NAME:

Computer Science 426 Midterm
4/29/10, 1:30PM-2:50PM

This test is 5 questions. Do all of your work on these pages (use the back for scratch space), giving the answer in the space provided. This is a closed-book exam -- you may use one-page of notes with writing on both sides during the exam. **Please write out and sign the Honor Code pledge before turning in the test.**

``I pledge my honor that I have not violated the Honor Code during this examination."

Question	Score
1	
2	
3	
4	
5	
Total	

Q1: Illumination (20 Points)

A) [4pts] Please circle True or False for each of the following statements:

True False : Diffuse lighting can be computed without knowing the camera location.

True False : Ambient lighting is an approximation meant to model the effect of diffuse inter-reflections between objects in a scene.

True False : The Phong illumination model accurately calculates the reflection of a material based on the reflections and shadows of tiny microfacets that make up its surface.

True False : The computation required for illumination calculations dominates the time required to render an image with your ray tracer from assignment #3.

B) [2pts] A bidirectional reflectance distribution function has four degrees of freedom. Please describe them with a phrase or two and show them with a picture.

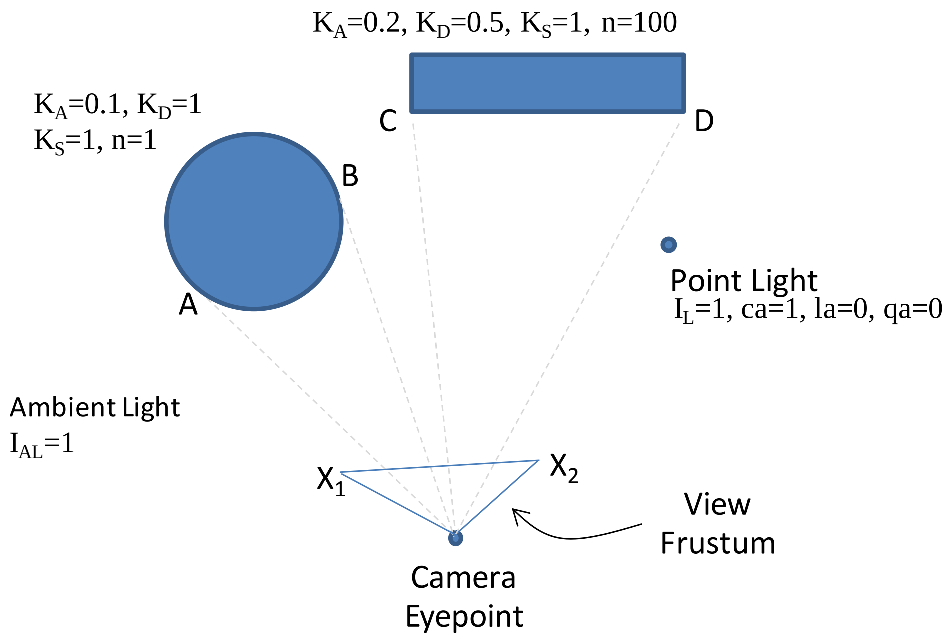
C) [6pts] Computation of the radiance leaving a point on a surface as a result of reflection of light from an area light source is an integration of a function.

