READ ME FIRST

- Don't spend too much time on any one problem.
- Amount of time spent on a problem is not necessarily proportional to the points.
- Scan through the entire test and do the easy problems first.
- If something is not clear, ASK.
- BE NEAT. We cannot give you points for something that we can't read.
- Write down your assumptions.
- Write an outline of your solution for each problem.

1	20 points	Objects and Normals	
2	5 points	Lighting	
2	5 points	Projections	
4	25 points	Lighting and Shading	
5	20 points	Curves	
6	25 points	Surfaces	
7	0 points	Bonus	
	100 points	GRAND TOTAL	

1. **Objects and Normals (20 points)**
Given the following object description:

7			
1,	1,	0,	1
2,	0,	1,	0
3,	1,	0,	-1
4,	-1,	0,	-1
5,	0,	-1,	0
6,	-1,	0,	1
7,	0,	0,	0

Figure 0.1: obj.coor

5				
poly	1	3	4	6
poly	1	3	2	
poly	3	4	2	
poly	4	6	2	
poly	6	1	2	

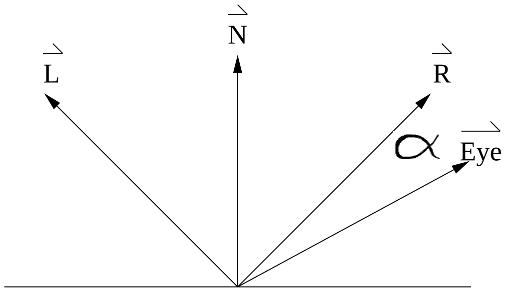
Figure 0.2: obj.poly

(a) (**10 points**) Draw and label the object. Find the normal for each polygon of the object. Show how you obtain your answers. Be careful with your signs.

(b) (**10 points**) Find the normal for each vertex of the object. Show your work.

2. **Lighting (5 points)**

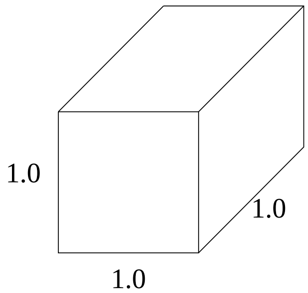
   What type of lighting function does the following calculate?



   $K_d(cos\ \alpha)^{shineness}$

3. **Projections (5 points)**

   Is this a cavalier or cabinet projection of a cube?



4. **Lighting and Shading (25 points)**

   A cross section of a polygonal surface (intersection with the z=0 plane) has the profile of a staircase – by connecting P_0 to P_1, P_1 to P_2, P_2 to P_3, and P_3 to P_4, where P_0 (0, 2), P_1 (1, 2), P_2 (1, 1), P_3 (2, 1), P_4 (2, 0).

   Assume that a white, **directional** light source is in the direction (1, 1), and the color of the surface are all (0.6, 0.4, 0.2).

   (a) (**10 points**) What are the color of polygons P_1 to P_2, and P_2 to P_3 due to diffuse reflection? Assume constant shading.

   (b) (**10 points**) What are the colors at vertices P_1, P_2, and P_3? Assume Gouraud shading.

   (c) (**5 points**) What are the color of polygons P_1 to P_2, and P_2 to P_3 due to diffuse reflection? Assume Phong shading.

5. **Curves (20 points)**

A *quadratic* parametric curve can be represented by:

$P(t) = TMG = \sum_{i=0}^{2} B_i(t)P_i$

(a) (**5 points**) What are blending functions for a *quadratic Bezier curve*? Note: since the rest of the problem depends on this part, you may buy (i.e. give up) the answer for 5 points from the professor. This is not recommended unless absolutely necessary.

(b) (**5 points**) Express the quadratic Bezier curve in $P(t) = TMG$ format. That is, what are T, M, and G?

(c) (**5 points**) What are the weights of the control points P_0, P_1 and P_2 on the cruve at $P(0.5)$, respectively?

(d) (**5 points**) Write the equation for $P'(t)$ to obtain the tangent to the curve.

6. **Surfaces (25 points)**

You are given the M_B matrix for a cubic Bezier surface and 16 control points.

$$M_B = \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

$$G_B = \begin{bmatrix} P_{00} = (-2,-2,0) & P_{01} = (-2,-2,1) & P_{02} = (-2,2,1) & P_{03} = (-2,2,0) \\ P_{10} = (-1,-2,3) & P_{11} = (-1,-2,6) & P_{12} = (-1,2,5) & P_{13} = (-1,2,4) \\ P_{20} = (1,-2,3) & P_{21} = (1,-1,6) & P_{22} = (1,1,5) & P_{23} = (1,2,4) \\ P_{30} = (2,-2,0) & P_{31} = (2,-1,2) & P_{32} = (2,1,2) & P_{33} = (2,2,0) \end{bmatrix}$$

Recall that the equation for a cubic Bezier surface is: $P(s,t) = SM_BG_BM_B^TT^T$, and $M_B = M_B^T$.

(a) (**10 points**) Label and draw the *curve* $P(s = 1, t)$. At the minimum, be sure to label the (a) xyz axes, (b) P_{00} P_{30}, P_{03}, P_{33}, and (c) the curve.

(b) (**10 points**) What are the corresponding weights of the 16 control points P_{00} ... P_{33} at $P(s = 1, t = 0.5)$?

(c) (**5 points**) What is the surface normal at $P(s = 1, t = 0.5)$?

7. **Bonus (0 points)** What did Travis wish for Christmas?