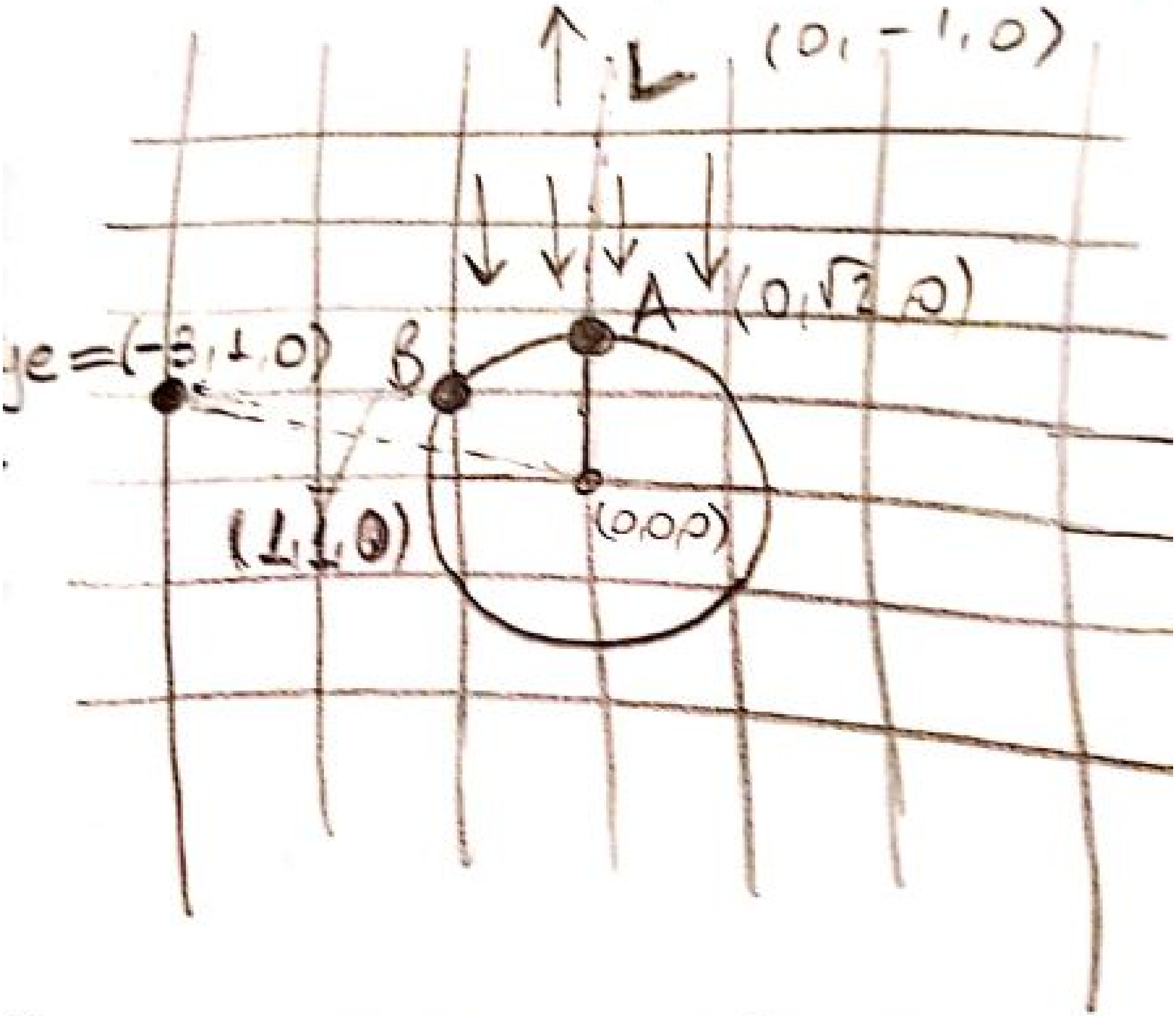
1) The scene below shows a s

There is only a directi

direction (0,−1,0) as s



$I_{L,spec} = k_s I_L \underbrace{(V \cdot R)}_{\cos\phi}^{n_s}$, if $V \cdot R >$

