UNIVERSITY OF COLOMBO, SRI LANKA

UNIVERSITY OF COLOMBO SCHOOL OF COMPUTING

DEGREE OF BACHELOR OF INFORMATION TECHNOLOGY (EXTERNAL)
Academic Year 2010/2011 – 3rd Year Examination – Semester 5

IT5503: Computer Graphics & Image Processing

Structured Question Paper

11th, March, 2011
(TWO HOURS)

To be completed by the candidate
BIT Examination Index No: ....

Important Instructions:

- The duration of the paper is **2 (Two) hours**.
- The medium of instruction and questions is English.
- This paper has **4 questions** and **12 pages**.
- **Answer all 4 questions: Each question carries 25 marks.**
- **Write your answers** in English using the space provided **in this question paper**.
- Do not tear off any part of this answer book.
- Under no circumstances may this book, used or unused, be removed from the Examination Hall by a candidate.
- Note that questions appear on both sides of the paper. If a page is not printed, please inform the supervisor immediately.
- **Non-programmable Calculators may be used.**

Questions Answered

Indicate by a cross (×), (e.g. X) the numbers of the questions answered.

	Question numbers				
To be completed by the candidate by marking a cross (×).	1	2	3	4	
To be completed by the examiners:					

1) (a) Briefly explain 4 (four) application areas of computer graphics.

(4 marks)

ANSWER IN THIS BOX

Any 4 of the following:

1. **CAD applications**
2. **Education**
3. **Entertainment (games)**
4. **Film and Video Creation**
5. **Virtual Reality**
6. **Advertising**
7. **Fine Arts**

(b) Explain the two terms ‘windows’ and ‘viewports’ in computer graphics applications.

(4 marks)

ANSWER IN THIS BOX

- ✓ **A window is a world coordinate area selected for display.**
- ✓ **A viewport is a selected display area on the screen to which a window is mapped.**
- ✓ **The window defines what is to be displayed and the viewport defines where it is to be displayed.**
- ✓ **For a 2D picture, a view is selected by specifying a sub-area of the total picture area. A user can select a single area for display, or several areas to display many picture parts at the same time.**

(c) A point at position (X_w, Y_w) in the window is mapped into position (X_v, Y_v) in the associated viewport. Derive the equations for the viewport position of (X_v, Y_v) using normalized coordinates.

(***Hint:*** the coordinates (Xw_{min}, Yw_{min}) and (Xw_{max},Yw_{max}) define the rectangle of the window and coordinates (Xv_{min}, Yv_{min}) and (Xv_{max},Yv_{max}) define the rectangle of the viewport.)

(6 marks)

ANSWER IN THIS BOX

$$\frac{Xw - Xwmin}{Xwmax - Xwmin} = \frac{Xv - Xvmin}{Xvmax - Xvmin}$$

$$\frac{Yw - Yw_{min}}{Yw_{max} - Yw_{min}} = \frac{Yv - Yvmin}{Yv_{max} - Yv_{min}}$$

We can rewrite above as

$$Xv = [(Xv_{max} - Xv_{min})/(Xw_{max} - Xw_{min})] * (Xw - Xw_{min}) + Xv_{min}$$

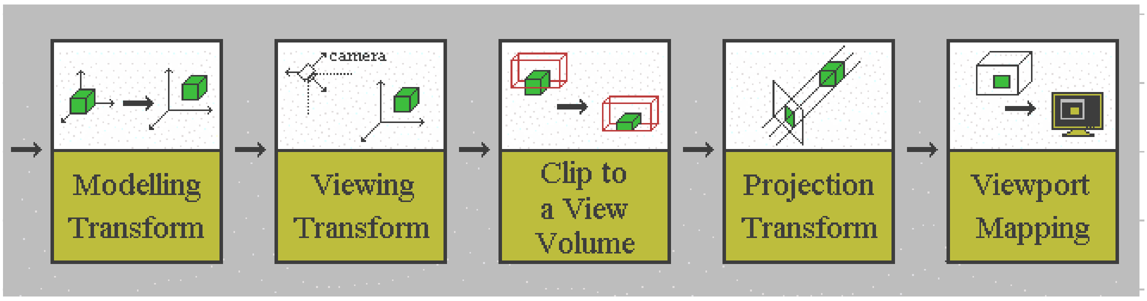
Similarly for Y,

$$Yv = [(Yv_{max} - Yv_{min}) / (Yw_{max} - Yw_{min})] * (Yw - Yw_{min}) + Yv_{min}$$

(d) Draw a flow chart to show the steps involved in a typical 3D Graphics Viewing Pipeline

(5 marks)

ANSWER IN THIS BOX



1. The viewing transformation takes vertices in the world coordinates into viewing coordinates.
2. The clipping operation eliminates the graphics outside the specified view volume.
3. The appropriate projection transformation to project 3D graphics in the view volume onto the view plane should be carried out.
4. The final two steps in this pipeline are the standard final processes in a two dimensional pipeline.
5. These involve transforming the view window contents on to the viewport (the part of the display surface selected) and then transforming these coordinates into physical device coordinates.

(e) Name and briefly explain the three components of illumination that are used to calculate shading for an opaque surface?

(6 marks)

ANSWER IN THIS BOX

1. Ambient light- combination of light reflections from various surfaces to produce a uniform illumination

2. Diffuse reflection- the reflection of light from a surface such that an incident ray is reflected at many angles

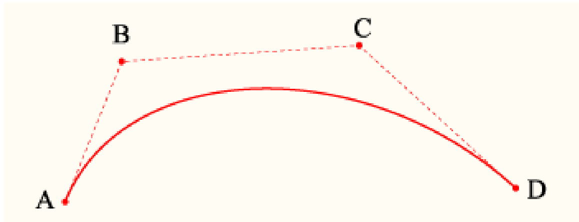
3. Specular reflection- the mirror-like reflection of light from a surface, in which light from a single incoming direction is reflected into a single outgoing direction

2) (a) Give the formula for a Cubic Bezier curve.

