CS3240

THE UNIVERSITY OF WARWICK

Third Year Examinations: Summer 2014

Computer Graphics

Time allowed: 3 hours.

Answer **FOUR** questions.

Read carefully the instructions on the answer book and make sure that the particulars required are entered on each answer book.

Use of approved calculators is permitted in this examination.

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1. (a) Why is the RGB model a good choice for graphic displays? [5]

   (b) Explain how LCD displays work. [7]

   (c) What advantages do GPUs have over CPU/video-controller architectures? [5]

   (d) State the main components of a viewing pipeline, giving the principal data values that are passed from stage to stage. [8]

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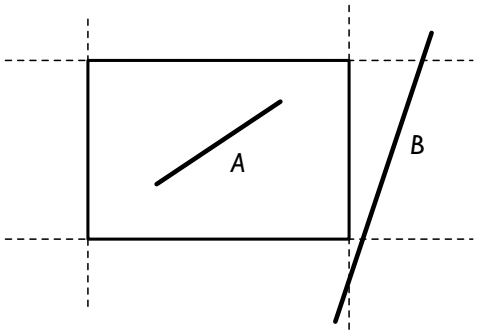
2. (a) Clip the following lines against the viewport shown using



   i. a brute-force method [4]

   ii. the Cohen-Sutherland technique [7]

   iii. the Liang-Barsky method. [7]

   In your answer you should number each step of the methods, stating any assumptions you make.

   (b) Show how the Sutherland-Hodgman polygon clipping algorithm can be made to fail. [7]

Continued

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3. (a) How is symmetry used to scan convert circles? [3]

   (b) Show with a diagram the setup of the Midpoint method for curves. [4]

   (c) Show that the increment in the decision parameter for Bresenham's midpoint circle drawing method is

   $$P_{k+1} = P_k + 2(x_k + 1) + (y_{k+1}^2 - y_k^2) - (y_{k+1} - y_k) + 1$$

   and hence state the appropriate increments of P_k for the two cases: $P_k \leq 0$ and $P_k > 0$. [10]

   (d) Derive a value for P_0. [4]

   (e) Give two simple ways of filling the circle. [4]

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4. (a) State the Bezier formula. What is the Bezier matrix for a **cubic** spline? [7]

   (b) A **quadratic** spline is specified by the equation

   $$\mathbf{x}(u) = \mathbf{U}\mathbf{B}^{-1}\mathbf{b}$$

   where $\mathbf{U}$ is the row matrix of powers of u, $\mathbf{B}^{-1}\mathbf{b}$ are the constraints for the curve. If a curve passing through the two points $\mathbf{p}_0$ and $\mathbf{p}_1$ is to be first-order continuous at $\mathbf{p}_0$, derive an expression for $\mathbf{x}(u)$ in terms of the endpoints and $d\mathbf{x}(u)/du$. [12]

   (c) How would you control a piecewise spline of the form given in (b)? Why might interpolating splines be preferred to approximating splines in drawing programs? [6]

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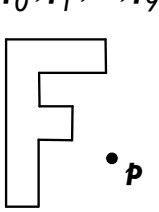
5. (a) Compare and contrast the Intersection of Half-Planes and Winding Number Rule as insideness tests. [8]

   (b) What are z-buffers and how are they used to: (1) perform hidden surface removal; (2) blend opaque and transparent geometry; and (3) generate shadows? [10]

   (c) Explain why Phong shading is computationally more expensive than Gouraud shading of triangles. What is the Phong shading value at $(0, 0)$ for the triangle $(1, -1)_0, (0, 1)_1, (-1, -1)_2$ if the vertices have illumination/vertex normal attributes $\{I_0, \mathbf{n}_0\}, \{I_1, \mathbf{n}_1\}$ and $\{I_2, \mathbf{n}_2\}$? [7]

Continued

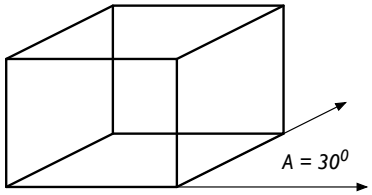
6. (a) The F-shaped object shown below is to be doubled in size and rotated about point **p** by 60^o. Give the homogeneous transformations which are performed on the vertices of the object and the final concatenated matrix.



[6]

(b) A View Volume is specified by the bottom-left hand corner of the Near plane, at (L, B) and the top-right hand corner of the Far clipping plane, at (R, T). If the clipping planes are at distances N and F from the viewpoint, derive the Orthographic Projection Matrix. [12]

(c) An Oblique Projection is required that displays all lines parallel to the z-axis drawn at an angle $A = 30^o$ to the horizontal on the view plane, as shown below.



Work out a transformation matrix that can be concatenated with your answer to (b), to perform this type of projection. [7]

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7. Using precise, labelled diagrams and clear explanation, write short essays on any **two** of the following topics.

(a) The Phong Reflection Model and its relation to Interpolated Shading.

(b) Texture, Bump and Environment mapping.

(c) Use of Raytracing and Radiosity in the quest for realism in computer graphics.

(d) Shadow generation.

[25]

End