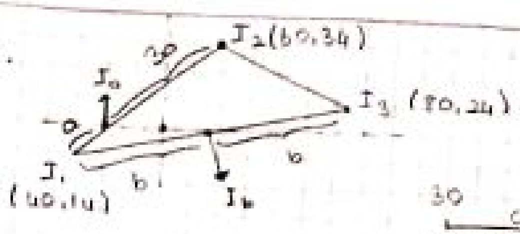
and

$N \cdot L$

$L = (0,1,0)$ $N = (0,1,0)$

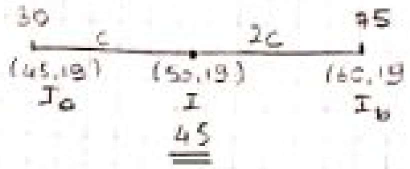
R =

Q6. a.



$I_a = (45,19)$

$I_b = (60,19)$



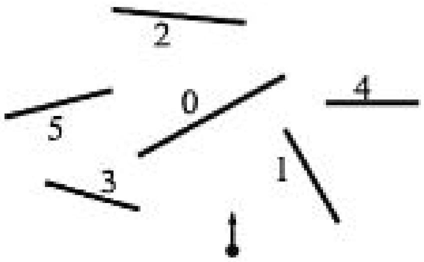
$I_a = \frac{1}{4} \cdot 90 + \frac{3}{4} \cdot 10$
$= 30$

$I_b = \frac{1}{2} \cdot 140 + \frac{1}{2} \cdot 10$
$= 75$

b. A Phong shader assumes the same input as Gouraud shading which means that it expects a normal for every vertex.

Q10. What is a-buffer? How can we handle transparent object in a scene and antialiasing by using a-buffer?

- An anti aliasing, area averaging, visibility detection method.
- Accumulation buffer
  - stores a variety of surface data in addition to depth values
  - allows a pixel color to be computed as a combination of different surface colors for transparency and anti-aliasing effects
- At each pixel, maintain a list of polygons sorted by depth.
- Algorithm: when drawing a pixel (first pass):
  - If polygon is opaque and covers pixel, insert into list, removing all polygons farther away.
  - If polygon is transparent or only partially covers pixel, insert into list, but don't remove farther polygons.
- Algorithm: Rendering pass (At each pixel, traverse buffer using polygon colors and coverage masks to calculate composite pixel color
- Advantage: can do more than z-buffer (antialiasing, transparent surfaces without ordering)
- Disadvantage: not implemented in hardware, and software imp. is slow over rendering, depth quantization problems.



Q6 Consider a triangle in the image plane. The intensities I(x,y) at the three vertices are

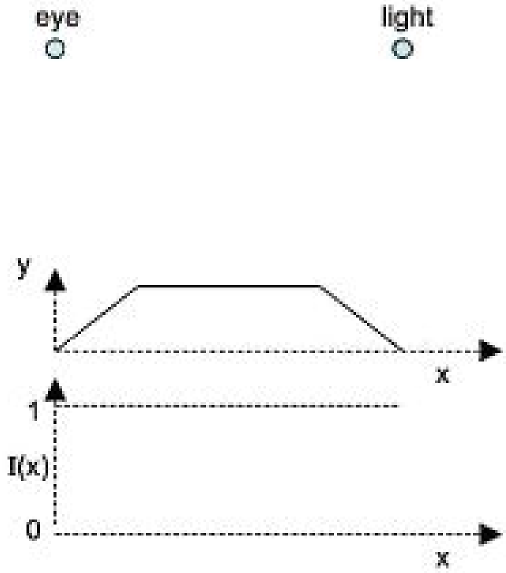
$I1 = I(40, 14) = 10$
$I2 = I(60, 34) = 90$
$I3 = I(80, 24) = 140$

(a) Using Gouraud shading, calculate the intensity at the point (50,19), i.e. I(50, 19).
(b) Describe how you could modify your method in order to calculate the intensities using Phong shading?

