CS 130, Final

Name: ____ ID: __________________

Read the entire exam before beginning. **Manage your time carefully.** This exam has 38 points; you need 34 to get full credit. Additional points are extra credit. 38 points $\rightarrow$ 3.0 min/point. 34 points $\rightarrow$ 3.5 min/point.

Problem 1 (2 points)

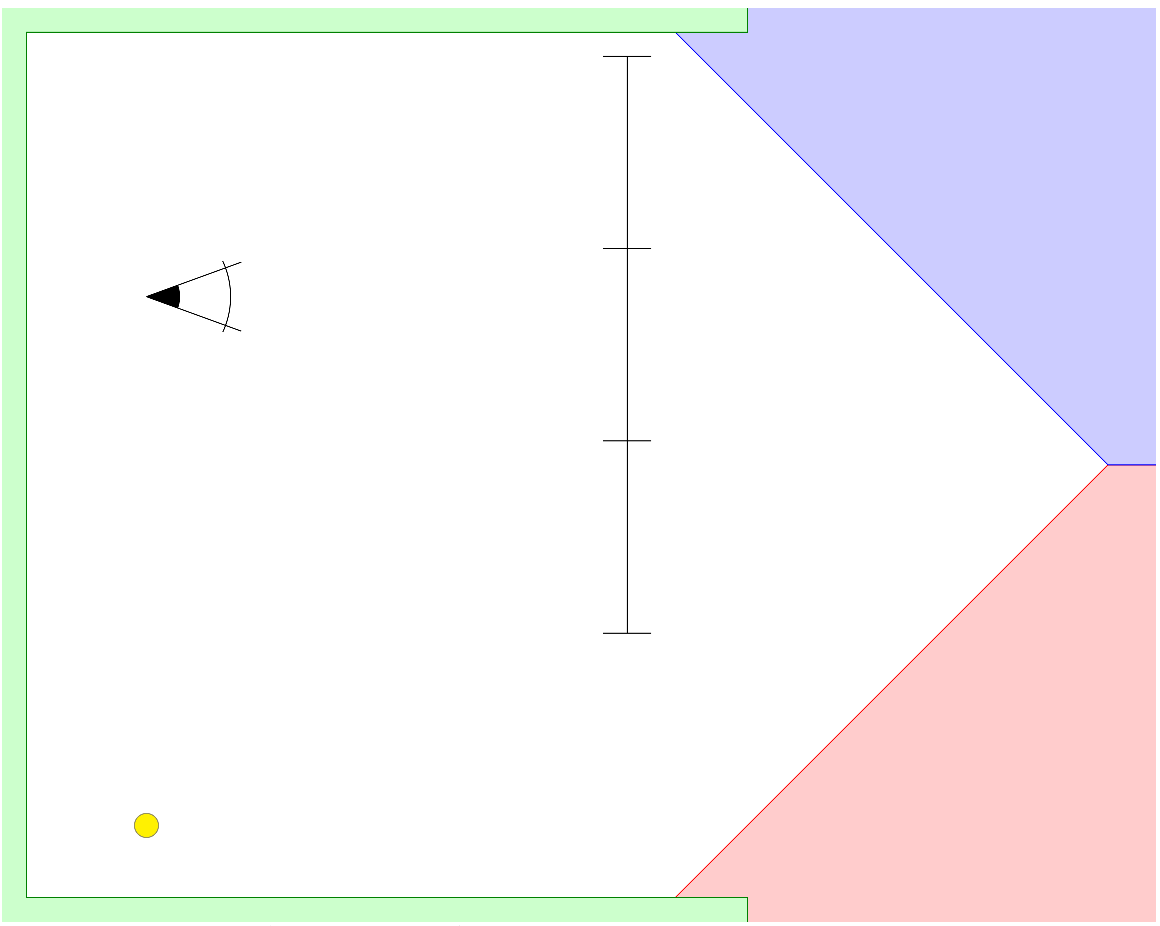
When working through 3D rotations, we defined a matrix $\mathbf{u}^*$ from a vector $\mathbf{u}$ such that matrix-vector multiplication was equivalent to cross product: $(\mathbf{u}^*)\mathbf{v} = \mathbf{u} \times \mathbf{v}$. Construct the matrix $\mathbf{u}^*$ explicitly from the components of $\mathbf{u} = \langle x, y, z \rangle$.

