NATIONAL UNIVERSITY OF SINGAPORE
SCHOOL OF COMPUTING

EXAMINATION FOR
Semester 2, 2009/2010

CS3241 - COMPUTER GRAPHICS

Apr/May 2010 Time Allowed: 2 Hours

INSTRUCTION TO CANDIDATES

1. This is an OPEN book examination.
2. This examination paper contains **EIGHT (8)** questions and comprises **EIGHT (8)** printed pages.
3. Answer **ALL** questions within the spaces provided in this booklet.
4. You are allowed to use the back of the paper but please remember to state "P.T.O."
5. ***Cross out any draft*** or otherwise we will mark the poorer answers.
6. No calculator should be needed in this exam. You can leave your answer in surd form, namely, you can write $\sqrt{2}$ instead of 1.4142...
7. In the programming questions, you can assume some basic normal vector arithmetic functions are provided for the 2D vector class `Vector`.
8. Please write your matriculation number below, but NOT your name.

TIDINESS COUNTS!

We will deduct marks if your writing is too messy.

MATRICULATION NUMBER:_____

(this portion is for examiner's use only)

Question	Max. Marks	Score	Check
Q1	9		
Q2	8		
Q3	5		
Q4	8		
Q5	4		
Q6	5		
Q7	4		
Q8	7		
Total	50		

Question 1 [9 marks]

You are given 9 statements below. State if each statement is True (T) or False (F) by writing your answer in the box provided. A correct answer will give you 1 mark. An empty answer will give you zero, but ***a wrong answer will result in -1 mark***. (Lowest mark for this question is 0)

☐ Texture mapping is done after projection transformation

☐ If we clip a convex polygon with the screen, the clipped polygon could have more than one connected components (meaning, more than one piece).

☐ If we have a lot of opaque polygons overlapping each other on the screen after projection and each of them has a very large area by itself before overlapping, depth sort is faster than z-buffer algorithm.

☐ We use high pass filters to filter the low frequency portion of an image to do anti-aliasing.

☐ In OpenGL, if we called `glRotatef` to rotate an object, e.g. a Bezier surface, we have to calculate the new normal vectors by ourselves after rotation when we call `glNormal` because the objects are rotated and the normal vectors will all have new directions.

☐ We can call OpenGL function `glScalef()` with only one parameter, e.g. `glScalef(2.0)`, to scale our objects if all the scaling factors are the same for the three dimensions *x*,*y* and *z*.

☐ In ray-tracing, we can apply Gouraud shading techniques if the shadow ray does not intersect any objects but only reaching a light source.

☐ The bottle neck of ray-tracing is object-ray intersection.

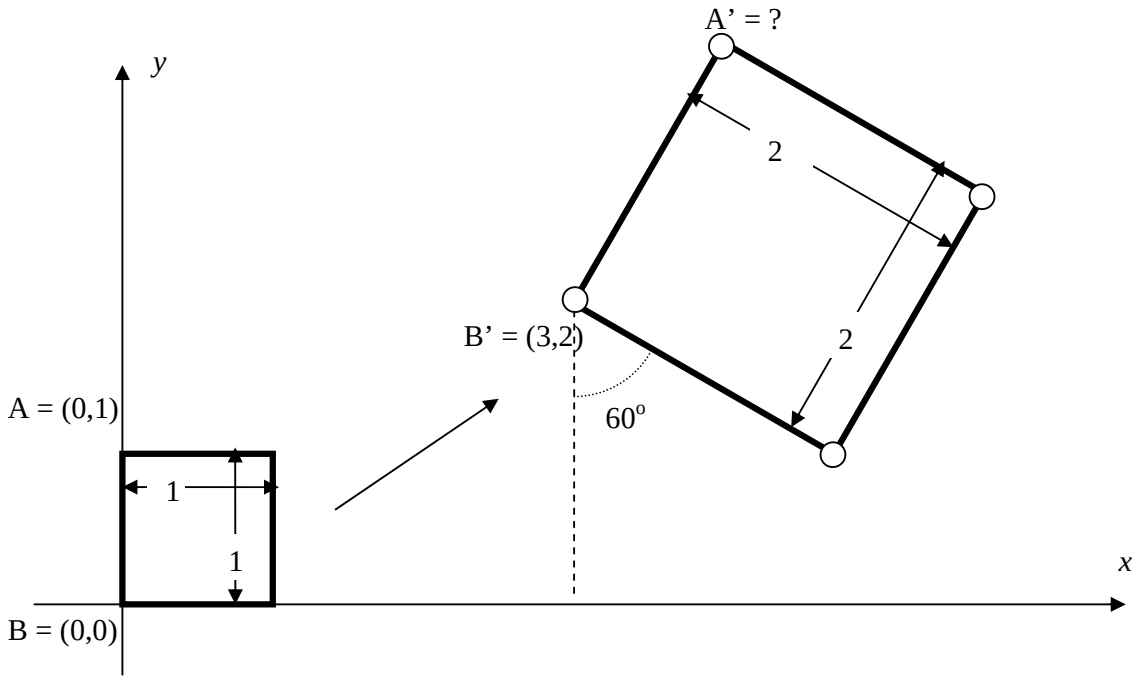
☐ Diffuse reflection is not viewer dependent.