Q7 The top part of the diagram below represents the cross section of a surface, with light source and viewing position. On the graph template below it sketch the ambient, diffuse, and specular illumination as functions of x. Assume the Phong illumination model, i.e.

$I = k_aI_a + k_dI_d(N.L) + k_sI_s(R.V)^n$,

where $k_a = 0.2$, $k_d = 0.6$, $k_s = 0.6$, $I_a = I_d = I_s = 1.0$, $n = 300$.



Q8. a) Given the following function call to gluPerspective:

gluPerspective(60.0,0.8,4.0,100);

where the first parameter is the viewing angle, the second parameter is the aspect ratio of the clipping window (width/height), the third parameter is the distance of the near plane to the viewing origin, and the forth parameter is the distance of the far plane to the viewing origin. Find the glFrustum parameters:

glFrustum (xwmin, xwmax, ywmin, ywmax, dnear, dfar)

c) How can we obtain an oblique perspective projection using glFrustum function?

Q9. Briefly explain how we apply ray casting algorithm to calculate the volume of an object in the scene? Assume the rays are parallel to z axis and a pixel has a unit area A_{ij}.

Q10. What is a-buffer? How can we handle transperent objects in a scene and antialising by using a-buffer?

Flat Shading
- "Constant intensity"
- No interpolation
- Applie... calcula...

Sayfa 1

Q3. $I = k_a I_a + I_L k_d (L.N) + I_L k_s (R.V)^3$

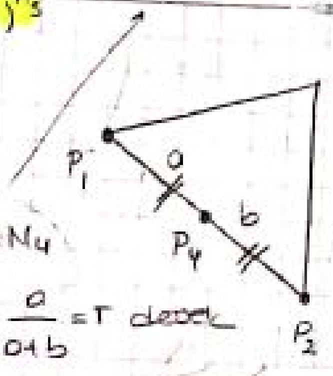
$R = 2(L.N)N - L$ / $L = (0, 0.7, 0.7)$

$\checkmark\ k_a . I_a = 0.05$ $V = (0, 0, 1)$

$\checkmark\ I_L k_d = 0.3$

$\checkmark\ I_L . k_s = 0.12$

$rN_2 + (1-r)N_1 = N_4$



$\frac{a}{a+b} . N_2 + \frac{b}{a+b} . N_1 = N_4$

$\frac{b}{a+b} = 1 - \frac{a}{a+b}$ $\frac{a}{a+b} = r$ dersek

$\vec{N_1} = (0, 1, 0)$ ve $\vec{N_2} = (0, 0, 1)$ ise $\vec{N_4} = \frac{N_1 + N_2}{2}$

$= (0, 0.5, 0.5)$ birim vektör değil.

$\underbrace{\frac{\vec{N_4}}{|N_4|}}$ ← $|N_4| = \sqrt{(0.5)^2 + (0.5)^2}$ ← (

$= \sqrt{0.5}$

birim normal vektör $\boxed{= (0, \sqrt{0.5}, \sqrt{0.5})}$

NOTE: vektör çarpımı $x_1x_2 + y_1y_2 + z_1z_2$

$R = 2(L.N)N - L$

$= 2(L.N) . (0, \sqrt{0.5}, \sqrt{0.5}) - (0, 0.7, 0.7)$

$= 2(0 \times 0 + \sqrt{0.5} \times 0.7 + \sqrt{0.5} \times 0.7)(0, \sqrt{0.5}, \sqrt{0.5}) - (0, 0.7, 0.7)$

$= 2,8 \times \sqrt{0.5}\ (0, \sqrt{0.5}, \sqrt{0.5}) - (0, 0.7, 0.7)$ H.N

$= (0, 14.0, 14.0) - (0, 0.7, 0.7)$

$= (0, 0.7, 0.7)$

$R.V = 0.7$ / $LN = 2.8 \times \sqrt{0.5}$

$I = 0.05 + 0.3 \times 1.4 \times \sqrt{0.5} + 0.12 \times 0.7$

$I = k_a . I_a\ I_L k_d\ (L.N)\ I_L k_s\ (H.N)$

Q1. Suppose a perspective projection is given by glFrustum (-5, 5, -5, 5, 5, 25).

a) Sketch the frustum in 3D.

