CPSC 314, Written Homework 4

Out: Wed 30 Mar 2016
Due: Wed 06 Apr 2016 2pm (hand in at start of lecture)
No homework accepted after Fri 08 Apr 2pm
Value: 4% of final grade
Total Points: 100

Name: _____

Student Number: _____

$Q1$	$/8$
$Q2$	$/6$
$Q3$	$/4$
$Q4$	$/20$
$Q5$	$/24$
$Q6$	$/22$
$Q7$	$/16$
$Total$	$/100$

Please check one of the following:

☐ I did not collaborate with anyone in the completion of this homework.
☐ I collaborated with people named below in the completion of this problem set:

Name: _____ Student Number: _____

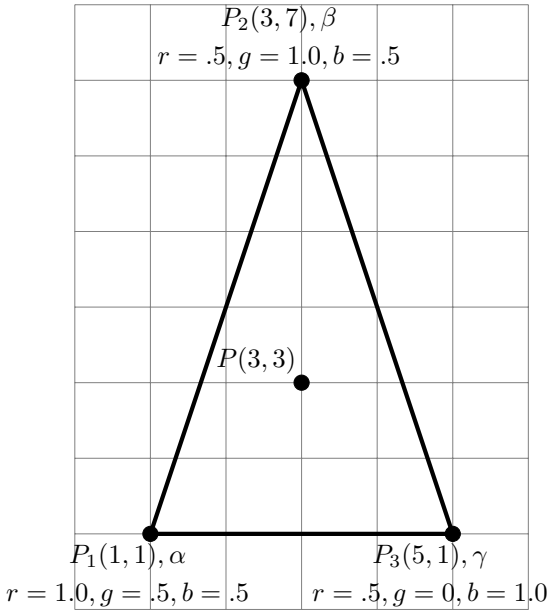
Name: _____ Student Number: _____

Name: _____ Student Number: _____

Interpolation (14 pts)

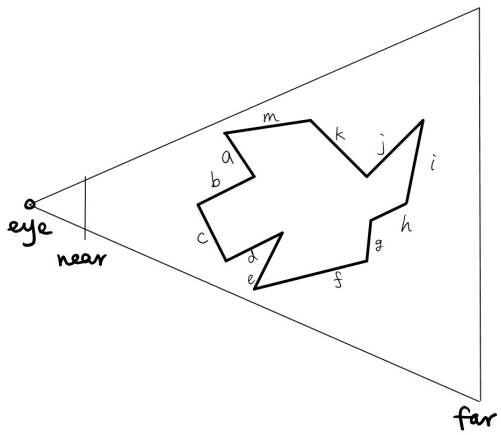
1. (8 pts) For the following triangle, given coordinates and color components of P_1, P_2 and P_3, use bi-linear interpolation to find the (r, g, b) color components at that point P. Show your work.

2. (6 pts) For the same triangle, find the barycentric coordinates α, β, and γ for P, and use them to interpolate the (r, g, b) color components at that point. Show your work.



Visibility

3. (4 pts) For the following 2D scene, an eye point is given with respect to an object formed by line segments. Which faces would be removed for the given eyepoint if backface culling were used? Show your work by drawing in the normals for each face.



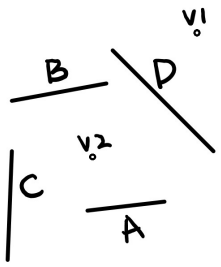
4. (20 pts) You have bought a very cheap graphics card, which has a Z buffer of only 3 bits. You can thus only determine the visibility relationships of objects in your scene at a very coarse resolution: there are only $2^3 = 8$ bins available. These bins are represented as the base-10 integers 0 through 7. You should assume that the general GL perspective matrix was used for projection, with the near plane set to $z = -.1$ and the far plane set to $z = -80$.

   a) Give the z-values of the planes forming the boundaries of these bins in DCS, the display coordinate system (which ranges from 0.0 at the near plane to 1.0 at the far plane). That is, what is the value of the plane between bin 0 and bin 1, between bin 1 and bin 2, and so on.

   b) Give the z-values of the planes in the camera coordinate system.

   c) Explain why this graphic card might be very bad in terms of depth test.

5. (24 pts) Build a BSP tree for the following scene using the polygons (shown as line segments). The cutting plane induced by a polygon should just extend along the line itself. The labelled side of the polygon should be the right child in the tree, and the unlabelled side should be the left child. If a polygon X gets split, name the split polygons as X_1 and X_2 with X_1 vertically on top of X_2 in the scene.



   a) Give the BSP tree with the single root node of polygon A, and sketch the entire scene with the addition of the new cutting plane.

   b) Same as above, building on the previous answer, after adding polygon B.

   c) Same as above, building on the previous answer, after adding polygon C.

   d) Same as above, building on the previous answer, after adding polygon D.

