American University of Beirut

الجامعة الأميركية في بيروت

Faculty of Arts & Sciences *Department of Computer Science*

CMPS 285 Computer Graphics

Final - Fall 2005-2006

Time: 2 hours

Ahmad Nasri

Student Id ....

Student Name ....

Signature ....

Question	**Grade**
1. General - 16 points	
2. Transformations - 30 points	
3. Texture Mapping - 10 points	
4. Clipping - 14 points	
5.Scan Conversion - 20 points	
6. Curves and Surfaces - 10 points	
Total /100	

Important

PLEASE read the followings before you start:

1. Keep your eyes on your paper. Any attempt to cheat will result in failing the course and may lead to disciplinary actions against the student.
2. You MUST NOT talk at all during the exam; any talk or chat will be considered as a cheating attempt.
3. You MUST switch your mobile phone off. Silent mode is not enough
4. The use of calculator is NOT allowed.

1 General - 10 points

1. The following terms are possible answers for the questions listed below. Use the number corresponding to a term in the space provided before the question if you think it is the **BEST** match for one of the terms. Each term may be used once, more than once, or not at all.

number	term	number	term
1	rotation about x axis	11	pixel
2	rotation about y axis	12	refresh rate
3	bitmap	13	viewport
4	culling	14	window
5	z-buffer	15	delta
6	flicker	16	overall scaling
7	Texture	17	GLUT
8	alpha	18	interlace
9	antialiasing	19	affine
10	screen window	20	wireframe

..... The number of times per second that an image must be displayed on a screen in order to maintain the illusion of a continuous image.

..... A 4×4 matrix such as $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \alpha & -\beta & 0 \\ 0 & \beta & \alpha & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$ where $\alpha^2 + \beta^2 = 1$.

..... A 4×4 matrix such as $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & \alpha \end{pmatrix}$ where $\alpha > 0$.

..... Below the critical fusion frequency in a CRT suffer from this problem

..... A standard television set employs this technique to effectively double the rate at which images seem to be displayed on the screen, thus providing a better illusion of a continuous image

..... The frame buffer or pixel array associated with a "bi-level" raster displays

..... This style of rendering draws only the edges of objects

..... The subset of the World Coordinate System that is eventually rendered as an image on the face of the CRT

..... The portion of the face of the CRT that displays an image stored in the physical frame buffer

..... This provides a set of "widgets" and auxiliary functions for quickly building user interfaces using lower-level functions in OpenGL and X Windows or some other window system.

2. You need to design a graphics system with a 1024 color displayable simultaneously out of a palate of 2^{30} possible colors. Assuming the size of the frame is 80 MB, answer each of the following (use power of 2 in your answers):

   `What is the maximum number of pixels your screen can have?`

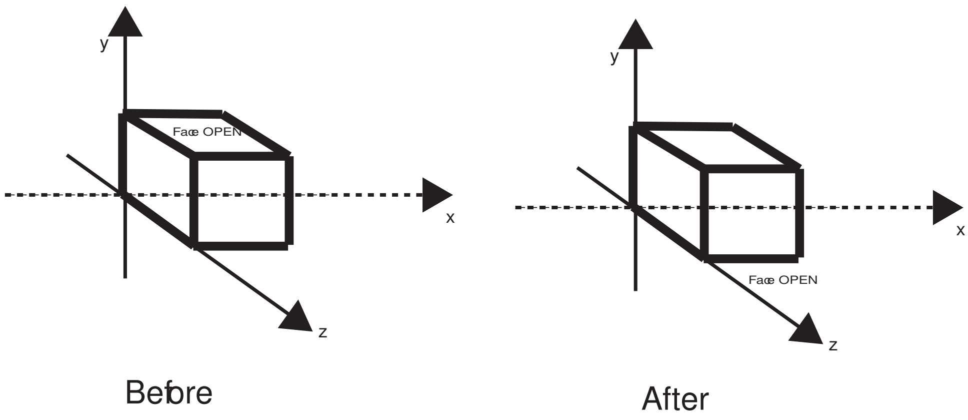
   `How many gray levels your system has?`

   `What is the size in bytes of your color table?`

2 Transformations

1. Consider a box formed by a unit cube with one face removed. Suppose that a call to glLookat() with the parameters indicated below displays the box centered in the

middle of the screen, aligned with the three planes, *xoy*, *xoz*, and *zoy*, with its top opening in normal orientation (Z axis coming out of the screen.), as indicated below:

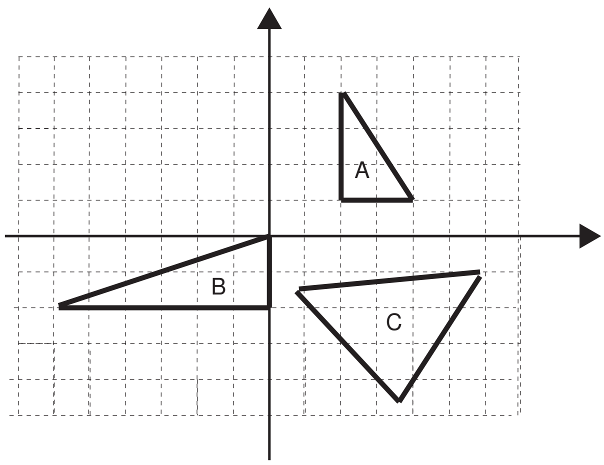



```
glLookAt (0., 0., 10., 0., 0., 0., 0., 1., 0.);
```

What changes to these parameters are needed in order to see the box upside down, *i.e. the opening is from below* and still aligned with the planes.

```
glLookAt (........................................);
```

2. Give tree lines of OpenGL code that will transform the bigger triangle B to the smaller triangle A.



```
........................................

........................................

.......................................

DrawTriangle(); // draw the triangle
```

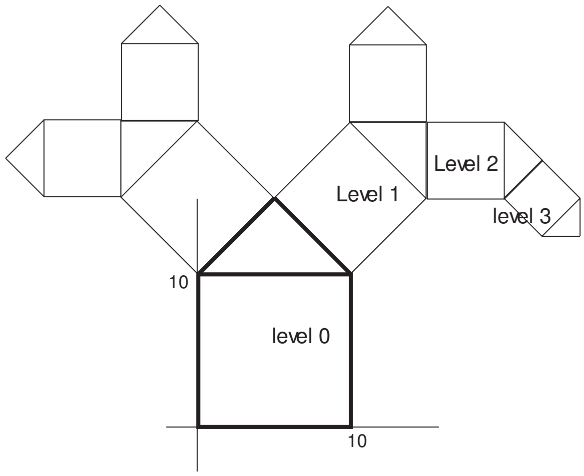
Show how to devise a transformation matrix to map the trianlge A to C which are both arbitrary.

3. The following piece of code produces some levels of Pythagoras tree using an initial shape shown in thick line (square with a half on one side).

```
Pythagoras(); // this is level 0
glTranslated(x1,y1,0);
glScale(sx,sy,1);
glRotatef(a,0,0,1);
glPhushMatrix();
Pythagoras(); // this is level 1

glLoadIdentity();
glTranslated(x2,y2,0);
for (i = 0, i < 2, i++){
        glScale(sx,sy,1);
        glRotatef(a,0,0,1)};
Pythagoras(); // this is level 2

glLoadIdentity();
glTranslated(x3,y3,0);
for (i = 0, i < 3, i++){
         glScale(sx,sy,1);
        glRotatef(a,0,0,1)};
Pythagoras(); // this is level 3
....
```



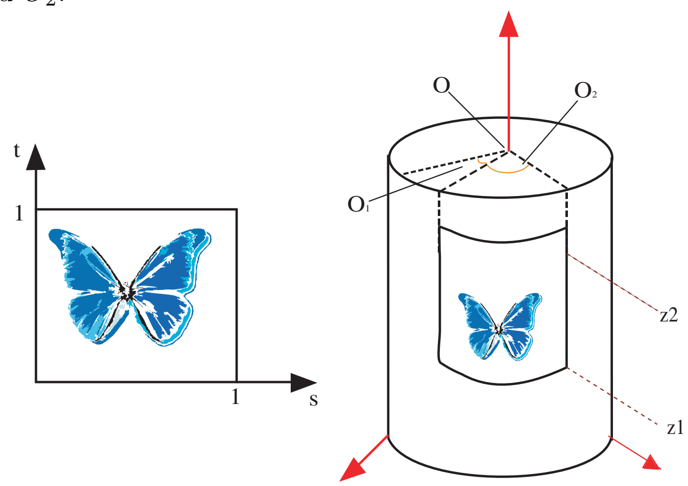
(a) Give the values of each of the parameters below in the table indicated.

$S_x =$	$S_y =$	a = ...	$x_1 =$	$y_1 =$ ....
$x_2 =$	$y_2 =$	$x_3 =$	$y_3 =$	

(b) Is it possible to find a recursive formula for computing x_{i+1} and y_{i+1} from x_i and y_i? If so what is it?