Question 2 [8 marks]

The below diagram shows a complicated 2D transformation applied to a unit square.

a. The overall transformation can be described in terms of a number of simpler transformations. Describe each of these simple transformations and write them down in OpenGL code. Note that the order of the transformation is important. Assuming the function drawAUnitSquare() will do the job of drawing a unit square (the left one) as shown in the diagram.

b. Calculate the coordinate of A' after transformation.




```
void myDisplay()
{

     // Assumming the color buffer is cleared, the correct
     // model matrix is selected, etc..

     glLoadIdentity();









     drawAUnitSquare();
}
```

Question 2 (Cont.)

Question 3 [5 marks]

Please describe one or two special techniques used in modeling the following objects/phenomena (1 mark for each correct technique, maximum 5 marks):

a. A piece of newspaper

b. The scales of a fish (when they are on the fish)

c. The trajectory of a flying homing missile in the sky.

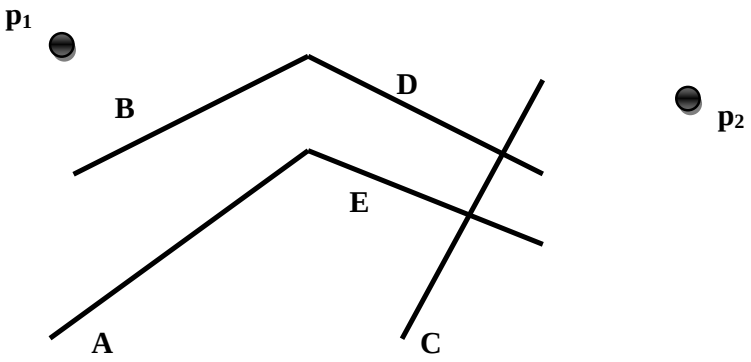
d. The thousands of audience sitting in the stadium in a real time football video game

Question 4 Tree [8 marks]

The following FIVE lines are the cross sections of five polygons in a 3D space.

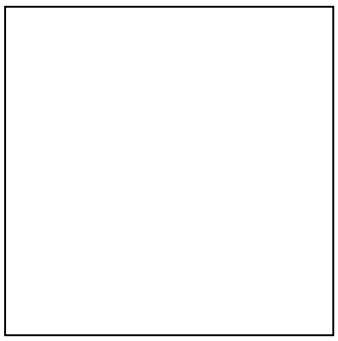
a) Construct their BSP tree according to the priority A > B > C > D > E.
b) Give the order of polygons to be drawn from the viewpoints p_1 and p_2

(Use dash lines in the diagram to help AND show your construction)

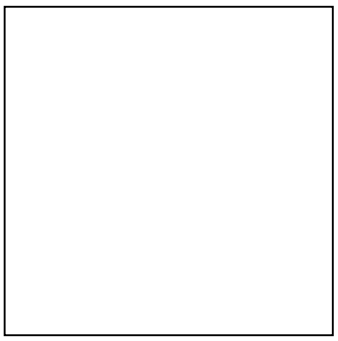


Question 5 [4 marks]

A stage is set by a square (a single polygon) on the *xz*-plane with y=0. The four corners of the squares are (-10, 0, -10), (-10, 0, 10), (10, 0, 10) and (10, 0, -10) . A white spot light (the only lighting, and all ambient lights are set to be 0) is set up at the position (0,5,0) with a direction downwards (0, -1, 0) and cut off angle 45 degree. We just want the spot light to be a simple circle and that is why we set the spotlight exponent to be $n = 0$. Briefly draw what the highlight of the stage by using Gouraud and Phong shadings separately. The squares below are the stage squares.



Gouraud Shading



Phong Shading

Question 6 [5 marks]

A student wants to draw a unit sphere (with radius 1) centered at the origin with OpenGL. He set the viewing as following:

```
glMatrixMode(GL_MODELVIEW);
gluLookAt( 10, 10, 10, 0, 0, 0, 0, 0, 1);
glMatrixMode(GL_PROJECTION);
glLoadIdentity();
gluPerspective(45,1.0,1.0,10.0 );
```

Can he see the sphere? Give explanation to support your “yes” or “no”. If it’s a “yes”, draw and explain why the sphere can be seen. If it is a “no”, give the best and minimal correction to the code so that he can see the sphere.

Question 7 [4 marks]

Given three control points p_0, p_1, and p_2 and the Bezier equation:

$$p(t) = \sum_{i=0}^{2} b_{2,i}(t)\, p_i \qquad\qquad b_{2,i}(t) = \binom{2}{i}(1-t)^{2-i} t^i$$

a) Compute the differentiation $p'(t)$ of $p(t)$
b) Compute $p'(0)$ and $p'(1)$

Question 8 [7 marks]

There are four spheres in the space with centers A:(0,4,7), B:(0,1,-10), and C:(0,2,8) and D:(0, 1 13). They all have the same radius of 2 units. A ray starts tracing from the eye which is at the point, (0,1,0) with direction (0,0,1). Compute all the intersections of the ray with the spheres and their "*t*" values. Which is the first sphere that is hit by the ray? Explain your answers.

- END OF PAPER -