Written Assignment W2

Computer Graphics 2 (15-463)

16 Mar. 1995

Due Thursday, 30 Mar 1995 in class

1. [10 pts.] The implicit equation for a torus with major radius a and minor radius b is

$$(x^2 + y^2 + z^2 - a^2 - b^2)^2 = 4a^2(b^2 - z^2)$$

Write pseudocode to find the first intersection of the ray $\mathbf{x} = (x, y, z) = \mathbf{p} + t\mathbf{d}$ with the torus. Your code can call a subroutine

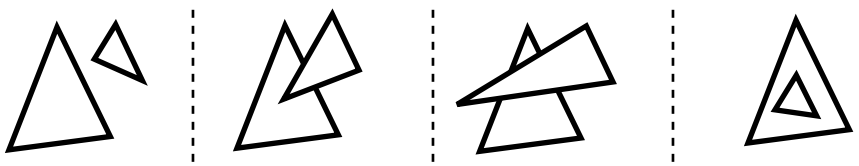
```
float first_real_root(int n, float *c)
```

that returns the smallest positive real root of the polynomial $f(x) = \sum_{i=0}^{n} c_i x^i$, or the value `NONE`, if none. Suggestion: vector notation simplifies the algebra.

2. [20 pts.] Give pseudocode for an algorithm for planar polygon depth ordering that would be suitable for a Painter's algorithm. In other words, given two polygons p and q, determine if p is in front of q, q is in front of p, or "don't care". Assume parallel projection along z. You may make use of subroutines

```
boolean point_in_polygon_2d(point x, polygon p)
boolean edge_intersect_2d(edge a, edge b)
```

which determine if a point is inside a polygon, and if two line segments intersect, respectively. Your algorithm should be able to handle any pair of nonintersecting, convex polygons, including the following:



3. [20 pts] This problem analyzes uniform grid subdivisions for ray casting. Assume that there are s surfaces uniformly distributed in a box which is divided into an $n \times n \times n$ grid of rectangular voxels, and the voxels are bigger than the surfaces for the values of n of interest, so that each surface is listed in no more than 8 voxels' lists. Let the time to step from one voxel to its neighbor be t_s, and the time to intersect a ray with a surface be t_i. What is the worst case time cost of intersecting a ray with the surfaces to find the first intersection point, as a function of n, s, t_s, and t_i? Graph cost as a function of n, qualitatively. State your assumptions clearly.