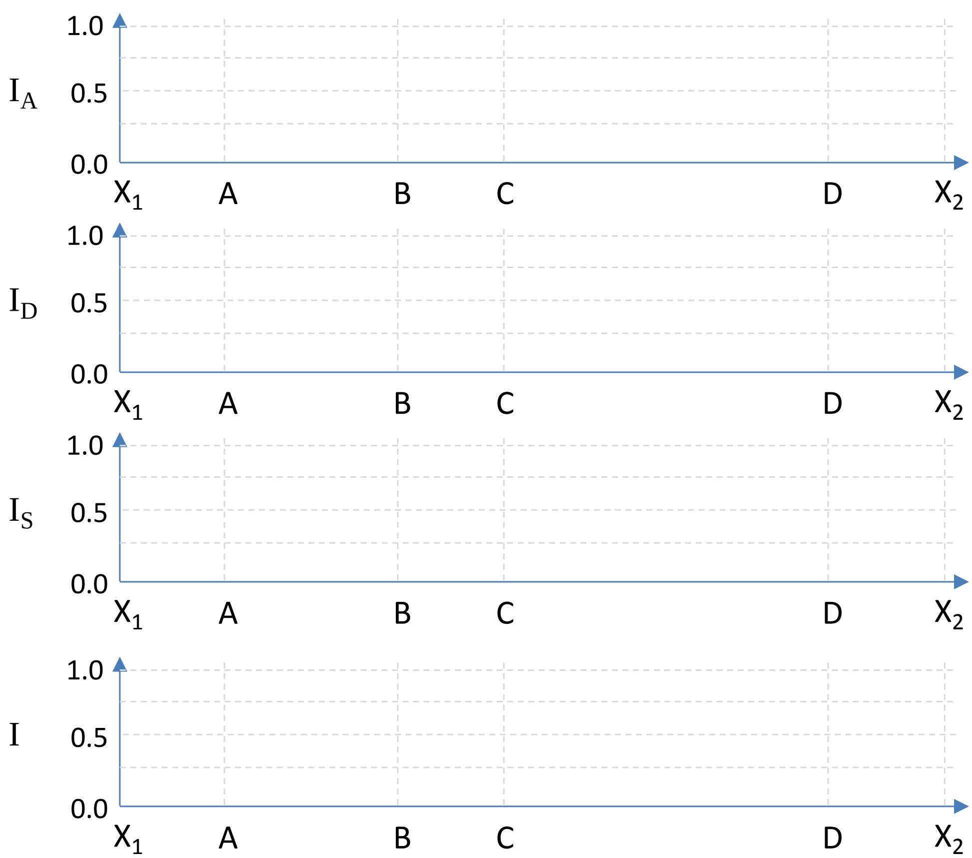
What is the domain of the function (one phrase)?

What is the function (one phrase or equation)?

What makes the integration particularly expensive to compute (one sentence supported by a simple picture)?

D) [8pts] Consider the 1D image that would be rendered with the Phong illumination model for the scene shown below. The scene has two geometric primitives (box and sphere), two light sources (ambient and point), and a camera. Relevant properties are listed next to each scene element. Please sketch a 1D curve on each of the axes below showing the contribution to the image of ambient illumination (I_A), diffuse illumination (I_D), specular illumination (I_S), and the overall final rendered image (I).





Q2: Polygon Rendering Pipeline (20 Points)

A) [4pts] Please circle True or False for each of the following statements:

True False : Parallel projections always preserve lengths.

True False : Perspective projections always preserve angles.

True False : Visible surface determination with the Z-buffer algorithm can create jaggy edges.

True False : Today's graphics hardware (GPU) has a hard-wired pipeline of processors to implement stages of the polygon rendering pipeline and cannot be used for any other type of computation.

B) [4pts] What is the time complexity (in big O notation -- e.g., O(N)) of rendering a scene with N fully visible triangles into an image with P pixels using the *triangle rendering pipeline* described in class (with z-buffering) assuming that Gouraud shading is used and every illumination calculation takes L time? Please provide a detailed justification for your answer, breaking down your analysis by steps of the algorithm.

C) [2pts] Please describe a scene in which rendering with Gouraud shading is *faster* than ray casting, assuming that the same CPU is used in both cases (one sentence).

D) [2pts] Please describe a scene in which rendering with Gouraud shading is *slower* than ray casting, assuming that the same CPU is used in both cases (one sentence).

E) [8pts] The transformation stages of the triangle rendering pipeline are shown below. Please write values for the vertex coordinates passed between these stages next to every arrow in the pipeline when it renders the triangle described below with the prescribed viewing parameters (assume that the xfov and yfov are half-angles).

