Sln

CPSC 314
Midterm 2

November 19, 2014

Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page.

Name: Solutions

Student Number: _____

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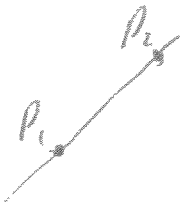
This exam has 7 questions, for a total of 47 points.

1. Lines and Barycentric Coordinates

(a) (4 points) Develop explicit, parametric, and implicit equations for a 2D line passing through points $P_1(x_1, y_1)$ and $P_2(x_2, y_2)$.



Explicit: $y = y_1 + \frac{(y_2 - y_1)}{(x_2 - x_1)}(x - x_1)$ (m) $\quad y = mx + b$

$= mx + (y_1 - mx_1)$ (b)

Parametric: $\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} x_1 \\ y_1 \end{bmatrix} + t\begin{bmatrix} x_2 - x_1 \\ y_2 - y_1 \end{bmatrix}$ equivalently $P(t) = P_1 + t(P_2 - P_1)$

Implicit: begin with the explicit form, move y to RHS

$F(x,y) = 0 = y_1 - y + \frac{(y_2 - y_1)}{(x_2 - x_1)}(x - x_1)$

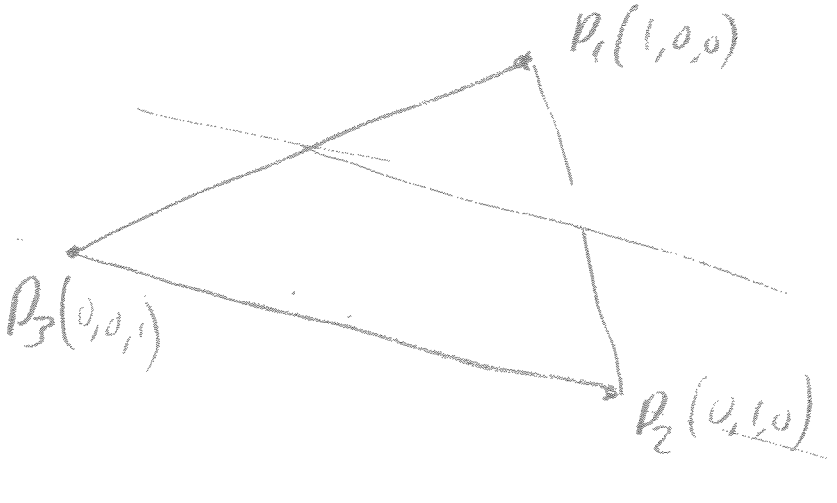
$0 = (y_1 - y)(x_2 - x_1) + (y_2 - y_1)(x - x_1)$

$= x(y_2 - y_1) + y(x_1 - x_2) + x_2y_1 - x_1y_1 + x_1y_1 - x_1y_2$

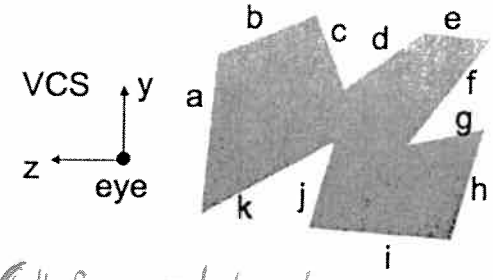
A B C

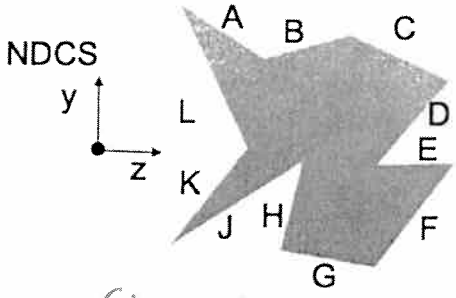
$0 = Ax + By + C$

(b) (4 points) Sketch a triangle with vertices P_1, P_2, P_3.
Suppose that barycentric coordinates are defined according to
$P(\alpha, \beta, \gamma) = \alpha P_1 + \beta P_2 + \gamma P_3$.
Label the vertices with their barycentric coordinates, i.e., $P(\alpha, \beta, \gamma)$.
Sketch and label the lines that correspond to $\alpha = 0$, $\alpha = 0.5$, and $\alpha = 1$.



