COS 426, Spring 2011
Exam 2

Name:

NetID:

Honor Code pledge:

Signature:

This exam consists of 4 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, but you may use one page of notes during the exam. **Put your NetID on every page, and 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	
Total	

1. Rendering roundup (18 points)

Which of the following rendering methods:

RT: Basic Ray Tracing
PT: Monte Carlo Path Tracing
Rad: Radiosity
Ras: Rasterization as in OpenGL

have each of the following properties? Choose *one or more* correct answers for each.

- Usually fastest for scenes with low to moderate polygon count:
- Fastest for a model with a huge number of polygons, but covering a tiny part of the screen:
- Can simulate mirror reflection on arbitrary scene objects:
- Can accurately render surfaces not illuminated by direct light:
- Can render partially-transparent materials (with or without refraction):
- Can simulate refraction:

2. Illumination (22 points)

Consider a ray tracer that implements the (local) illumination model with which we have been working:

$$I_E + K_A I_A + K_D(N \cdot L)I_L + K_S(V \cdot R)^n I_L$$

For each quantity in this equation, state whether its value depends on:

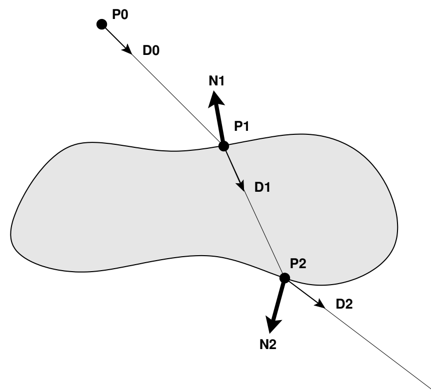
G: Surface geometry (shape)
M: Surface material
L: Property (including position) of a specific light source
I: Approximation of indirect illumination in scene
D: Ray direction
C: Coordinates of ray/surface intersection
S: Result of casting one or more new rays

Choose *one or more* correct answers for each.

- I_E:
- K_A:
- I_A:
- K_D:
- N:
- L:
- I_L:
- K_S:
- V:
- R:
- n:

3. Refraction (30 points)

Consider a recursive sequence of rays being traced through a glass object. (Index of refraction is $\eta_{glass} = 1.5$ in glass and $\eta_{air} = 1$ in air.) The original ray began at point P_0 with direction D_0, and hit the surface at P_1.



a) What is the direction D_1 of the secondary transmissive (refracted) ray? Show the derivation from Snell's Law: $\eta_1 \sin\theta_1 = \eta_2 \sin\theta_2$.

b) How would you test whether a light source at position P_L should be used in the lighting equation at P_1? (Give the origin and direction of any additional rays you cast, and/or the expression for any back-facing tests you do.)

c) How would your answers to questions (a) and (b) be different for the intersection found at P_2? (Hint: it is not always sufficient to change indices on the previous equations.)

4. Dynamics (30 points)

Consider simulating a 1-dimensional mass-spring system, with a particle of mass 1 attached to a frictionless spring with rest length 0 and spring constant 1. The other end of the spring is fixed at $x = 0$. The initial conditions are:

Initial position $x_0 = 1$
Initial velocity $v_0 = 0$

a) Write down the forces on the particle, as well as the position and velocity after each of three iterations of Euler's method with a time step of $\Delta t = {}^1/_2$. Please write all results as fractions rather than decimals.

b) What is the total energy in the system at each time step? Recall that kinetic energy $KE = {}^1/_2 mv^2$ while a spring's potential energy $PE = {}^1/_2 k(l - l_0)^2$.

c) Now simulate three iterations of a different method, in which the *new, updated* velocity is used to compute the position at each timestep, rather than the velocity from the previous timestep. (This is a special case of the "leapfrog" method for solving ODEs.) Comment on the expected stability of the two solution methods for simulating mass-spring systems.