Triangle: vertex1=(-1,-1,-1), vertex2=(0,-1,-1), vertex3=(-1,0,-1)
Modeling transformation: Translate by (1, 1, 1)
Camera : eyepoint = (0, 0, 1), towards = (0, 0, -1), up = (0, 1, 0), xfov=45, yfov=45
Image viewport: bottom-left=(100,100), top-right=(200,200)

Q3: Global Illumination (20 Points)

Consider the rendering equation written below .

$$L_o(x', \vec{\omega}') = L_e(x', \vec{\omega}') + \int_\Omega f_r(x', \vec{\omega}, \vec{\omega}')(\vec{\omega} \bullet \vec{n}) L_i(x', \vec{\omega}) d\vec{\omega}$$

A) [8pts] Please provide a description of each of the following terms: (one phrase each)

$L_o(x', \vec{\omega}') =$

$L_e(x', \vec{\omega}') =$

$f_r(x', \vec{\omega}, \vec{\omega}') =$

$(\vec{\omega} \bullet \vec{n}) =$

$L_i(x', \vec{\omega}) =$

$d\vec{\omega} =$

$\Omega =$

B) [2pts] Please explain wheter/how the **polygon rendering pipeline** (as described in class) provides an approximation to this integration (one sentence).

C) [2pts] Please describe a scene for which the **polygon rendering pipeline** (as described in class) is a good approximation (one sentence with a sketch including a light and camera).

D) [2pts] Please explain whether/how **recursive ray tracing** (as implemented in assignment #3) provides an approximation to this integration (one sentence).

E) [2pts] Please describe a scene for which **recursive ray tracing** (as implemented in assignment #3) is a good approximation
(one sentence with a sketch including a light and camera).

F) [2pts] Please explain whether/how **distributed ray tracing** provides an approximation to this integration (one sentence).

G) [2pts] Please describe a scene for which **distributed ray tracing** is a good approximation
(one sentence with a sketch including a light and camera).

Q4: Shading and Textures (20 Points)

A) [4pts] Please circle True or False for each of the following statements:

True False : Texture mapping is often used to increase the visual complexity of a scene without adding geometric primitives.

True False : The mapping from a texture coordinate system to the image coordinate system of the screen is usually a linear transformation.

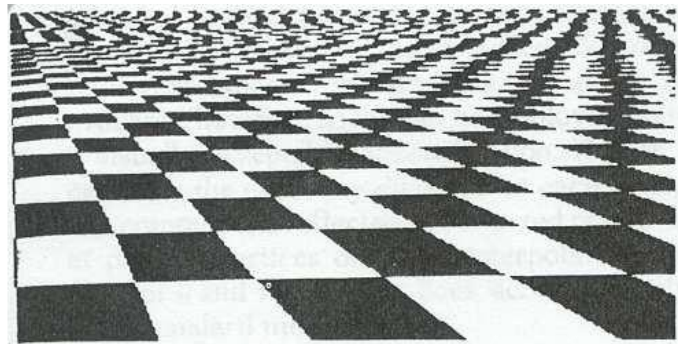
True False : Phong shading would be better than Flat shading for rendering a triangle mesh of a teapot.

True False : Illumination calculations are performed at three positions per triangle in Phong shading.

B) [4pts] What does it mean to "parameterize" a surface (for the purpose of applying a texture)?

C) [4pts] Please explain how the sweep-line algorithm for scan conversion (as described in class) takes advantage of spatial coherence in the Y dimension. (One or two sentences supported by a picture)

D) [8pts] After Princeton, you accept a job at Acme Rendering Inc. and your first task is to fix their texture mapping implementation. Currently when they render a checkerboard pattern onto a flat polygon it produces the image to the right.



What is the problem?

What is your suggested solution?

Please describe a data structure that you could compute once for each texture image (rather than once per frame or once per pixel) to help accelerate your solution.

Q5: Animation (20 Points)

A) [2pts] What is the basic difference between dynamics and kinematics? (one sentence)

B) [2pts] What is the basic difference between forward kinematics and inverse kinematics? (one sentence)

C) [2pts] What are space-time constraints? (one sentence)

D) [4pts] Please list at least four inputs that would be required of a user to specify a single hop for Luxo Jr. using space-time constraints that would not be required by keyframe animation. (list of four phrases)

E) [2pts] Under what conditions are space-time constraints more useful than keyframe animation? (one or two sentences)

F) [4pts] Please draw a biomechanical model that could be used to animate the dynamics of a tadpole in 2D. Please label the degrees of freedom controllable during an active dynamics simulation (labeled drawing)

G) [4pts] Please describe a plausible way to build a controller that will enable your biomechanical model to swim with a physical simulation of forces in water. (a few sentences)