COM1370 Summer 2002 -- Final Exam

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This is a closed-book, closed-notes, no-calculators exam. Exam given Tuesday, August 27th. Write all answers in your exam book. Do not turn in this question sheet.

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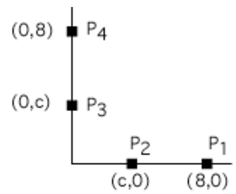
1. 27% credit for this required question. In the diagram to the right, a Bézier curve is to be drawn from P_1 to P_4 using control points P_2 and P_3 as shown. Specifically, the four points have x,y locations: $\mathbf{P}_1$ = (8,0), $\mathbf{P}_2$ = (c,0), $\mathbf{P}_3$ = (0,c) and $\mathbf{P}_4$ = (0,8). Use the cubic Bézier formula for the curve:

$\mathbf{Q}(t) = (1 - t)^3\, \mathbf{P}_1 + 3t(1 - t)^2\, \mathbf{P}_2 + 3t^2(1 - t)\, \mathbf{P}_3 + t^3\, \mathbf{P}_4$



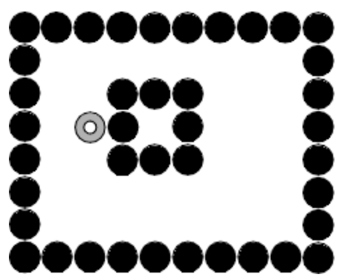
Do the following:

a. For c=4, draw the convex hull within which the curve must lie.
b. For c=4, compute the x and y values of $\mathbf{Q}(1/2)$.
c. For c=4, write down the x,y values of the midpoint of the line from (c,0) to (0,c). (Hint: This is trivial.) How does the value you computed in b compare to this value? Add the point from part b and the midpoint to your picture from part a. Does it all make sense? Explain.
d. Compute the x,y value of $\mathbf{Q}(1/2)$ in terms of c, which will apply to any value of c. What are the values of $\mathbf{Q}(1/2)$ for c=0 and for c=8? Do these make sense? Draw pictures for the two cases and explain what is going on. Draw the corresponding convex hulls and the x,y values for $\mathbf{Q}(1/2)$. (Hint: The picture for c=8 and the "curve" in it is unusual -- a degenerate case.)

2. 27% credit for this required question. The point PR has x,y location (10,0) and will be used as the point around which a rotation is to occur. The point P at (10,1) is to be rotated around PR by $+\pi/2$ radians. Using 3x3 transformations in homogeneous coordinates for two dimensions, do the following:

a. Write out three transformation matrices: T1, that translates the rotation point PR to the origin, the matrix R that rotates by $+\pi/2$ and the matrix T2 that translates the rotation point back to its original position.
b. Multiply the matrices together, in the correct order, to produce a composite matrix C that can rotate any point around PR.
c. Without doing any matrix transformations, describe how you expect the point P to be transformed and draw a picture showing its original location and what its transformed location should be.
d. Then apply the matrix C to P and show that it produces the expected result.

3. 27% credit for this required question. For the irregular region shown to the right, show the steps in the recursive boundary-fill algorithm until the entire region is filled. Show the contents of the stack at each stage, numbering the stacked points from 1 up (don't reuse any numbers).



From the following four questions, 4-7, pick one to answer.

4. 19% credit for this choice out of the four. On the left below are the values in an 3x3 image array in memory. Each is a 3-bit value. On the right is the color lookup table (CLUT) which is used to determine the final values output to a device (screen or printer) represented as an RGB triple (in that order), using one bit per color. Using the labels R (red), G (green), Bu (blue), Bl (black), W (white), C (Cyan, 011), M (magenta, 101) and Y (yellow, 110), draw and label the pixels in a 3x3 output array with the CLUT-mapped values. (Hint: The final pattern is similar to a very familiar one.)

Values in memory

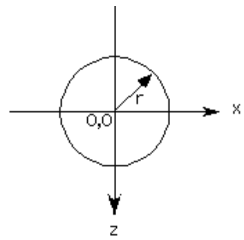
000	111	100
101	001	101
100	010	111

CLUT

index	value
111	100
110	000
101	111
100	100
011	111
010	100
001	111
000	001

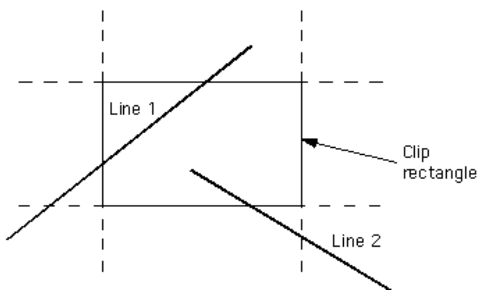
5. 19% credit for this choice out of the four. Write and illustrate the basic differences between Gouraud and Phong shading. You do not need to be specific to the level of using any numerical values in your discussion. Only proper qualitative explanations and diagrams are required. (Hint: Gouraud involves intensities.) 2D diagrams are sufficient, but some indication of how things work for a 3D patch would be better.

6. 19% credit for this choice out of the four. In the diagram on the right, ray tracing is done to a cylinder of radius r in the scene, not a sphere. The governing equation is $x^2 + z^2 = r^2$. Assume a ray is traced anti-parallel to the z axis at x=V. Show that for V > r there is no intersection. Then show that there is a value of V for which the x,z intersection with the cylinder has x=z=V. In addition show that the normal at this point is oriented at and angle $\pi/4$.



7. 19% credit for this choice out of the four.

a. Show the steps in the Cohen-Sutherland clipping algorithm for the two lines and the rectangular clipping region shown. Process line 1 first and then line 2. Use the window edge order: top, bottom, right and left. Label any line vertices you use or create: a, b, c, d, etc.
b. Briefly discuss how region outcodes can be used for rapid rejection of certain lines. (Use the relations first bit = top, second bit = bottom, third bit = right and fourth bit = left.)



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