3 Texture Mapping

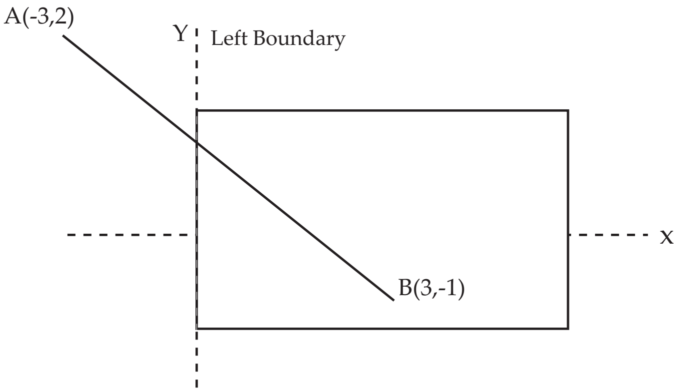
1. Consider the picture of the butterfly as a texture map $T(s,t)$ to be mapped to a part of the cylinder whose base is a circle centered at the origin and whose axis is aligned with the z- axis. The part of the cylinder is limited by the height Z_1 and Z_2 and the angle O_1 and O_2.



Explain how to get the texture value $T(s_0, t_0)$ of a point P_0) on this part of the cylinder. Indicate those for the corners if the butterfly is to be seen upside down.

4 Clipping

1. In line clipping, a line segment is represented by a parametric equation using a parameter $t \in [0, 1]$. The line segment defined by the points $A(-3, 2)$ and $B(3, -1)$ is to be clipped against the left window boundary shown in the figure below. Find the coordinates of the intersection point and its corresponding parameter t.

