## CSC 240: Computer Graphics Midterm: Fall 2021 Friday, October 15 – Sunday, October 17

- This is a self-scheduled, closed book exam.
- While completing the exam you are allowed to use one page of notes, 8.5x11, both sides.
- Testing hours are Friday 3:00-9:00 pm, Saturday and Sunday 12:00-6:00 pm.
- You have two hours to complete the exam from the time you sign it out.
- Students with accommodations allowing extra time can compute their time accordingly.
- Exams must be turned in by the end of the testing window, so please plan ahead.
- Students with accommodations for individual space can reserve a room in advance.
- If you are unable to make progress on any part of the exam, tell me what you tried: describe your thought process. I may be able to grant partial credit.
- When your exam is complete, before submitting it, please copy, sign, and date the statement below:

"I certify that my work on this exam adheres to the Smith Honor Code and the instructions given above."

Signed:

Date:

## Part 1: Lines and Curves (20 points)

Suppose that you have a little brother who is learning computer graphics. He has written his own function to implement line drawing, and used it to write a function that draws Bézier curves. But there's a problem, and he comes to you for advice. The curve that was drawn has sections with gaps in them, as shown at right.

a.) Given what you know about line drawing and Bézier curve algorithms, what do you think is likely wrong with his program? What advice would you give for fixing it?

b.) Your brother works for a long time making changes to the program and comes back with the image at right. The part that was incomplete before is now solid at last, but another part of the curve is now dotted! He's still not happy, and hopes you can tell him again what is wrong. Now what is likely wrong with the program?

c.) After more work, your brother thinks he almost has it. The program is drawing a connected sequence of points. However, it has sharp angles instead of the smooth curve he wanted. He has made so many changes to the program he's not sure which ones are responsible. What is likely to be causing the curve to look jointed?

d.) What is the minimum order of the Bézier curve in this question (linear, quadratic, etc.)?





## Part 2: Fill Algorithms (20 points)

a.) The shape at right is to be filled using a flood fill algorithm. The implementation attempts recursive calls in the following order: north, south, east, west. If the flood fill starts at point A, list the order in which the labeled points would be filled.



b.) A polygon is to be drawn using the vertices A through M below, connected in alphabetical order. Draw how the resulting shape would be filled in using the scanline fill algorithm.



A robot arm is simulated using a hierarchical model with two segments. Segment A1 is the root part and segment A2 is a subpart. Both are drawn using the command graphics.fillRect((0,0,100,20); with different modeling transforms accounting for the difference in results. The function to draw the arm is shown below. As shown, the code generates the image shown above.

```
function applyA1Transform() {
    // identity
}
function applyA2Transform() {
    graphics.translate(100,0);
}
function draw() {
    applyA1Transform();
    drawA1();
    graphics.save();
    applyA2Transform();
    drawA2();
    graphics.restore();
}
```

Below are several pictures showing different configurations of this system. Give the graphics transformations that would be required in applyA1Transform and applyA2Transform to generate these images, assuming that none of the other code changed. All are combinations of translation and rotation only.



- a.) Compute the point at t = 0.7 for a linear Bezier curve with control points  $p_0 = (3,5)$  and  $p_1 = (7,1)$ .
- b.) Compute the point at t = 0.5 for a quadratic Bezier curve with control points  $p_0 = (2,2)$ ,  $p_1 = (4,0)$  and  $p_2 = (4,8)$ .

c.) Visually find the points at t = 0.25, 0.5, and 0.75 for the control points below and sketch the resulting curve. Use one box for each t value, and the last box for the final curve.



d.) Why might splines be a better choice than single curves for creating some alphabetic letter shapes?

## Part 5: Line Clipping (20 points)

In this problem, you are given a clipping window (defining the "viewport") and an example line, and asked to perform the steps of the Cohen-Sutherland line clipping algorithm. Assume the origin is at the top left and y is increasing going down (like HTML canvas).

**Input**: viewport defined by the lines  $x_{\min} = 3$ ,  $x_{\max} = 11$ ,  $y_{\min} = 2$ ,  $y_{\max} = 10$ . line defined by the points  $p_1 = (12,0)$  and  $p_2 = (1,11)$ .

**Output**:  $p'_1$  and  $p'_2$ , the points defining the line that should actually be drawn.

a.) Draw out the viewport and the line, labeling  $p_1, p_2, x_{\min}, x_{\max}, y_{\min}$ , and  $y_{\max}$ .

b.)Write out the binary 4-digit codes for  $p_1$  and  $p_2$ .

c.) Identify what case each point falls under and show how the algorithm would update the points, showing all intermediate points. What are the final  $p'_1$  and  $p'_2$ ?



- d.)Label  $p'_1$  and  $p'_2$  on your picture and make sure they agree visually with your calculations.
- e.)How many "rounds" of clipping are required to make this line fall within the viewport?