**COMSATS University Islamabad Lahore Campus**

**Terminal Examination – Semester Spring 2021**

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|---|---|---|---|---|---|---|---|
| Course Title: | Computer Graphics | | | Course Code: | CSD353 | Credit Hours: | 3(2,1) |
| Course | Aamer Mehmood | | | Programme Name: | BS Computer Sciences | | |
| Semester: | 5th, 7th | Batch: | SP17,FA17 | Section: | A,B,C | Date: | |
| **Time Allowed:** | **3 Hours** | | | **Maximum Marks:** | | **100** | |
| Student's Name: | | | | Reg. No. | CIIT/SDP-SP( )-BCS- | | |

**Important Instructions / Guidelines:**

- Use proper indentation, comments, naming conventions and self-explanatory names if you want to secure better marks.

# Solutions

## Raster System

**Q. (A). Suppose RGB raster system is to be designed using on 8 inch x 10 inch screen with a resolution of 100 pixels per inch in each direction. If we want to store 6 bits per pixel in the frame buffer, how much storage (in bytes) do we need for frame buffer?**

Here, resolution = 8 x 10 inch
First, we convert it in pixel then
Now resolution = 8X100 by 10 X 100 pixel = 800 X 1000 pixel
1 pixel can store 6 bits
So frame buffer size required = 800 X 1000 X 6 bits
= (800 X 1000 X 6) / 8
= 6 x $10^5$ bytes
(**B). How much time is spent scanning across each column of pixels during screen refresh on a raster system with resolution of 800 X 600 and a refresh rate of 29 frames per second?**
Here, resolution = 800 X 600
That means system contains 800 columns and each column contains 600 pixels
Refresh rate = 29 frame/sec.
So, 1 frame takes = 1/29 sec.
Since resolution = 800 X 600
1 column takes,
1/29 X 800 = 27.5 sec

## Line Drawing Algorithms

**Q.** Provide the Pseudo code of Bresenham's midpoint line drawing algorithm.

BRESENHAM'S LINE DRAWING ALGORITHM
(for |m| < 1.0)

1. Input the two line end-points, storing the left end-point in (x0, y0)
2. Plot the point (x0, y0)
3. Calculate the constants Δx, Δy, 2Δy, and (2Δy - 2Δx) and get the first value for the decision parameter as:
$$p_0 = 2\Delta y - \Delta x$$
4. At each xk along the line, starting at k = 0, perform the following test. If $p_k < 0$, the next point to plot is ($x_{k+1}$, $y_k$) and:

$$p_{k+1} = p_k - 2\Delta y$$

Otherwise, the next point to plot is ($x_{k+1}$, $y_{k+1}$) and:

$$p_{k+1} = p_k - 2\Delta y - 2\Delta x$$

5. Repeat step 4 (Δx – 1) times

# 2D transformation

**Q. Find a transformed point A caused by rotating B (7, 9) about the origin through an angle of 30º.**

x` = xcosø-sinø

y`=xsinø+ycosø

x`=7(0.866)-9(0.5)=1.526

y`= 7(0.5)+ 9(0.866)=11.294

**Q. Prove that simultaneous shearing in both direction (X & y direction) is not equal to the composition of pure shear along x-axis followed by pure shear along y-axis.**

We know that the simultaneous shearing

$S_h = \begin{bmatrix} 1 & a \\ b & 1 \end{bmatrix}$

Shearing in x direction is $\begin{bmatrix} 1 & a \\ 0 & 1 \end{bmatrix}$ and in y direction is $\begin{bmatrix} 1 & 0 \\ b & 1 \end{bmatrix}$ therefore

Shearing in x direction followed by y direction is

$$\begin{bmatrix} 1 & a \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ b & 1 \end{bmatrix} = \begin{bmatrix} 1+ab & a \\ b & 1 \end{bmatrix}$$

