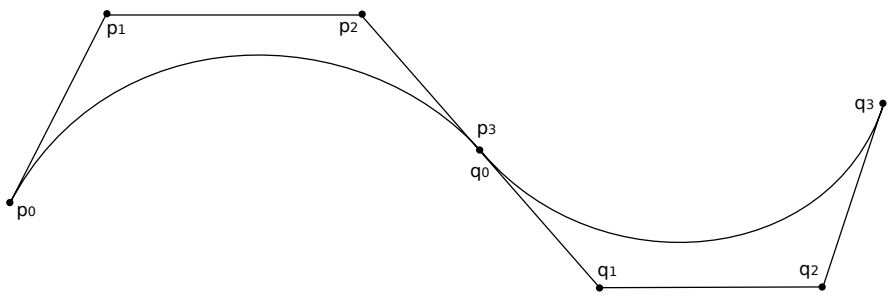
Name: _____

CS 354 **Second Exam** **Spring 2009**

DIRECTIONS: Work on these sheets (both sides, if needed) only — **do not turn in any supplementary sheets of paper**. There is plenty of room for your answers. This is an open book, open notes exam.

Each problem is worth the indicated number of points.

1. (20 pts) You are given a composite curve comprising two cubic Bézier curves as shown below. They are arranged so as to provide C^1 continuity.



   (a) Are they G^1 as well? Are they C^0? Are they G^0? In each case, explain why or why not.

   (b) Suppose the shared endpoint of the two curve segments is fixed and you move point q_1 by -10 units in x and -2 units in y. What do you have to do to maintain C^1 continuity? Be specific, with numbers.

   (c) Suppose the internal control points can only move if explicitly dragged by the user, but the end control points can be moved at will. If you do the same move of q_1 described above, now what will you have to do to maintain C^1 continuity?

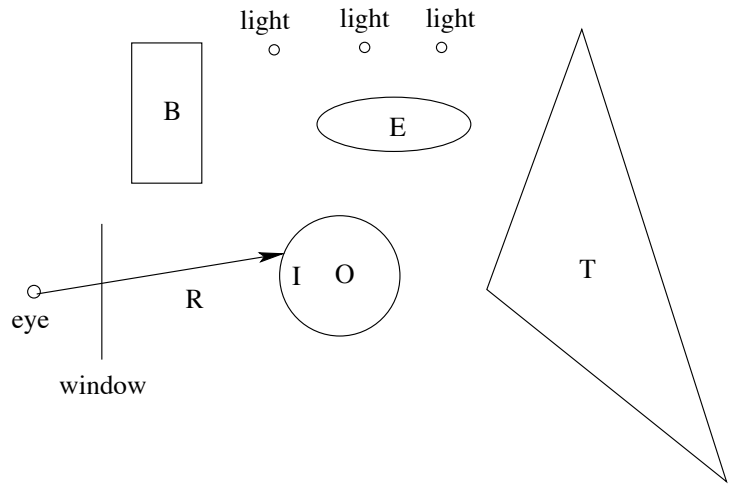
2. (20 pts) You are given a triangle with vertices A=(10,10,10), B=(10,10,0), and C=(0,0,0). Suppose you have a point of intersection of the plane of support with a ray whose barycentric coordinates are $\alpha = 0.5$, $\beta = 0.5$ and $\gamma = 0.0$.

   (a) Is this point inside, outside, or on the boundary of the triangle? Why?

   (b) Give the 3-d coordinates of the intersection point.

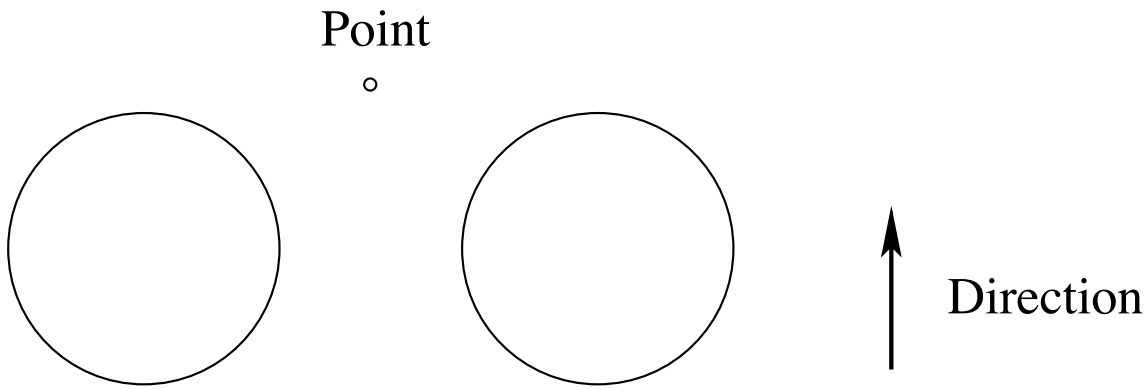
   (c) Suppose the vertices had texture coordinates given by A = (0,0.5), B = (0.5, 0.5), and C = (0.5,0). What are the texture coordinates of the given point?

3. (20 pts) You are ray tracing the scene shown below in two-dimensional cross section, and you have just calculated that primary ray **R** starting at the eye and passing through the window hits object **O** as shown. Object **O** is a transparent polished glass sphere which reflects light from its surface as well as passing transparent light through. It is also shiny, meaning it has a specular highlight, but it doesn't reflect any light diffusely and it doesn't reflect any ambient light. All other objects in the scene are opaque. Light sources are labelled as such. Sketch every ray which originates at the intersection point **I** of **R** and **O** and which is needed to calculate the color of the intersection point **I**. Make sure to indicate clearly any object or light source that each ray hits. Do any objects cast shadows on **I**? If so, which ones?



4. (20 pts) You are implementing backface culling to speed up hidden surface removal. That is, you assume all objects in the scene are closed objects, with the "front" of the polygons facing outwards. Given the eye position $E = (E_x, E_y, E_z)$, the lookat point $L = (L_x, L_y, L_z)$ and the three vertices $A = (A_x, A_y, A_z)$, $B = (B_x, B_y, B_z)$, and $C = (C_x, C_y, C_z)$ of a triangle, and assuming the normal counterclockwise convention in which the points appear to be listed counterclockwise (in alphabetical order) to a viewer looking at the "front" of the triangle, give an expression for determining whether the triangle is facing toward or away from the observer.

5. (20 pts) Consider the two-dimensional projection of a scene containing two spheres, a point light source, and a direction that may be considered either as a vector pointing to a directional light source at infinity or alternatively as a vector pointing toward a viewing position far from the spheres, as depicted below.



a) If the two spheres are assumed to have matte surfaces, indicate the brightest spot on the each sphere if the directional light is the only one turned on by placing an "d" at that spot on each sphere.

b) If the two spheres are assumed to have matte surfaces, indicate the brightest spot on the each sphere if the point light is the only one turned on by placing an "p" at that spot on each sphere.

c) Shade the portion of each sphere, if any, that will be completely unlit if both lights are on but there is no ambient light.

d) Now assume that the point light is turned on, and the direction vector points to a distant eye (or camera) position rather than a directional light source. If the spheres are specular, where will the center of the highlight be on each sphere? You may sketch on the spheres to indicate where this is, but be sure to include in the sketch or in the written explanation the specific reason why that is the point in each case.