan segment, Write OpenGL code to describe a segment that draws the windmill. Assume that the body of the windmill is available in a segment WindMill() and the new center of the fan is at $(0.7, 0.5)$.



E. Antialiasing (10 points)

1. A line is supersampled using subpixels as indicated in the following picture.



What is the color at each of the two pixels $(10, 20)$ and $(11, 20)$. Assume that the line is drawn with intensity $(255, 0, 0)$ on a background color of intensity $(100, 100, 100)$.

2. Assume that the maximum intensity of a primitive is $(255, 0, 0)$, and that half the area of a pixel is covered by that primitive, What is the intensity contribution (i_r, i_g, i_b) of that pixel using a filter function $f(x, y) = 2$. Show how to get your answer.

F. Windowing/Clipping (10 points)

1. A window in the world coordinates is defined by:

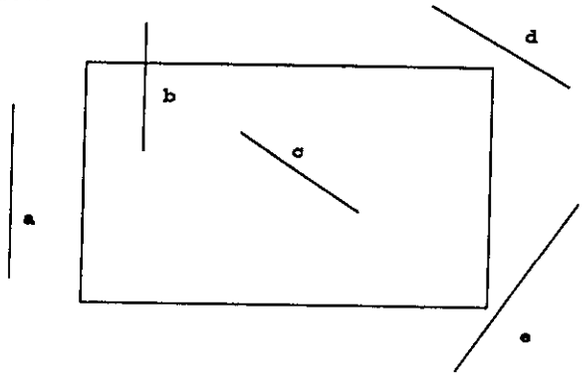
$Xw_{min} = 10 \quad Xw_{max} = 70$
$Yw_{min} = 20 \quad Yw_{max} = 40$

is to be mapped to a viewport defined by:

$Xv_{min} = 0.5 \quad Xv_{max} = 1.0$
$Yv_{min} = 0.0 \quad Yv_{max} = 0.5$

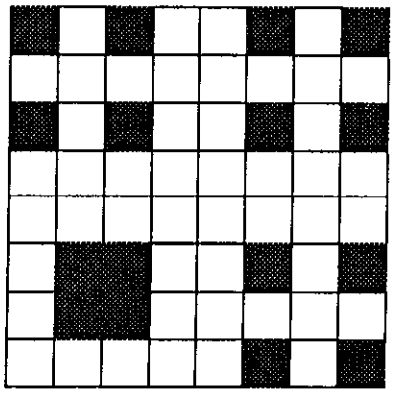
Give the Window-to-viewport transformation matrix in terms of a product of matrices.

2. Using the Cohen-Sutherland algorithm for line clipping, Which of the following segments (a to e) are can be *trivially* rejected? *i.e. which do not need further processing.* Show an example, where this algorithm fails to produce correct result. The box represents the window.

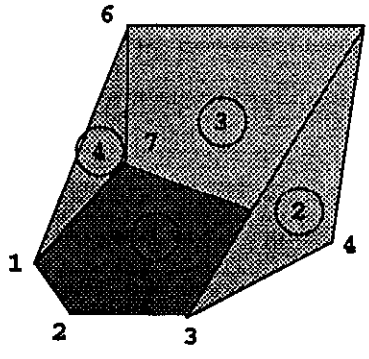


G. Object Representation (10 points)

1. Give the quadtree representation of the object shown below:

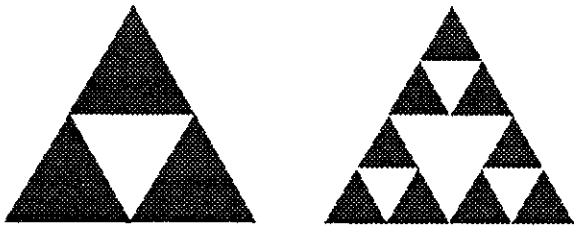


2. Give the Polyhedral representation (vertices, faces and edges) of the following object:



H. Fractals (10 points)

1. Given the following first two successive steps of a fractal object:



Answer each of the following:

(a) What is the initiator and the generator? Draw them.

(b) What is the Fractal Dimension?

(c) What are the main properties of this fractal object? *i.e. statistically-self similar, self-similar, or etc?*

I. Transformation (15 points)

1. Assume that the basic transformations are given in the following table:

translation	$T(t_x, t_y)$	
Rotation	$R(\theta)$	about origin
Scaling	$S(s_x, s_y)$	factors positive
Shear	Sh_x or $Sh_y(\alpha)$	

A composite transformation

$$T(\beta, s_x, s_y, \alpha) = R_(\beta).S(s_x, s_y).R(\alpha)$$

is applied to a unit square with corner at the origin:

(a) Draw a picture of the transformed square after applying each of the transformations in T for the values $(\alpha = 90, \beta = 0, s_x = s_y = 2)$.

(b) Find the transformation matrix of the composite transformation in terms of β, s_x, s_y, and α.

(c) Explain how to find the values of α, β s_x and s_y to make T a shear in the x-direction.