2. (4 points) For the following scene, the polygons forming a closed solid object are represented by edges. Which faces would be removed by back-face culling, in the VCS and NDCS illustrations? Note that in NDCS the z-axis points towards the back of the scene, as illustrated below.

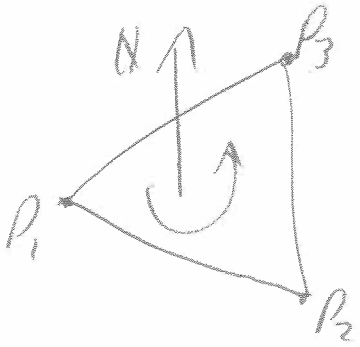




Cull if eye is below plane:
Therefore cull: b, c, e, f, h, i, k

Cull if $N_z > 0$, i.e., points away from viewer
Cull A, C, D, (E), F, J

3. (4 points) Show how to compute the implicit plane equation that embeds a triangle in 3D space, given its three vertices, P_1, P_2, and P_3. Ensure that the implicit equation returns a positive value for points that are *above* the plane. Assume that the vertices are specified in a counter-clockwise order when seen from *above*.



$\vec{N} = (P_2 - P_1) \times (P_3 - P_1)$

Normalize if desired, but not necessary.

$\text{Plane}(x,y,z) = 0 = N \cdot P + D$

Substitute in any point to compute D.

e.g., $0 = N \cdot P_1 + D$

$\Rightarrow D = -N \cdot P_1$

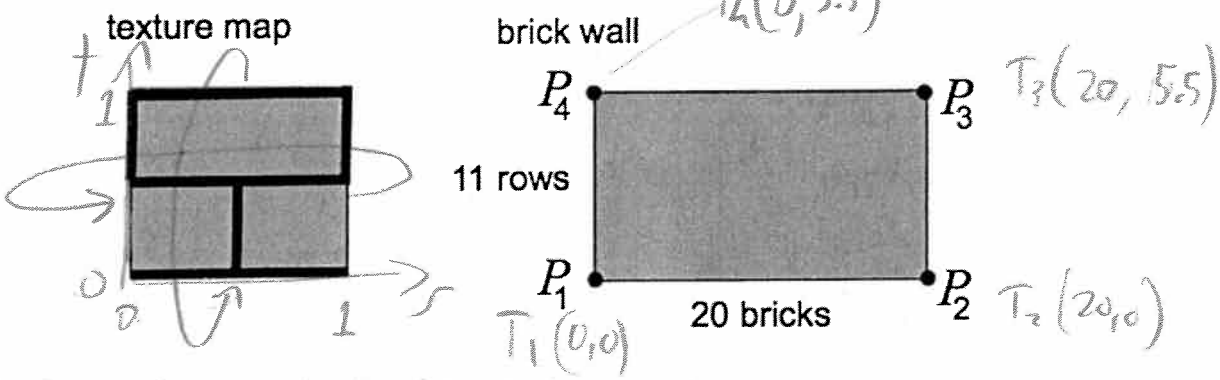
Final:

$F(P) = N \cdot P + D$

as above.

4. Texture Maps

(a) (4 points) Give the texture coordinates $T(s,t)$ to be associated with each of the four vertices of the polygon below, which should model a brick wall using the given brick texture. The brick wall should be 20 bricks wide and be 11 bricks tall, i.e., has 11 rows of bricks in the vertical direction. You can assume that repeat-mode texturing is enabled. Note that the brick texture contains two half-bricks in its bottom half, which will tile correctly once multiple copies of the texture are placed adjacent to each other. It is fine if the final brick wall has rows that start and end with these half-bricks.