Problem 2 (2 points)

Given two vectors $\vec{u}$ and $\vec{w}$, construct a vector $\vec{q}$ orthogonal to both of them.

In the raytracing problems below, green objects are wood, red objects are reflective, and blue objects are transparent. The scenes are in 2D with a 1D image. yellow circles are point lights; the ray tracer supports shadows. Draw all of the rays that would be cast while raytracing each scene. Use a maximum recursion depth of 3. (Don't worry about precisely what counts as depth 3; I just care that recursion is being performed correctly when necessary and that important rays are not missing. There are no more than 30 rays in the "exact" solution.)

Problem 3 (5 points)



Problem 4 (2 points)

Let $\mathbf{z} = \mathbf{e} + t\mathbf{u}$, where $\mathbf{z}, \mathbf{e}, \mathbf{u}$ are vectors and are given to you. You may assume that $\mathbf{u}$ has been correctly normalized. Find t. *Be careful.*

Problem 5 (2 points)

What sort of activity might one perform in a fragment shader? Be specific.

Problem 6 (2 points)

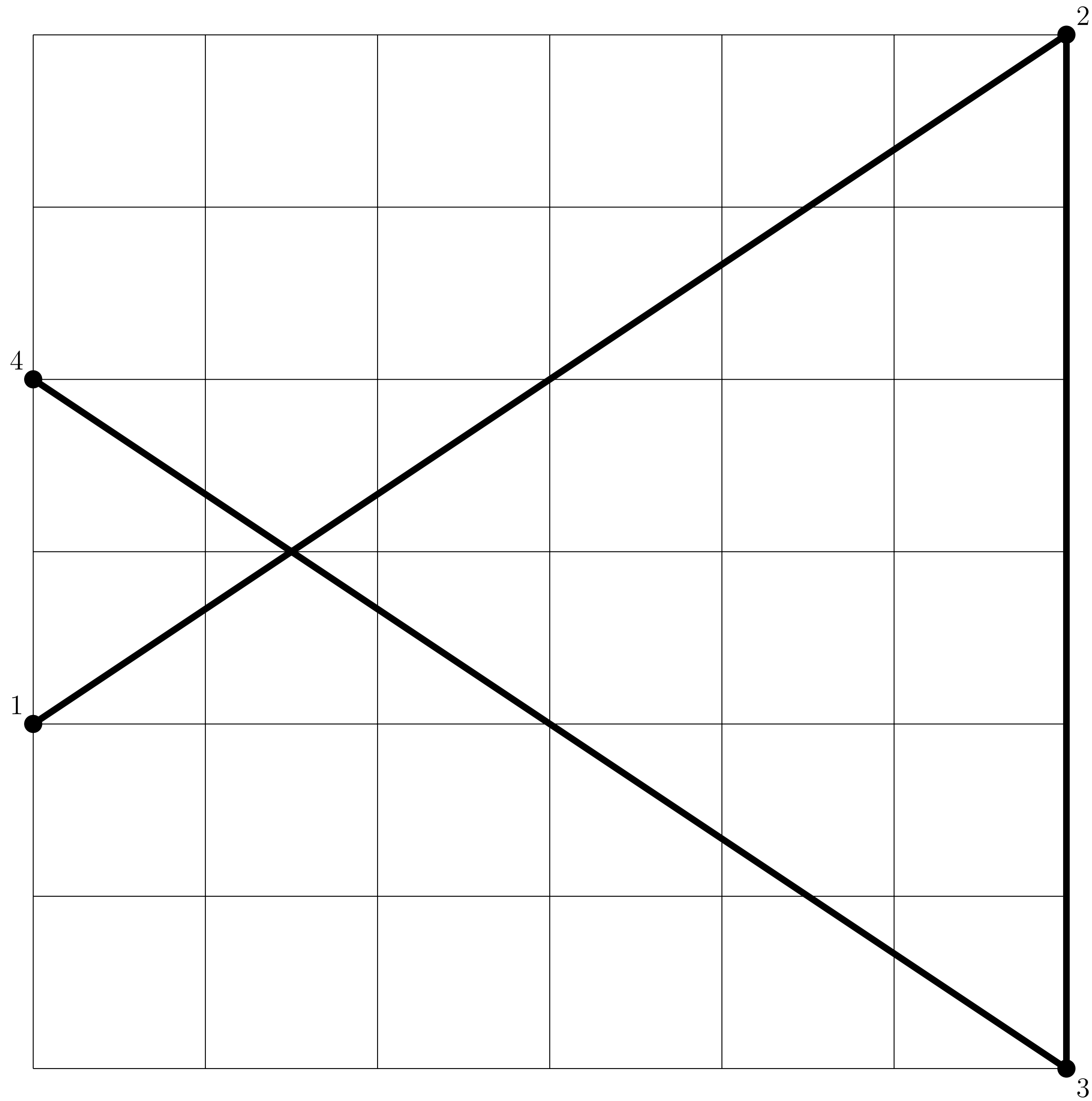
Why do we use red, green, and blue when producing images? Why not two or four colors instead of three? Why not a different set of three colors?