And this is not equal to $S_h$

# 3D transformation

**Q. Rotate A= (7,8,9) by 30 degrees along Y-axis.**

c = cos(30) = 0.866, s = sin(30) = 0.5, and

$$\begin{bmatrix} x` \\ y` \\ z` \\ 1 \end{bmatrix} = \begin{bmatrix} cos\theta & 0 & sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -sin\theta & 0 & cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} x` \\ y` \\ z` \\ 1 \end{bmatrix} = \begin{bmatrix} cos30 & 0 & sin30 & 0 \\ 0 & 1 & 0 & 0 \\ -sin60 & 0 & cos60 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 3 \\ 1 \\ 4 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} x` \\ y` \\ z` \\ 1 \end{bmatrix} = \begin{bmatrix} 0.866 & 0 & 0.5 & 0 \\ 0 & 1 & 0 & 0 \\ -0.5 & 0 & 0.866 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 7 \\ 8 \\ 9 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} x` \\ y` \\ z` \\ 1 \end{bmatrix} = \begin{bmatrix} 0.866 & 0 & 0.5 & 0 \\ 0 & 1 & 0 & 0 \\ -0.5 & 0 & 0.866 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} 7 \\ 8 \\ 9 \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} x` \\ y` \\ z` \\ 1 \end{bmatrix} = \begin{bmatrix} 10.6 \\ 8 \\ 3.7 \\ 1 \end{bmatrix}$$

# Lighting and Projection

**Q. How the world look like in following situations?**
**1. without ambient light.**
**2. with too much ambient light.**

Ambient light means the light that is already present in a scene, before any additional lighting is added. It usually refers to natural light, either outdoors or coming through windows etc. It can also mean artificial lights such as normal room lights.

Photography and video work rely largely or wholly on ambient lighting.

Ambient light can be a real trouble if it conflicts with what the photographer wants to achieve. For example, ambient light may be the wrong color temperature, intensity or direction for the desired effect. In this case the photographer may choose to block out the ambient light completely and replace it with artificial light.

**Q:** Find the intersection point and clip the line using Figure (1).

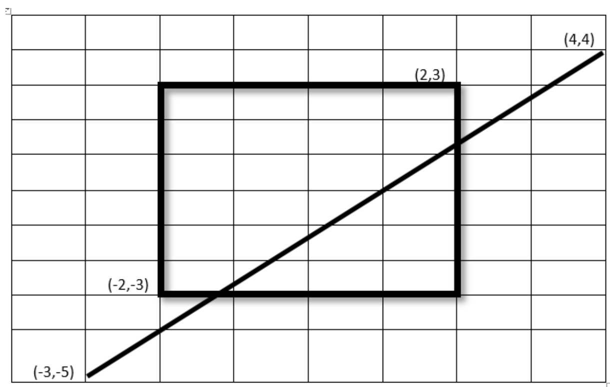



Figure 1.

**Answer:** Slope (m) of the line is 4+5/4+3
=9/7

So using equation of the line,

$y=y_0+m(x-x_0)$

=-5+9/7(2+3)

=-5+45/7

=10/7

So the first intersection point is $I_1$ (2,10/7)

For second intersection point, using the same line equation,

$x=x_0+1/m(y-y_0)$

=-3+7/9(-3+5)

=-3-14/9

=-41/9

**Q. The Phong reflection model is an approximation of physical reality to produce good rendering under a variety of lighting conditions and material properties. Describe the four vectors, the model uses to calculate a color for an arbitrary point p. Illustrate with a figure.**

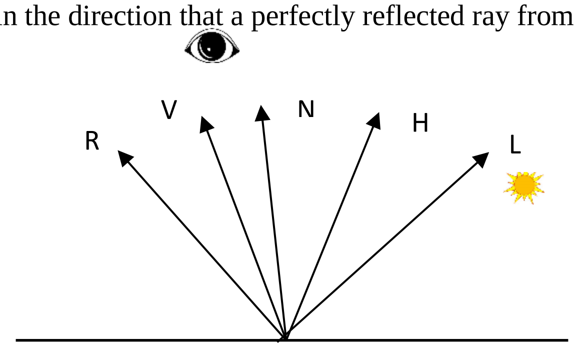
The Phong reflection model uses four vectors to calculate a color for an arbitrary surface point P

i. The vector N is the normal at P

ii. The vector V is in the direction from p to the viewer (or the center of projection, COP)

iii. The vector L is in the direction from P to the (point) light source

iv. The vector R is in the direction that a perfectly reflected ray from L would take; R is determined by vectors N and L




# Curves

**Q . Derive an implicit equation for a torus whose center is at the origin. You can derive the equation by noting that a plane that cuts through the torus reveals two circles of the same radius.**

Consider two identical circles of radius r centered at (a, 0) and (−a, 0). We can describe them through the single implicit equation

((x − a) 2 + y2 − r2)((x + a) 2 + y2 − r2),

By simply multiplying together their individual implicit equations. We can form the torus by rotation these circles about the y axis which is equivalent to replacing x2 by x2 + z2.