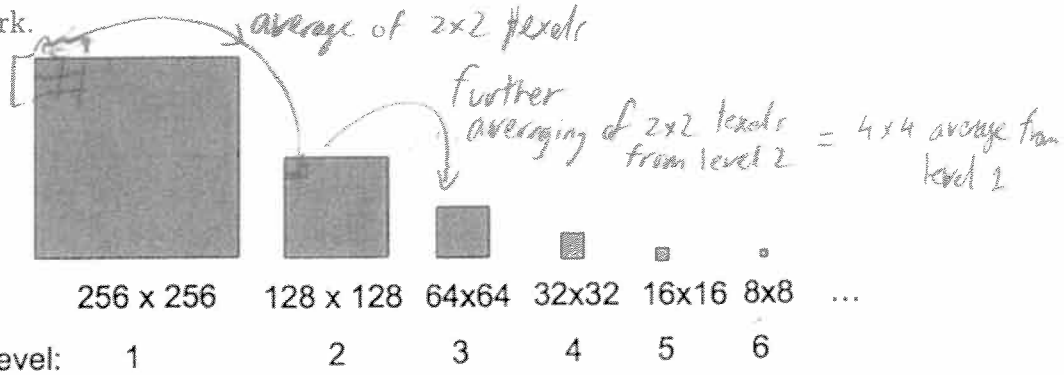


Walking off one of the edges of a texture map, e.g., $s > 1$ or $t > 1$, results in returning to other edge, as illustrated on the above texture map. Thus $s = 3.2$ is equivalent to $s = 3.2$, etc.

(b) (1 point) Storing texture MIPMAP requires 33 % additional space.

(c) (1 point) Minification describes how to handle the case when texels are: **larger** or **smaller** (circle one) than pixels.

(d) (2 points) Consider the following MIPMAP pyramid. If we choose to use the *nearest* MIPMAP level, which level is used for a pixel that covers 15 texels? Show your work.



5. Shaders

(a) (6 points) For each of the following computations or steps, indicate where the computation typically happens by circling one of: VS (vertex shader); FS (fragment shader); FF (fixed function).
Use your experience from Assignment 2 to help with this, i.e., things that you have not implemented in shaders are probably part of the fixed function pipeline.

ModelView transform	**VS** FS FF
/ h	VS FS **FF**
Projection transform	**VS** FS FF
Viewport transform	VS FS **FF**
texture map lookup	VS **FS** FF
z-buffer test	VS FS **FF**
clipping	VS FS **FF**
culling	VS FS **FF**
assigning fragment color	VS **FS** FF
lighting computation	**VS** **FS** FF either, depending on per-vertex or per-pixel lighting.
fog computation	VS **FS** FF
transforming vertex normals	**VS** FS FF
perspective correct interpolation	VS FS **FF**

(b) (2 points) What is the purpose of `attribute` variables? Give examples of two common uses. These store vertex information. "Vertex attributes" would be a better name. Typical vertex attributes include: position, normal, texture coordinates.

(c) (2 points) What is the purpose of `varying` variables? Give examples of two common uses. Varying variables are interpolated across the triangles in a perspective-correct way. The vertex shader assigns their value for the vertices. The fragment shader sees the interpolated result as an input, for every pixel.

(d) (2 points) What is the purpose of `uniform` variables? Give examples of two common uses. Uniform variables allow other parameters to be passed to vertex or fragment shaders. These would not change for each vertex (the way attributes do) or for each fragement/pixel, (as varyings do).

(e) (2 points) What would be the benefit of having the z-buffer test **before** the fragment shader? **After** the fragment shader?

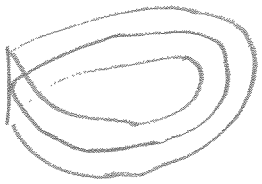
before: avoids wasting time on a fragment shader computation that might then fail the z-buffer test and then be discarded.
after: lets the fragment shader customize the z-value computation if desired

6. Guest Lectures

(a) (2 points) Give an example of what can be done with the *Vector Graphics Complex* that cannot be done with current vector graphics modeling tools, such as Adobe Illustrator.

The vector graphics complex properly models the topology, i.e., connectivity, of drawings.

(b) (1 point) What results after cutting a mobius strip along it's center line?



⇒ a single loop results, (with a full twist)

(c) (2 points) Briefly describe the key idea(s) behind the water simulation described by Prof. Robert Bridson.

Wave equations at multiple frequencies are a good simplified model of fluid dynamics.

(d) (2 points) When is visualization needed or suitable, as described by Prof. Tamara Munzner? Give an example of its use in biology.

Visualization methods are particularly useful when trying to understand complex data and it is not clear what questions need to be asked of the data. Examples include the biological tree visualizer, understanding gene regulatory networks, and similarities between genomic features.

7. (2 points) Give a topic (or topics) that you would like to see briefly covered in the last class. This could be a review topic, an aspect of graphics that we have not yet covered, or a "common practice in industry" question.

(open)