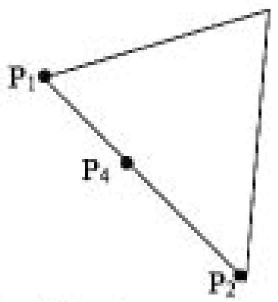
b) If eye position is at P(0, 0, 0), what is the coordinates of the point $P_{prp}(3, 3, 7)$ on the projection plane.

Q2. Two Bezier curves are given with control point p_0, p_1, p_2, p_3 and q_0, q_1, q_2, q_3. What conditions should be met to join these two curves to have a circular closed curve? Sketch the final curve and show the control points.

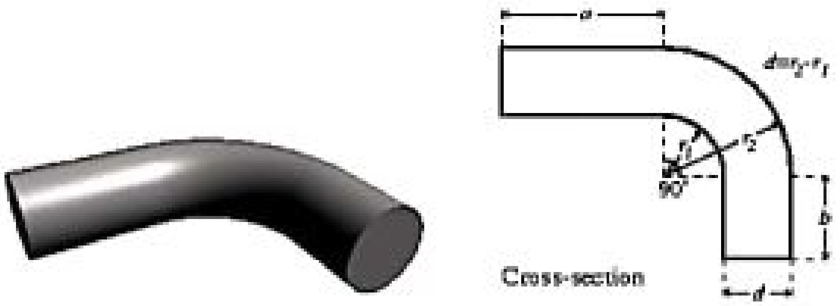
Q3. The coordinate values of the points in the following figure are given as $P_1=(1,2)$, $P_2=(5,0)$, $P_4=(3,1)$ and the normal vectors on the points P_1 and P_2 are given as $N_1=(0,1,0)$ and $N_2=(0,0,1)$, respectively.

The other parameters are given as follows:
$V=(0,0,1)$, $L=(0,0.7,0.7)$, $I_L=0.6$, $K_a=0.1$, $I_a=0.5$, $K_d=0.5$, $K_s=0.2$, $n_s=1$,

Find the illumination intensity at the point P_4 using Phong shading model.



Q4 Work out how to represent the following object using constructive solid geometry (CSG). You may assume the following primitives whose parameters can be set: sphere, cylinder, cone, torus, box (cuboid). Describe your construction method, detailing the operations on the primitives: Draw a labelled binary tree to illustrate the processing of the primitives (leaf nodes) to create the final object (root node)



Q5 (a) Construct the binary space partition tree for the line segments shown below, adding the objects to your tree in numerical order.
Note: Use the convention that the number identifier is on the front of the line segment, and segments to the front side of a segment will be represented by the right sub-tree of the corresponding node in the BSP tree.
(b) Show the traversal order of the BSP tree given the eye point shown with a dot and arrow in the picture. Show intermediate stages of computation of the traversal.

Flat Shading

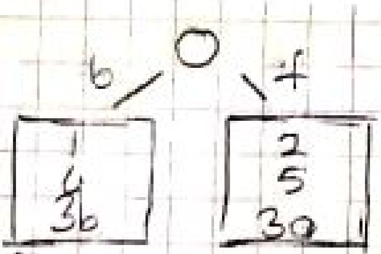
- "Constant intensity"
- No interpolation
- Applies only one illumination calculation for each primitive

Drawback

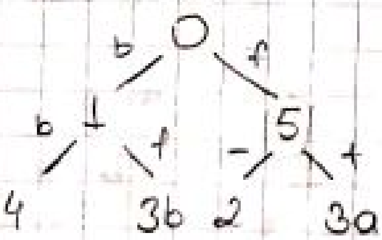
- the direction to the ligh...
- the direction to...

