[Gr.G] The general graphics section (20 points)

Problem Gr.G-1. Color gamuts (7 points)

The gamut of a typical CRT, when drawn on a chromaticity diagram, does not intersect the locus of spectral colors. Why not?

Problem Gr.G-2. Antialiasing (8 points)

Discuss each of the following methods for reducing jaggedness in lines on a raster display. How effective or ineffective are they? How do they differ?

- **(a)** (2 points) The line is blurred by averaging together a rectangular block of pixels after the line is drawn.
- **(b)** (2 points) The line is drawn at higher resolution, and averaged down to the resolution of the display.
- **(c)** (2 points) The value of each pixel is set equal to the area of the line (assume it has width equal to the size of a pixel) intersecting the pixel.
- **(d)** (2 points) A random point within a pixel is chosen; the pixel is drawn if the random point lies on the line, otherwise it is not drawn.

Problem Gr.G-3. Perspective (5 points)

The point to which railroad tracks converge in a perspective image is called a vanishing point. How many vanishing points can be present in a single perspective image?

[Gr.S] The specialized graphics section (40 points)

Problem Gr.S-1. Gamma correction (8 points)

What effect does failure to gamma correct have on the chromaticity of colors in a graphics display? Sketch your answer on a chromaticity diagram and defend it.

Problem Gr.S-2. Sampling theory (15 points)

The jagged outlines of polygons or the staircased appearance of lines drawn on raster displays are annoying and undesirable artifacts of most polygon or line drawing algorithms.

(a) (5 points) What is "aliasing" and why or why not does it contribute to the jaggies?

(b) (5 points) What is "reconstruction" and why or why not does it contribute to the jaggies?

(c) (5 points) What is "quantization" and why or why not does it contribute to the jaggies?

Discuss each phenomena in both the spatial and frequency domains where applicable. Be specific to the cases of polygon edges and lines. Be brief.

Problem Gr.S-3. Global illumination (17 points)

We wish to help out the architects of the Gates Building by using distribution ray tracing to evaluate the illumination on the carpeted floor of a conference room due to a spotlight placed in the center of the ceiling. Let us approximate the spotlight as a circular disk of diameter d. Suppose that we render diffuse reflections by distributing m secondary rays independently and uniformly throughout the hemisphere over each point in the room.

(a) (6 points) Derive an expression giving the probability p of hitting the spotlight with at least one of the secondary rays emanating from a point x on the floor which is at a distance w away from the center of the floor. The height of the room is h. You may assume that h is large relative to d.

(b) (6 points) Where on the floor is the probability of completely missing the spotlight highest? Using the expression you derived in part (a), and assuming a square room 5 meters on a side and 2.5 meters high, a 10 cm diameter spotlight, and 50 secondary rays distributed uniformly throughout the hemisphere above this point, what is the probability of missing the spotlight?

(c) (6 points) Aside from casting more rays, how might you improve this probability?