Name: Student ID:

CS174A – Introduction to Computer Graphics
MIDTERM EXAM FALL 2020
NOV 5, 2020

1. Displays & Framebuffers

a. (5 points) What is meant by rasterization (or scan conversion) of a line?

b. (5 points) What are the 2 factors to consider while determining an algorithm for scan converting lines or polygons in CG?

Here are some specs for the recently released iPhone 12:

The iPhone 12 features a resolution of 2532-by-1170 pixels, but perhaps even more notably, it uses OLED display technology. This means you get improved colors and deeper blacks on the iPhone 12, alongside a wider dynamic range, a higher contrast ratio, and HDR support. Let's assume its display uses 8-bits/color RGB (actually it uses wide color P3 display), refreshed at 60 Hz.

c. (5 points) For iPhone 12, how much data is read (in bytes) from the frame-buffer per second? Assume non-interlaced display. No need to multiply the numbers, just the expression will be sufficient.

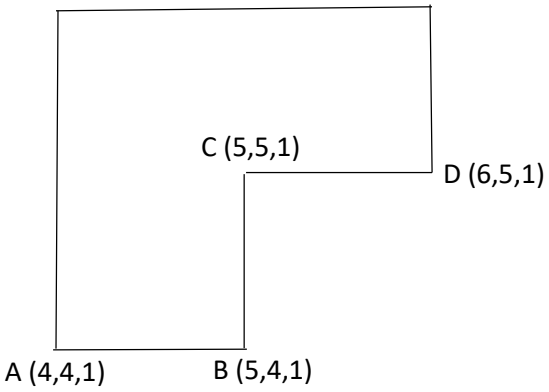
Name: Student ID:

2. Vectors & Matrices

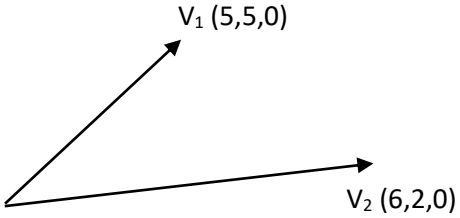
a. (9 points) Using cross product between first 3 vertices A, B, and C, find the equation of the plane in which the polygon lies.

b. (6 points) For the given 2 vectors (V_1 and V_2), determine the length of the perpendicular projection of V_1 onto the direction of V_2.

(a)



(b)



Name: Student ID:

3. Tessellation

- **a.** (4 points) What is meant by tessellating a 3D object?
- **b.** (8 points) Write pseudo-code (8-10 lines) to tessellate a 2D circle into 16 triangles, with the center of the circle (0,0) as a common vertex for all 16 triangles, radius 10 units, stepping equally by angle. Your pseudo-code need not be at code-level, but should sufficiently describe all the steps needed to translate it into a program, e.g., initializations, what should be each step, what does your loop look like, what should be done in each iteration of the loop, what's needed to calculate coordinate for each vertex of each triangle, etc.
- **c.** (8 points) Write the indexed data structure (as was discussed in class) for the above tessellated circle in the first-quadrant only. No need to figure out exact values, just expressions will do.

Name: Student ID:

4. Transformations

a. (8 points) Find the resulting homogeneous matrix by first applying 3D translation with factors (1,1,1) and then rotation about z-axis by 90 degrees. Multiply the 2 transformation matrices to find the resulting matrix.

b. (8 points) Show by finding dot-products that the upper-left 3x3 sub-matrix of the resulting matrix is orthogonal.

c. (4 points) Write the inverse of the 3x3 orthogonal sub-matrix.

Name: Student ID:

5. Viewing

a. (5 points) What parameters are needed to form non-square perspective projection matrix?

b. (7 points) Prove (with the help of a diagram) that the pers projection of a 3D point (x,y,z) onto the plane z=d is given by $(\frac{x}{z}d, \frac{y}{z}d, d)$

c. (8 points) Mention what changes would you expect to see in the image with respect to the following changes in viewing parameters; assume all other params remain unchanged:

   i. Half-angle-of-view increases
   ii. Aspect ratio decreases
   iii. Eye point moves closer to COI
   iv. Top vector becomes upside down

Name: Student ID:

6. Projections and Viewing

- **a.** (5 points) What is canonical view volume? What are its dimensions (as discussed in class) and why do we need it?
- **b.** (5 points) What is the canonical parallel projection matrix used for mapping a point in eye space to a point in projection space, for a view volume (in eye space) given by $-W/2 \leq X \leq W/2$, $-H/2 \leq Y \leq H/2$, $N \leq Z \leq F$
- **c.** (BONUS: 5 points) For the 3D point (W/4, H/4, F/2), transform it to canonical space using matrix multiplication; convert it to Cartesian (or normal) form.

Name: Student ID:

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