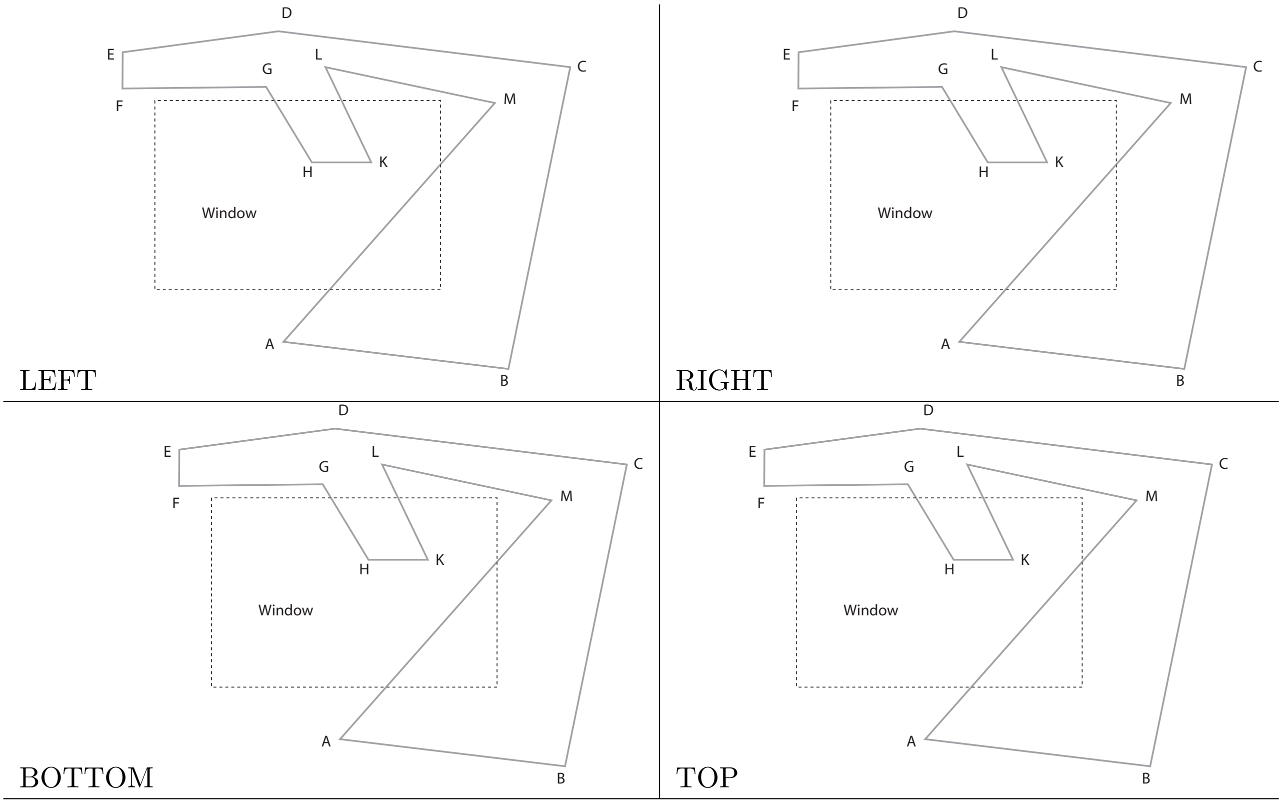


   (a) What is the region code of both vertices. Put that on the Figure provided

   (b) The intersection point is:

(c) The value t is:

2. Given Sutherland-Hodgman algorithm to clip the polygon below. You must show the results gradually by drawing the clipped polygon and give the resulting vertices for each window boundary and in the proper order.



`Put vertices in anti-clockwise order`

`Left Clipper Vertices: ................................`

`Right Clipper Vertices: ................................`

`Bottom Clipper Vertices: ................................`

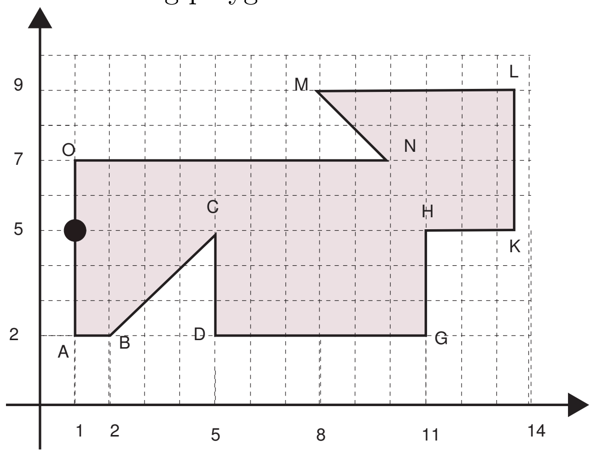
`Top Clipper Vertices: ................................`

5 Scan Conversion

1. Using the Brsenham's line algorithm, fill in the table by the first six pixels generated by the line between the two vertices $(2, 2)$ and $(9, 5)$. You must give the precision factor at each step.

X	2					
Y	2					
$E(x, y)$						

2. In the scan conversion of the following polygon:



black circle indicates a filled pixel, for example pixel (1,5) is filled. Answer the following questions:

(a) Indicates on the picture the pixels that are NOT filled by the scan line conversion algorithm using black circles.

(b) Give the active edge list for the scan line Y = 5. How many spans will be generated? Give your spans in terms on intervals such as $[a, b[$ or $[c, d]$.

Active Edge	Y_{max}	X	$1/m$
AO			

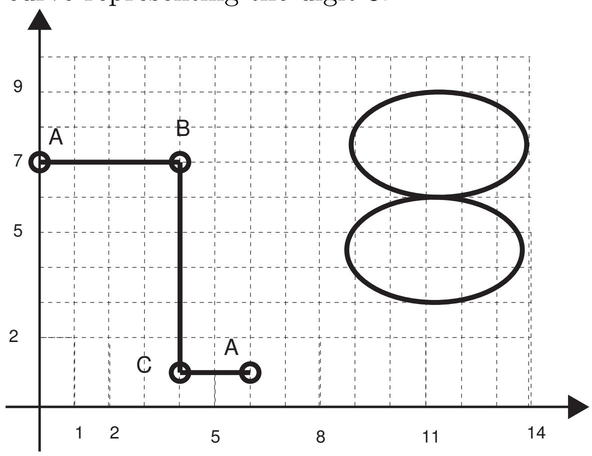
`The spans are : ...............................................`

(c) How many spans will be generated for the scan line Y = 2? Give your spans in terms on intervals such as $[a, b[$ or $[c, d]$.

`The spans are : ...............................................`

6 Curves and Surfaces

1. On the figure, we have a control polygon of the Bézier curve defined by A,B,C,D and a curve representing the digit 8.



(a) What is the degree of the curve defined by A,B,C,D. Show how to evaluate the curve at the parameter $t = 0.5$. Just simplify the equation and no need for much calculation.

(b) What is the coordinates of the tangent vector at the first point D? Show this on the picture.

(c) How many pieces of Bézir curve can be used to design the digit 8? Draw the control polygons of these curves on the Figure.