Adva...

Q5 **(a)** Construct the binary space partition tree for the li... ...nents shown below, adding the objects to your tree in numerical order.
Note: Use the convention that the number identifier is ... ...e front of the line segment, and segments to the front side of a segment will be r... ...ted by the right sub-tree of the corresponding node in the BSP tree.
(b) Show the traversal order of the BSP tree given the ... ...oint shown with a dot and arrow in the picture. Show intermediate stages of co... ...of the traversal.



3'ü parçaladık.



✓ eye is front of the root "back, root, front"
✓ eye is back of the root "front, root, back"

b) (1, 4, 3b), 0, (5, 2, 3a)
(3b, 1, 4), 0, (3a, 5, 2)

3. Briefly explain how we apply ray casting algo to calculate the volume of an object in the scene?
Assume that rays are parallel to z axis and a pixel has a unit area A...

Scanned by CamScanner

shading

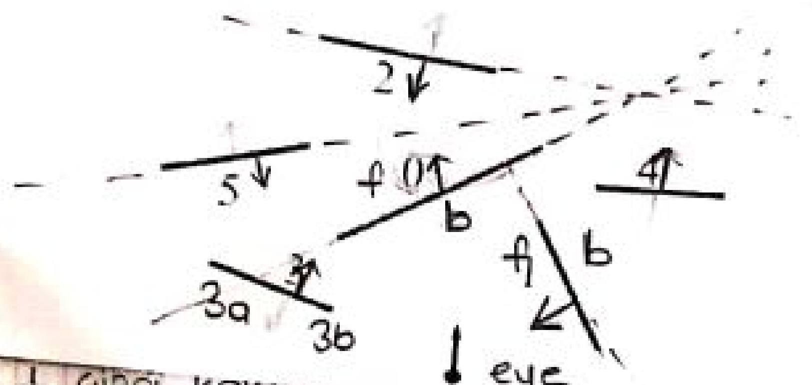
- "Constant intensity"
- No interpolation
- Applies only one illumination calculation for each primitive

Drawback

- the direction to the light
- the direction to t...

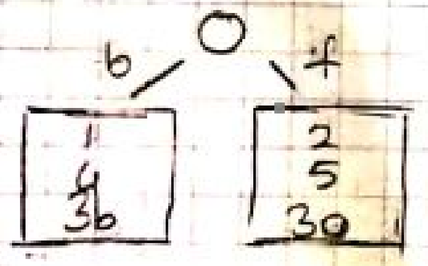
Advantage...

Sayılar önde yazılır.

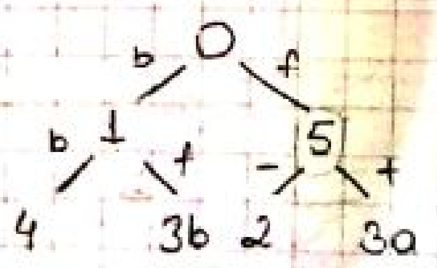


Her hücrede 1 çizgi kalana ...

Okun old. taraf front ve ağaçta sağda yer alır



3'ü parçaladık.



✓ eye is front of the root "back, ro...

✓ eye is back of the root 'front, r...

b) (1, 4, 3b), 0, (5, 2, 3a)

(3b, 1, 4), 0, (3a, 5, 2)

Q9. Briefly explain how we apply ray casting algo to calculate the volu... of an object in the scene?

Q5. BSP Tree

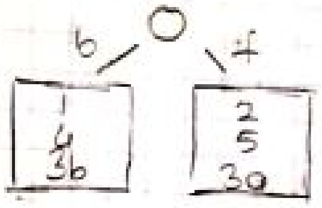
Nesneleri ortadan öne doğru numaraladır.

Keyfi bir çizgi seç.

