Computer Graphics Comprehensive Exam

Computer Science Department
Stanford University
Fall 2000

NAME:

Note: This is exam is *open-book.*

The exam consists of 5 questions. Each question is worth 20 points. Please answer all the questions in the space provided, overflowing on to the back of the page if necessary.

You have 60 minutes to complete this exam.

A. The Honor Code is an undertaking of the students, individually and collectively:

(1) that they will not give or receive aid in examinations; that they will not give or receive unpermitted aid in class work, in the preparation of reports, or in any other work that is to be used by the instructor as the basis of grading;

(2) that they will do their share and take an active part in seeing to it that others as well as themselves uphold the spirit and letter of the Honor Code.

B. The faculty on its part manifests its confidence in the honor of its students by refraining from proctoring examinations and from taking unusual and unreasonable precautions to prevent the forms of dishonesty mentioned above. The faculty will also avoid, as far as practicable, academic procedures that create temptations to violate the Honor Code.

C. While the faculty alone has the right and obligation to set academic requirements, the students and faculty will work together to establish optimal conditions for honorable academic work.

By writing my "magic number" below, I certify that I acknowledge and accept the Honor Code.

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1. [Total: 25 points] Color.

1A. (5 points) Monitors and other display devices often use three color components, such as R, G and B. Lights, however, are described by their power spectra; that is the amount of power per unit wavelength interval. Why are only three color components sufficient to represent a given color?

1B. (5 points) Suppose two colored light sources are directed at the same spot on a perfectly reflective diffuse white wall. Derive the color components of the reflected light?

1C. (10 points) A colored filter such as a piece of cellophane may be characterized by its transmission spectrum. The transmission spectrum is defined to be the percentage of light (represented as a number between 0 and 1) passing through the filter per unit wavelength interval. Suppose two filters are stacked on top of each other and placed over an ideal white light with a flat spectrum (that is, the same amount of light energy is present at each wavelength). Derive the color of the transmitted light in terms of the spectra of the filters? How are the color components (RGB) of the transmitted light related to the color components of the filters?

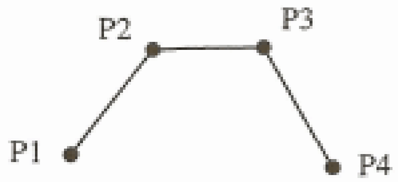
2. [Total: 20 points] Transformations.

2A. (10 points) Consider transforming a point in 2D. Derive a transformation matrix that corresponds to first rotating the point by 45 degree and then translating it by (1,1).

2B. (10 points) The above transformation may be executed in the reverse order. That is, by first translating and then rotating. Derive the amount of rotation and translation that must be applied to have the same effect as the sequence in 2A.

3. [Total: 20 points] Bezier curves.

3A. [10 points] Drawn below are four points P1, P2, P3, and P4 that can be used to define a cubic Bezier curve P(t). Describe an algorithm to evaluate point P(t) given t.



3B. (10 points) Suppose you wanted to find an intersection of a Bezier curve with a line. Describe a recursive algorithm that will find *all* the intersections of the curve with the line. What properties of the Bezier curve form the basis of your algorithm?

4. [Total: 20 points] Reflection models.

Consider reflection off a surface in 2D. By 2D we mean the surface is actually a curve segment all directions and points are in the plane (think flatland). There are several important directions: **L**, the direction to the light source; **E**, the direction to the eye; **H**, the half way vector between **L** and **E** (that is, the direction what would reflect **L** to **E**, and vice versa); and the normal **N**. Also, consider the reflection operator **R**(**D**,**N**) which reflects any direction **D** about the normal **N**. For the purposes of this problem, consider **L**, **E**, **H**, and **N** to have unit length.

4A. (5 points) Derive an expression for the reflection operator **R**(**D**,**N**) in terms of vector algebra.

4B. (15 points) There are two common reflection models used to model highlights, the Phong Model and the Blinn Model. The Phong Model uses $(\mathbf{R}(\mathbf{E},\mathbf{N}) \bullet \mathbf{L})^s$ and the Blinn Model uses $(\mathbf{H} \bullet \mathbf{L})^s$. What is the geometric interpretation of these particular dot products? And, hence, what is the difference in the shape of the highlights between the Phong and Blinn Models.

5. [Total: 20 points] Ray Tracing.

Consider ray tracing in 2D. Derive an equation for the intersection of a ray in 2D with an ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$.

SCORES:

1. Color (20)

2. Transformations (20)

3. Bezier curves (20)

4. Reflection models (20)

5. Ray Tracing (20)

TOTAL SCORE :