Problem 7 (2 points)

When working through 3D rotations, we defined a matrix $\mathbf{u}^*$ from a vector $\mathbf{u}$ such that matrix-vector multiplication was equivalent to cross product: $(\mathbf{u}^*)\mathbf{v} = \mathbf{u} \times \mathbf{v}$. Construct the matrix $\mathbf{u}^*$ explicitly from the components of $\mathbf{u} = \langle x, y, z \rangle$.

Problem 8 (3 points)

Geometrically subdivide the Bézier curve given by the control points below and at $t = 0.3$ along the curve. Label the new control points A, B, C, ..., G. (The two resulting Bézier curves should share their common point, so only 7 control points are required.)



Problem 9 (2 points)

Which of the following types of transformations benefit from the use of homogeneous coordinates? No explanation is necessary, but no partial credit is possible. (a) Translation, (b) uniform scale, (c) non-uniform scale, (d) rotation, (e) reflection, (f) perspective projection, (g) orthographic transformation.

Problem 10 (2 points)

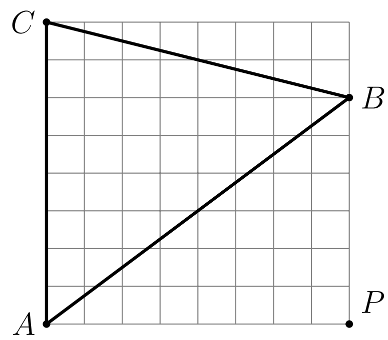
What is the *difference* between C^1 and G^1 continuity in the context of a car traveling down a road?

Problem 11 (2 points)

On the project, we discarded intersections closer than `small_t` when computing the closest intersection. Why?

Problem 12 (3 points)

Find the barycentric weights for the point P in the triangle below.



Problem 13 (2 points)

A surface (rather like a spiral staircase) is given by the parametric equations $x = r\cos\theta$, $y = r\sin\theta$, $z = \theta$. What is the normal direction at an arbitrary point on the surface? You may express your result as a function of (r, θ) or (x, y, z) as you prefer.

Problem 14 (3 points)

Construct a 3×3 matrix that performs each of the following 2D operations (in homogeneous coordinates). You may express it as the product of other matrices if you prefer.

(a) Rotate 45° counterclockwise about the origin.

(b) Translate 2 units in the positive x direction.

(c) Rotate 90° counterclockwise about the point $(1, 2)$.

Problem 15 (2 points)

The clipper tends to remove the significant majority of triangles. Since the vertex shader can be quite expensive, running the vertex shader after clipping could result in a significant performance boost. Nevertheless, this is never done. Why do we run the vertex shader before performing clipping?

Problem 16 (2 points)

Explain why (a) a flashlight shined on a nearby wall is much brighter than when shined on a far wall but (b) a laser pointer appears about the same brightness in both cases.