Her hücrede 1 çizgi kalana kadar bölmeye devam et.

Okun old. taraf front ve ağaçta sağda yer alır

3'ü parçaladık



✓ eye is front of the root "back, root, front"
✓ eye is back of the root "front, root, back"

b) (1, 4, 3b), 0, (5, 2, 3a)

(3b, 1, 4), 0, (3a, 5, 2)

Q9. Briefly explain how we apply ray casting algo to calculate the volume of an object in the scene?

Assume that rays are parallel to z axis and a pixel has a unit area A_{xy}

$x = x_0 + t\Delta x$ ✓ for Sphere;

$y = y_0 + t\Delta y$ $\quad (x-a)^2 + (y-b)^2 + (z-c)^2 = r^2$

$z = z_0 + t\Delta z$ ✓ Eğer denklemin kökü yoksa raylar birbirine paralel

Algorithm: Cast ray from viewpoint through each pixel to find front-most surface.

Flat Shading

5. Pyramid shape on screen. Each face of the different color.

```
function triangle (a,b,c, color){

    var baseColors = [ vec3 (1.0, 0.0, 0.0),
                       vec3 (0.0, 1.0, 0.0),
                       vec3 (0.0, 0.0, 1.0),
                       vec3 (0.0, 0.0, 0.0)
                     ];

    colors.push (baseColors [colors]);
    points.push (a);
    colors.push (baseColors [colors]);
    points.push (b);
    colors.push (baseColors [colors]);
    points.push (c);
}
function tetra (a,b,c,d){

    triangle (a,c,b,0);
    triangle (a,c,d,1);
    triangle (a,b,d,2);
    triangle (b,c,d,3);
}
```

Flat Shading

Department of Computer Engineering

1. What is z-buffer and what is it used for?

✓ It cannot handle visibility when an object occludes another object. For this, need to enable z-b.

- An image-space algorithm
- For each pixel, we want to draw the closest object projecting to that pixel. But, the objects are processes in any order
- So, for each pixel, we keep the distance of the currently drawn object

For all pixels, this information called DEPT-TEST or z-buffer.

2. How does it work?

1. Initialize z buffer with a max value corresponding to far plane
2. For each fragment, compare its depth with the current value in z-buffer

_ If greater, ignore.

_ otherwise, use it to set the color in color buffer and update the value in z-buffer

3. Advantages and Disadvantages

✓ Computing the required depth values is simple

✓ Over-renders
✓ Dept quantization errors can be annoying
✓ Can't easily do trasparency or filtering for anti-aliasing.

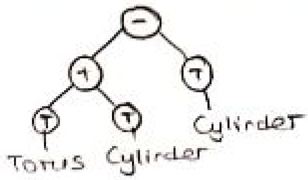
4. Can you name another method for the same problem? Compare it.

A buffer (Accumulation buffer)
_ stores a variety of surface data in addition to depth values
_ allows a pixel color to be computed as a combination of different surface colors for trasparency and anti-aliasing.

A buffer

- Can do more than z-buffer anti aliasing / trasparent surfaces without ordering
- coverage mask idea can be used in other visibility algorithms
- still at heart a z-buffer: over-rendering and depth quantization problems.

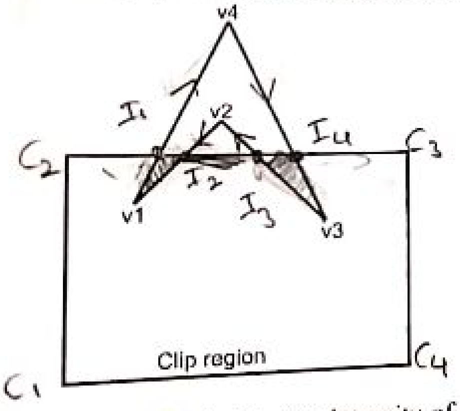
... can you model a cup like the one shown below using constructive solid geometry? You can use simple primitives such as a sphere, cylinder, cone, torus, box (cube). Describe your construction with details of the operations on the primitives. Draw a labeled binary tree to illustrate the processing of the primitives (leaf nodes) to create the final object (root node).