(3 marks)

ANSWER IN THIS BOX

Four points A, B, C and D in the plane or in three-dimensional space define a cubic Bézier curve.



P(u) $= \sum P_k \, {}^3C_k \, u^k \, (1-u)^{3-k}$

$= P_0 (1-u)^3 + P_1 3u(1-u)^2 + P_2 3u^2(1-u) + P_3 u^3$

(b) Write down the cubic Bezier curve in matrix form.

(4 marks)

ANSWER IN THIS BOX

P(u) = $\begin{bmatrix} u^3 & u^2 & u & 1 \end{bmatrix} \begin{bmatrix} 1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} P0 \\ P1 \\ P2 \\ P3 \end{bmatrix}$

(c) Find the parametric representation of any point (x(u), y(u)) on the Bézier curve which starts at (2,2) and ends at (4,1) and has control points (0,1) and (3, -1) respectively.

(6 marks)

ANSWER IN THIS BOX

x(u) = $\begin{bmatrix} 1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 2 \\ 0 \\ 3 \\ 4 \end{bmatrix}$

y(u) = $\begin{bmatrix} 1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 2 \\ 1 \\ -1 \\ 1 \end{bmatrix}$

(x(u), y(u)) = ($2-6u+15u^2-7u^3$, $2-3u-3u^2+5u^3$)

(d) Derive the conditions necessary for two Bezier curves to join with following characteristics:

(i) C0-continuity
(ii) C1-continuity
(iii) C2-continuity

(6 marks)

ANSWER IN THIS BOX

(i) C0-continuity: two curve segments have the same coordinates at the boundary point.

(ii) C1-continuity: parametric first derivatives are proportional at the intersection of two successive sections.

(iii) C2-continuity: the first and second parametric derivatives of the two curve sections are proportional at their boundary.

(e) In 3D Computer Graphics, curves are represented using a parametric representation rather than a mathematical (analytical) representation. Why are parametric curves preferred over the polygonal representation?

(6 marks)

ANSWER IN THIS BOX

any 3 of the following:

- ✓ Because of tiny size, automatic detail resolution and scalability
- ✓ Computationally less expensive as mathematical representation involves non-linear function evaluations
- ✓ Evaluation of derivatives not necessary to determine the independent parameter
- ✓ Ease of programming
- ✓ Can be represented in matrix form, hence geometric transformations can be performed easily

3) (a) Give 4 applications of Digital Image Processing.

(04 Marks)

ANSWER IN THIS BOX

1. **Character recognition**
2. **Medical image analysis**
3. **Finger print recognition**
4. **Desk top publishing**
5. **Industrial object quality control**

(b) Explain briefly the following two noise removal techniques

(i) Neighbourhood averaging
(ii) Median filtering

(06 marks)

ANSWER IN THIS BOX

(i) Neighbourhood averaging

Replace the center pixel value of a neighbourhood with the average grey-level value of the neighbourhood.

$$g(x,y) = 1/n \sum_{(i,j) \in S} f(i,j)$$

where S is a neighbourhood of (x,y) and n is the number of pixels in S.

(ii) Replace the center pixel value of a neighbourhood with the median grey-level value of the neighbourhood.

(d) Calculate the new pixel values of the shaded pixel of the following image when the above two techniques are applied separately using a 3x3 neighbourhood. Give steps of your calculations.

3	4	6	5	4
4	5	7	6	5
7	8	0	4	6
8	7	6	5	7
9	7	8	9	8

(06 marks)

ANSWER IN THIS BOX

(i) value = (3+4+6+4+5+7+7+8+7)/9 = 51/9 =5.7 =5

(ii) value = median (3,4,4,5, 6,7,7,7,8) = 6

(e) Segmentation of an image into useful regions is an important operation in image analysis. Name two image segmentation techniques.

(04 marks)

ANSWER IN THIS BOX

(1) Threshold based segmentation

(ii) Pixel aggregation

(f) An image needs to be enhanced as the objects in the image are not visible. What is the technique you would suggest?

(05 marks)

ANSWER IN THIS BOX

Histogram equalization

4 (a) What operation is achieved by convoluting an image with the following mask?

1	0	-1
2	0	-2
1	0	-1

(04 marks)

ANSWER IN THIS BOX

Horizontal line detection

(b) Give another 3x3 mask which can be used to detect edges in an image together with the mask given in (a).

(04 marks)

ANSWER IN THIS BOX

1	2	1
0	0	0
-1	-2	-1

(c) Give steps of detection of edges using the Laplacian operator.

(06 marks)

ANSWER IN THIS BOX

(1) Convolute the image with digital Laplacian filter

0	***-1***	***0***
-1	***4***	***-1***
0	***-1***	***0***

(2) Identify zero-crossings as edge points.

(d) If n_1 and n_2 denote the number of information carrying units in two data sets that represent the same information, write the formula for *relative data redundancy* R_D of the first data set (the one characterized by n_1).

(05 marks)

ANSWER IN THIS BOX

$R_D = 1 - 1/C_R$

where $C_R = n_1/n_2$

(e) Outline the difference between Lossy and Lossless data compressions.

(04 marks)

ANSWER IN THIS BOX

Lossy compression techniques reduce the image quality and Lossless techniques will not reduce the image quality

(f) Name one Lossless image compression technique and one Lossy image compression technique.

(02 marks)

ANSWER IN THIS BOX

Lossless – Run length encoding, BMP

Lossy – GIF, JPG

****