**Q**. Given $B_o = [1,1]$, $B_1 = [2,3]$. $B_2 = [3,1]$ and $B_3 = [4,3]$ the vertices of a Bezier polygon. Determine 7 points on the Bezier curve for t=0, t=0.15, t=0.35, t=0.5, t=0.65, t=0.85, t=0.1. (10 marks)

Answer:
Here n = 3, since there are four vertices.

$$\begin{bmatrix} n \\ i \end{bmatrix} = \frac{n!}{i!\,(n-i)!}$$

Where n = 3, i = 0, then

$$\begin{bmatrix} n \\ i \end{bmatrix} = 1$$

| J(n,i) | | |
|---|---|---|
| J(3,0) | (1) $t^o\,(1-t)^{3-0}$ | $= (1-t)^3$ |
| J(3,1) | (3) $t^1\,(1-t)^{3-1}$ | $= 3t(1-t)^2$ |
| J(3,2) | (3)$t^2\,(1-t)^{3-2}$ | $= 3t^2(1-t)$ |
| J(3,3) | (1)$t^3\,(1-t)^{3-3}$ | $= t^3$ |

Therefore, $p(t) = B_0 J_{3,0} + B_1 J_{3,1} + B_2 J_{3,2} + B_3 J_{3,3}$
$p(t) = B_0 (1-t)^3 + B_1 3t(1-t)^2 + B_2 3t^2(1-t) + B_3 t^3$
$x(t) = x_0 (1-t)^3 + x_1 3t(1-t)^2 + x_2 3t^2(1-t) + x_3 t^3$
$y(t) = y_0 (1-t)^3 + y_1 3t(1-t)^2 + y_2 3t^2(1-t) + y_3 t^3$
Using there equations, the seven points on the bezier curve are computed as below:

| t values | P(t) | x(t) and y(t) | x and y values | p(x,y) |
|---|---|---|---|---|
| t=0 | X(0)<br>Y(0) | =1<br>=1 | =1<br>=1 | (1,1) |
| t=0.15 | X(0.15)<br><br>Y(0.15) | $=1(1-0.15)^3+3(2)(0.15)(1-0.15)^2+3(3)(0.15)^2(1-0.15)+4(0.15)^3$<br>$=1(1-0.15)^3+3(3)(0.15)(1-0.15)^2+3(1)(0.15)^2(1-0.15)+3(0.15)^3$ | =1.45<br><br>=1.657 | (1.45, 1.657) |
| t=0.35 | X(0.35)<br><br>Y(0.35) | $=1(1-0.35)^3+3(2)(0.35)(1-0.35)^2+3(3)(0.35)^2(1-0.35)+4(0.35)^3$<br>$=1(1-0.35)^3+3(3)(0.35)(1-0.35)^2+3(1)(0.35)^2(1-0.35)+3(0.15)^3$ | =2.05<br><br>=1.973 | (2.05, 1.973) |
| t=0.50 | X(0.50)<br><br>Y(0.50) | $=1(1-0.5)^3+3(2)(0.5)(1-0.5)^2+3(3)(0.5)^2(1-0.5)+4(0.5)^3$<br>$=1(1-0.5)^3+3(3)(0.5)(1-0.5)^2+3(1)(0.5)^2(1-0.5)+3(0.5)^3$ | =2.5<br><br>=2 | (2.5, 2) |
| t=0.65 | X(0.65)<br><br>Y(0.65) | $=1(1-0.65)^3+3(2)(0.65)(1-0.65)^2+3(3)(0.65)^2(1-0.65)+4(0.65)^3$<br>$=1(1-0.65)^3+3(3)(0.65)(1-0.65)^2+3(1)(0.65)^2(1-0.65)+3(0.65)^3$ | =2.95<br><br>=2.027 | (2.95, 2.027) |
| t=0.85 | X(0.85)<br><br>Y(0.85) | $=1(1-0.65)^3+3(2)(0.65)(1-0.65)^2+3(3)(0.65)^2(1-0.65)+4(0.65)^3$<br>$=1(1-0.65)^3+3(3)(0.65)(1-0.65)^2+3(1)(0.65)^2(1-0.65)+3(0.65)^3$ | =3.55<br><br>=2.34 | (3.55, 2.34) |
| t=0.1 | X(0.1)<br><br>Y(0.1) | $=1(1-0.1)^3+3(2)(0.1)(1-0.1)^2+3(3)(0.1)^2(1-0.1)+4(0.1)^3$<br>$=1(1-0.1)^3+3(3)(0.1)(1-0.1)^2+3(1)(0.1)^2(1-0.1)+3(0.1)^3$ | =4<br><br>=3 | (4, 3) |