Q2. [17] A line is given with endpoints (2,3) and (8,7). Determine the pixels for drawing this line using Bresenham's algorithm. Show your decision parameter at each step clearly.

Q3. [17] Calculate and write the transformation matrix for rotating the ABCD parallelogram with vertices A(1,2), B(4,5),C(5,8), D(2,5) 45° counter-clockwise.

Q4. [16] For following polygon in the clip region, apply Weiler-Atherton polygon clipping algorithm.



Subject	Clip
V_1	C_1
I_1	C_2
V_4	I_1
I_4	I_2
V_3	I_3
I_3	I_4
V_2	C_3
I_2	C_4
V_1	C_1
I_1	C_2

Shutherland
Hodgman

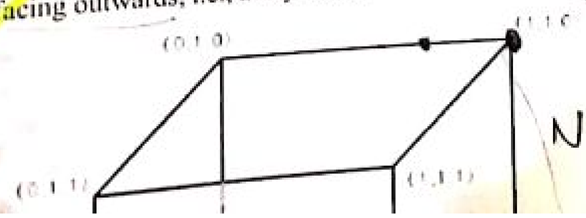
Q5. [17] Calculate the intensity of the vertex at (1, 1, 1) by using the basic (Phong) illumination model. V=(0,0,1), I_L=0.8, K_a=0.1, K_d=0.5, K_s=0.2, n_s=1, I_a=0.5, L= (0.71,0.0.71). Assume that all the normals of the cube's sides are facing outwards, i.e., away from the cube.

$R = 2(L.N)N - L$

$I_L k_s (R \cdot V)^{n_s}$

$N = \frac{P}{|P|}$

H.N

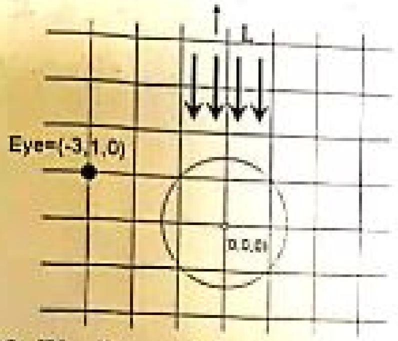


Ankara University
COM337
Computer Graphics
Duration: 60 minutes
Student ID:
20 points for each question

Department of Computer Engineering
23/01/2018
Resit Examination

Name Surname:

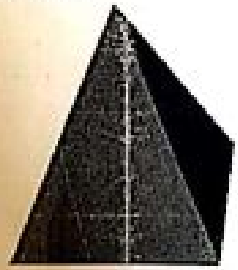
Q1. The scene below shows a sphere of radius √2 centred at the origin. There is only a directional light in the scene towards the direction (0, -1, 0) as shown. The eye location is at (-3, 1, 0).



(i) At what point (coordinates) on the sphere will we get maximal specular reflection? Explain your answer.
(ii) At what point (coordinates) on the sphere will we get maximal diffuse reflection? Explain your answer.

Q2. We discussed three surface rendering methods in the course. These were flat shading, Gouraud shading, and Phong shading. Explain these methods briefly and state their advantages and disadvantages.

Q3. Write an OpenGL program to display a solid pyramid object on screen using perspective projection. Each face of the pyramid should be a different color. Your program output should be similar to the image below (but in color).



Q4. Calculate 3 different points that will be on the Bezier curve created using control points p1=(1,4), p2=(3,7), p3=(11,5), and p4=(7,1).

Q5. We have two triangles: one with vertices P1=(2,1,-1), P2=(4,2,-1), and P3=3,3,-2); and the other with Q1=(2,4,-1), Q2=(3,4,-3), and Q3=(4,5,-2). Determine an order between these polygons using Depth-sort algorithm. Explain your steps and final decision clearly.