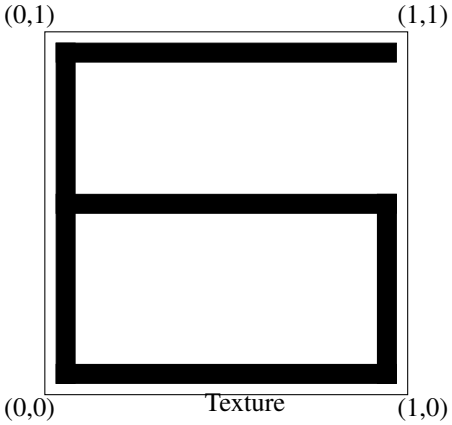
   e) Traverse your BSP tree to produce a painter's algorithm ordering from eye point V_1. Show your work at each step in the traversal, starting from the root of the BSP tree.

   f) Same as above, instead using eye point V_2.

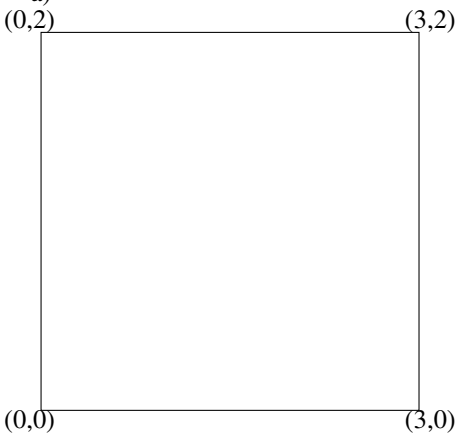
Textures (22 pts)

6. Texture Mapping

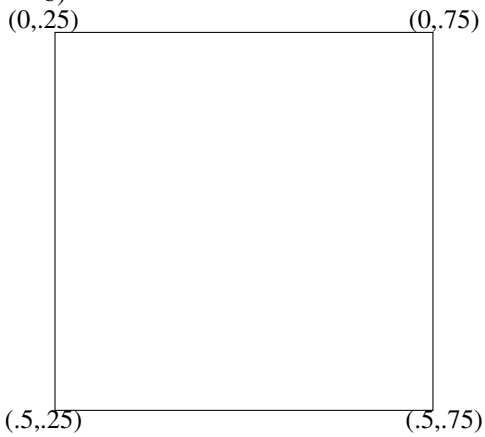
a) (20 pts) In the following figure, sketch the texture (top) as it would appear in each of the rectangles with the specified texture coordinates. Assume the texture mode is GL_REPEAT.



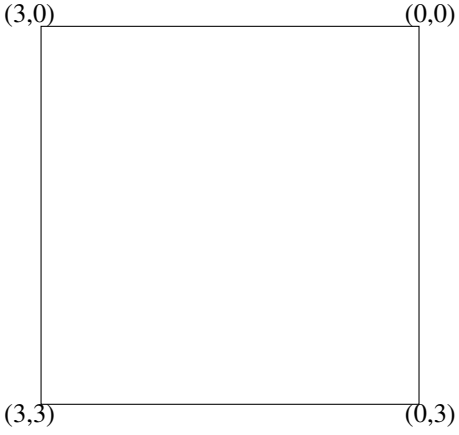
a)



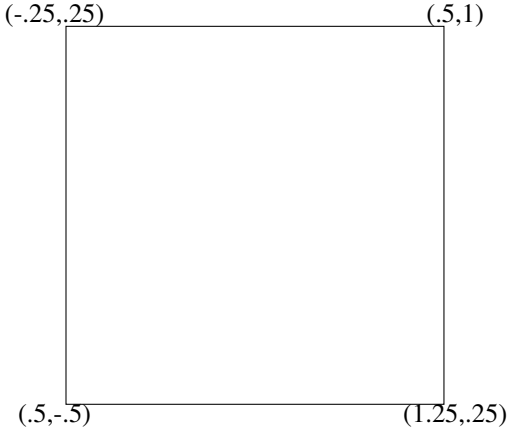
b)



c)



d)



b) (2 pts) Storing texture MIPMAP requires _____% additional space.

Ray Tracing (16 pts)

7. A ray $R(t)$ begins at a known eyepoint $E = (1, 2, -1)$, and travels in a direction $V = (0, 0, -1)$ towards a given screen pixel. In the scene, there is a sphere of radius r = 5 centered at the point $(1, -1, -10)$.

   a) (2 pts) Give the parametric equation of the ray $R(t)$ in terms of parameter t.

   b) (8 pts) Decide whether this ray will intersect with the sphere in the scene or not. If intersect, compute the intersection point(s). Show your work.

   c) (6 pts) Suppose we have another ray $R'(t)$ begins at the same eyepoint E, and travels towards another screen pixel in a direction $V' = (3, -3, -13)$. After calculation, you find one of the intersection points with sphere to be $P' = (4, -1, -14)$. Compute the normal N' for the intersection point P'. Then decide whether the point P' is on the backside of the sphere from the eyepoint E.